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ENCYCLOPÆDIA BRITANNICA.

HIRING, in law, may be defined as a contract by which one man grants the use of a thing to another in return for a certain price. It corresponds to the *locatio-conductio* of Roman law. That contract was either a letting of a thing (*locatio-conductio rei*) or of labour (*locatio operarum*). The distinguishing feature of the contract was the price. Thus the contracts of *mutuum, commodatum, depositum,* and *mandatum,* which are all gratuitous contracts, become, if a price is fixed, cases of *locatio-conductio.* In modern English law the term can scarcely be said to be used in a strictly technical sense. The contracts which the Roman law grouped together under the head of *locatio-conductio*—such as those of landlord and tenant, master and servant, &c.—are not in English law treated as cases of hiring but as independent varieties of contract. Neither in law books nor in ordinary discourse could a tenant farmer be said to hire his land. Hiring would generally be applied to contracts in which the services of a man or the use of a thing are engaged for a short time.

HIRSCHAU, or HIRSAU, a village within the amt of Calw and the circle of Schwarzwald, Würtemberg, on the Nagold, is a station on the Pforzheim-Horb Railway, and has paper and other factories. Population 800. It owes its origin and its historical interest to the now ruinous Benedictine monastery in the neighbourhood, the Monasterium Hirsaugiense, at one period one of the most famous in Europe. It was founded in 830 or 832 by Count Erlafried of Calw, at the instigation of his son, Bishop Notting of Vercelli, who enriched it with, among other treasures, the body of St Aurelius. Its first occupants (838) were a colony of fifteen monks from Fulda, disciples of Hrabanus Maurus and Walafridus Strabus, headed by the abbot Liudebert. During about a century and a half, under the fostering care of the counts of Calw, it enjoyed great prosperity, and became an important seat of learning; but towards the end of the 10th century the ravages of the pestilence combined with the rapacity of its patrons, and the selfishness and immorality of its inmates, to bring it to the lowest ebb. After it had been desolate and in ruins for upwards of sixty years it was rebuilt in 1059, and under Abbot William "der Selige" (1069-1091) more than regained its former splendour. By his *Constitutiones Hirsaugienses,* a sort of new religious order, Ordo Hirsaugiensis, was formed, of which the rule was afterwards adopted by many monastic establishments throughout Germany, such as those of Blaubeuren, Erfurt, and Schaffhausen. The friend and correspondent of Pope Gregory VII., and of Anselm of Canterbury, he took active part in the politico-ecclesiastical controversies of his time; while a treatise from his pen, *De Musica et Tonis,* as well as the *Philosophicarum et astronomicarum institutionum libri III.,* bears witness to his interest in science and philosophy. About the end of the 12th century the material and moral welfare of Hirschau was again very perceptibly on the decline; and it never afterwards again rose into importance. In consequence of the Reformation it was secularized in 1558; in 1692 it was laid in ruins by the French. The *Chronicon Hirsaugiense,* or, as in the later edition it is called, *Annales Hirsaugienses* of Trithemius (Basel, 1559; St Gall, 1690), is, although containing much that is merely legendary, an important source of information, not only on the affairs of this monastery, but also on the early history of Germany. The *Codex Hirsaugiensis* was printed at Stuttgart in 1844. See Christmann, *Geschichte des Klosters Hirschau* (1782); Steck, *Das Kloster Hirschau* (1844); Wolff, "Joh. Trithemius u. die älteste Geschichte des Klosters Hirschau," in the *Württembergisches Jahrbuch* for 1863; and Helmsdörfer, *Forschungen zur Geschichte des Abts Wilhelm von Hirschau* (Göttingen, 1874).

HIRSCHBERG, the chief town of a circle in Prussian Silesia, government district of Liegnitz, is beautifully situated at the confluence of the Bober and Zacken, and on the Silesian mountain railway, 30 miles S.W. of Lauban by rail. It is the seat of a circle court and of a chamber of commerce. A great portion of its old walls still remains, and to the south of the town there are pleasant promenades. It possesses an Evangelical church, one of the six stipulated for in the agreement between Charles of Sweden and the emperor Joseph I. in 1707; four Catholic churches, one of which dates from the 14th century; a synagogue, an Evangelical gymnasium, a school of the middle grade, a female school of the higher grade, an orphanage, and an asylum. The town is the principal emporium of commerce in the Silesian mountains, and its industries include the carding and spinning of wool, and the manufacture of linen and cotton fabrics, Brabant lace, veils, artificial flowers, paper, Portland cement, porcelain, sealing-wax, blacking, chemicals, machines, fire-engines, champagne, and cider. There is also a lively trade in corn and agricultural produce. The town is celebrated for its romantic surroundings, including the Cavalierberg, from which there is a splendid view, the Hausberg, the Helicon, crowned by a small Doric temple, the Kreuzberg, with walks commanding beautiful views, and the Sattler ravine, over which there is a railway viaduct. The population in 1875 was 12,954.

Hirschberg was in existence in the 11th century, and obtained town rights in 1108 from Boleslaus III. of Poland. It withstood a siege by the Hussites in 1427, and an attack of the imperial troops in 1640. The foundation of its prosperity was laid in the 16th century by the introduction of the manufacture of linen and veils.

HIRTIUS, Aulus, one of Cæsar's chief supporters and most intimate friends. He was with him as *legatus* in Gaul. After the civil war broke out in 49 B.C., he seems to have been generally stationed in Rome to protect Cæsar's interests there. He was a personal friend of Cicero, and used his influence with Cæsar in behalf of the orator's brother and nephew. He was nominated along with Pansa by Cæsar for the consulship of 43 B.C.; and after the dictator's assassination in March 44, this honour made him for a short time one of the leading actors in that troubled time. The consuls supported the senatorial party against Antony, and led their armies into Umbria, where Antony was blockading Dec. Brutus in Mutina. On March 27th a double battle was fought: in the first Antony had the upper hand, and Pansa was mortally wounded; and in the second Hirtius completely defeated the enemy, but was himself killed in the subsequent assault on the enemy's camp. Hirtius was perhaps an author: the eighth book of Cæsar's commentaries on the Gallic war, which was certainly not written by Cæsar himself, is commonly attributed to him; and the accounts of the Alexandrian, African, and Spanish wars are perhaps also due to his pen.

HISPANIOLA. See Hayti.

HISSÁR, a British district belonging to the division of the same name,[1] in the lieutenant-governorship of the Punjab, India, lying between 28° 36′ and 29° 49′ N. lat., and between 75° 16′ and 76° 22′ E. long. It is bounded on the N. and N.W. by the Patiála state and a small portion of the British district of Sírsa, on the E. and S. by the territory of Jhínd and the British district of Rohtak, and on the W. by the deserts of Bíkaner. Area, 3539 square miles; population (1868), 484,681.

Hissár forms the western border district of the great Bíkaner desert, and consists for the most part of sandy plains dotted with shrub and brushwood, and broken by undulations towards the south, which rise into hills of rock like islands out of a sea of sand. The Ghaggar is its only river, whose supply is uncertain, depending much on the fall of rain in the lower Himálayas; its overflow in times of heavy rain is caught near Fatehábád and Murakhera by *jhíls*, which dry up in the hot season. A canal, known as the Western Jumna Canal, crosses the district from east to west, irrigating 54 villages. The soil is in places hard and clayey, and difficult to till; but when sufficiently irrigated it is highly productive. Old mosques and other buildings exist in parts of the district.

Rice is the staple crop of the district. In favourable seasons, cotton is extensively grown in lands irrigated by the Western Jumna Canal. In 1872–73, 1,431,541 acres were under tillage, out of an assessed area of 2,265,428 acres. Hissár produces a breed of milk-white oxen, 17 or 18 hands in height, which are in great request for the carriages of natives. The district has always been subject to famine. The first calamity of this kind of which we have authentic record was the famine of 1783; since then there have been several more or less serious failures of the crops.

The principal exports are oil-seeds, gram, grains, copper and brass utensils, hides, and a little cotton; the imports—salt, sugar, fine rice, cotton goods of English make, spices, and iron. The exports are double the imports in value. The rural manufactures comprise coarse cotton cloth, vessels made of prepared skins, and copper and brass vessels. The annual out-turn of rough saltpetre is estimated at 450 *maunds*. The trade of the district centres in Bhawáni, where nine lines of traffic converge. The main road, about 50 feet wide, unmetalled, traverses the district, passing through Hánsi and Hissár towns; fourteen other roads supply communication. The census of 1868 returned the population at 484,681 (males, 266,847; females, 217,834). The Hindus numbered 373,937; Mahometans, 102,928; Sikhs, 1812; and "others," 6004. There are three municipalities, viz., Bhawáni, 32,254; Hissár, 14,133; and Hánsi, 13,563. The district police numbered 396 men in 1872–73, and the municipal police 174. In the same year there were 50 schools, with 1729 scholars. The climate of Hissár is very dry; hot westerly winds blow from the middle of March till July. The average rainfall for the six years 1867–68 to 1872–73 was 14·57 inches. The principal diseases are fevers and small-pox. Cholera occasionally breaks out. Skin diseases also are common. Government dispensaries are situated at Bhawáni and Hánsi.

Prior to the Mahometan conquest, the semi-desert tract of which Hissár district now forms part was the retreat of Chauhán Rájputs. Towards the end of the 18th century, the Bhattís of Bhattíána gained ascendency after bloody struggles. To complete the ruin brought on by these conflicts, nature lent her aid in the great famine of 1783. Hissár passed nominally to the British in 1803, but they could not enforce order till 1810. Early in the mutiny of 1857 Hissár was wholly lost for a time to British rule, and all Europeans were either murdered or compelled to fly. The Bhattís rose under their hereditary chiefs, and the majority of the Mahometan population followed their example. Before Delhi had been recovered, the rebels were utterly routed.

Hissár, municipal town and administrative headquarters of the above district, 29° 9′ 51″ N. lat., 75° 45′ 55″ E. long.; population (1868), 14,133 (Hindus 9211, Mahometans 4805, Síkhs 34, Christians 83). The town is situated on the Western Jumna Canal, 102 miles W. of Delhi. It was founded in 1354 by the emperor Firoz Sháh, who constructed the canal to supply it with water; but this fell into decay during the last century, owing to the constant inroads of marauders. Hissár was almost completely depopulated during the famine of 1783, but was afterwards occupied by the adventurer George Thomas, who built a fort and collected inhabitants. It contains a cattle farm, both for commissariat purposes and for improving the breed of the province; attached is an estate of 43,287 acres for pasturage. There is an import trade in grain, *ghí*, sugar, oil, cotton, tobacco, and English piece goods. The municipal revenue in 1875–76 was £1229.

HISSAR, a state in Central Asia, lying between the meridians of 66° 30′ and 70° E. and the parallels of 39° 15′ and 37° N., and dependent on the amir of Bokhara. It forms that part of the basin of the Oxus which lies on the north side of the river, opposite the Afghan province of Balkh. The western prolongation of the Tian Shan, which divides the basin of the Zarafshan from that of the upper Oxus, after rising in one peak to a height of 12,300 feet, bifurcates in 67° 45′ E. long. Its two arms include between them the province of Shahr-i-Sabz, with the towns of Shahr Sabz, Kitab, Yakobagh, and Karchi. The main chain and the southern arm of its bifurcation, sometimes

[1] The division of Hissár is under a commissioner, and comprises the three districts of Hissár, Rohtak, and Sírsa. Area, 8478 square miles. Population (1868), 1,232,435

called Koh-i-tan, form the N. and N.W. boundaries of Hissar. On the W. it is wholly bounded by the desert; the Oxus limits it on the S. and S.E.; and the states of Karategin and Darwaz complete the boundary on the E. Until 1875 it was one of the least known tracts of Central Asia, but in that year a Russian expedition from Tashkend traversed and surveyed a great portion of it, and since then successive expeditions have explored various other portions, so that it is now very fairly known. Hissar is traversed from north to south by four important tributaries of the Oxus, viz., the Surkhab or Vakhsh, Kafirnihan, Surkhan, and Shirabad-Daria, which descend from the snowy mountains to the north and form a series of fertile valleys, disposed in a fan-shape, within which lie embosomed the principal towns of Hissar. The two chief roads by which Hissar is approached from Bokhara and Russian Turkestan lie through Karchi and Shahr-i-sabz respectively. Both these routes unite at Ak-roba, on the crest of the range between Khuzar and Baisun. There is also a difficult route, running through fine forests from Yakobagh across the mountains to Sarijui. A little way down the other side of the mountain chain between Khuzar and Derbend is situated the famous defile formerly called Kohluga (Mong. "Barrier") and the Iron Gate, but now styled Buzghol-khana or Goat's House. This pass is described by the Russians, who visited it and were vividly impressed with its solemnity, as a huge but narrow chasm in a transverse range, whose frowning rocks overhang and threaten to choke the tortuous and gloomy corridor (in places but 5 paces wide) affording the only exit from the valley. In ancient times it was a vantage point of much importance, and commanded the chief route between Turkestan and India. Hwen-Tsang, who passed through it in the 7th century on his way southward, states that there were then two folding doors or gates, cased with iron and hung with bells, placed across the pass. Clavijo, the Spanish ambassador to the court of Timur, heard of this when he passed through the defile 800 years after, but the gates had then disappeared. Derbend, the first inhabited place met with, is a poor village in the valley of the Shirabad-Daria, along which runs the road to the Oxus and to Afghanistan. Shirabad town itself is a place claiming great antiquity. It has a citadel and three rows of walls, and with its surrounding villages presents the aspect of a flourishing oasis. There are four ferries over the Oxus in the Shirabad chiefship or district, viz., Chushka-guzar (boar's ferry), Patta-kissar, Shur-ab, and Kara-kamir.

Baisun, a picturesque Uzbek town considered to be very healthy, lies on the road from Derbend to Hissar town. Emerging from the somewhat complex mountain mass which fills up this part of Hissar, the valley of the Surkhan is reached. This large river is formed by several affluents from the snowy range to the north, one of which, the Tupalan, formerly gave its name to the whole stream. The valley in its upper part is between 40 and 45 miles wide; the banks of the river are flat and reed-grown, and are frequented by wild hogs and a few tigers. The Surkhan valley is highly cultivated, especially in its upper portion, where the villages are crowded. It supplies Bokhara with corn and sheep, but its chief products are rice and flax. When Hissar was independent the valley of the Surkhan was always its political centre, the town of Hissar being simply an outlying fortress. Passing by four fortified towns, Dehinau, Sarijui, Regar, and Karatagh, all in the basin of the Surkhan, Hissar (=fort) claims notice. Its position at the entrance of the Pavi-dul-dul defile commanded the entrance into the fertile valleys of the Surkhan and Kafirnihan, just as Kubadian at the southern end of the latter stream defended them from the south. The famous bridge of Pul-i-sanghin (stone bridge, Tash-kepri in Turkish) lies on the road from Hissar and Kafirnihan to Baljuan and Kulab. It spans the Surkhab, which is here hemmed in between lofty and precipitous cliffs barely 30 paces apart. The bridge itself abuts on projecting rocks, and is ten paces wide. The next place of importance is Kulab, in the valley of the Kichi Surkhab, so called from the lakes or inundations near which it stands. The district is part of that once famous as Khotl. The town (which, strictly speaking, is the capital of Kulab district as distinct from Hissar) contains about 500 houses and a poor citadel, and from it there are roads to Badakhshan and Kurgan-tepe and Kubadian. These two lie in the valleys of the Vaksh (or Surkhab) and Kafirnihan respectively. Kulab produces wheat in great profusion, and gold is brought thither from the surrounding districts. Kubadian is a large, silk-producing town, and is surrounded with rice-fields. Formerly the two last-named valleys were densely peopled, and a series of settlements extended southward from Dehinau, from which town an arik or canal provided the city of Termez with water. Termez, or Termedh, was an ancient and important city on the Oxus. After being destroyed by Jenghiz Khan and lying for some time in ruins, it rose again into note in the following century, and when visited by Ibn Batuta, and later by Clavijo, it had grown again into a place of some importance. It is now a mass of ruins.

The population of the districts of Hissar and Kulab consists principally of Uzbeks and Tajiks, the former predominating, and, as in the valleys of the Sír and Zarafshán, gradually pushing the aboriginal Tajiks into the hills. East of Dushamba the Tajiks are the dominant race. On the banks of the Oxus there are some tribes of Baigush Turkmans who work at the ferries, drive sheep, and accompany caravans. Lyuli (gipsies), Jews, Hindus, and Afghans are also to be found in Hissar. But the Uzbeks are the most numerous, and their influence is so great that at Bokhara Hissar is known as Uzbekistan. The climate of the valleys of Hissar and Kulab is pleasant, as they are shut in by mountains to the north and open towards the Oxus to the south. Baisun (3410 feet) is the most elevated town. Hissar and Kulab produce in abundance all the cereals and garden plants indigenous to Central Asia. Cotton is grown in considerable quantities in the district of Shirabad, whence it is exported by way of Khuzar to Karshi. The difficulties of transport would prevent its being brought in any quantity from other places. Dehinau, Hissar, and Dushamba export corn and flax to Bokhara. From the vicinity of Khuzar is exported rock-salt, and sheep are brought to Bokhara and Karshi from all parts of Hissar district, as well as from Baljuan, Yurchi, and Afghanistan. A species of juniper, called archa, is used for timber. Salt is found at Bash-kurd, in the mountains of Hazret-Imam, and at other places. There are numerous brine springs in various quarters, indicating generally an inexhaustible supply of rock-salt. Auriferous sand has been discovered in the Vaksh, and the inhabitants wash the sands after the floods in spring. Merchandize is conveyed by means of camels, mules, and horses from Hissar to Karshi and Bokhara. Not a single waggon is to be found in the district, and the wooden *arba* is not even known there. Politically, Hissar now consists of seven sub-districts, governed by begs, Shirabad, Baisun, Dehinau, Yurchi, Hissar, Kurgan-tepe, and Kubadian; and Kulab of two, Baljuan and Kulab. The fact of the chief route between the Russian and British possessions in Asia lying through Hissar has served of late years to bring it into prominence, and will always invest it with a certain importance.

History.—Our knowledge of the history of Hissar is most fragmentary. In early written history this country was part of the Persian empire of the Achaemenidæ, and probably afterwards of the Græco-Bactrian kingdom, and then subject to the Eastern swarms who broke this up. In the time of the Sassanian kings of Persia it was under the Haiathalah, the Ephthalites or White Huns of the Greeks, subdued by the Turks in the early part of the 7th century, these soon to be displaced by the Mahometan power. Termedh, Kubadian, and Chagánián are named as places of importance by the Arab geographers of the 10th century; the last name was also applied territorially to a great part of the Hissar province, but is now obsolete. The country was successively subject to the Mongol Chagatai dynasty and to Timur and his successors; it afterwards became a cluster of Uzbek states of obscure history. Hissar was annexed by the amir of Bokhara in 1869–70, soon after the Russian occupation of Samarcand. (C. E. D. B.)

HISTOLOGY

I. Animal Histology.

ANIMAL HISTOLOGY (from ἱστός, a web or tissue, and λόγος, discourse) is the study of the minute structure of the tissues of animals. By a tissue is meant any part of an organism which has undergone special changes in structure in adaptation to the performance of special functions. These special changes are expressed by the general term "differentiation." In the lowest animal organisms, the whole of whose bodies are composed of the undifferentiated living substance termed "protoplasm," we find all its functions shared by every part of the organism. An amœba, for example, it is well known, is capable of finding, seizing, devouring, digesting, and assimilating food, has a special provision for collecting fluid and pumping it out of its body, respires by its whole surface, moves about apparently where it will, exhibits a sensibility to tactile impressions, and reacts in all probability to smell if not to sound and light,—in short, is capable of performing, although with the lowest possible amount of activity, almost every function which animals vastly higher in the scale of organization exhibit. But even in the amœba we cannot say certainly that there is no differentiation of its protoplasm. For a condensed portion—the nucleus—is set aside to initiate the reproductive function, and it is by means of the external and firmer layer (ectoplasm) that its movements are effected and its relations with the external world maintained, while the internal more fluid protoplasm (endoplasm) is concerned with the digestion of the food. Still there are simple organisms whose protoplasm is probably absolutely undifferentiated. On the other hand, there are other organisms which are also regarded as composed of simple protoplasm, and are constituted by a single cell, which nevertheless show a marked progress in the differentiation of portions of their substance apart altogether from the presence of a nucleus. Such differentiation in unicellular organisms generally takes the form of the production of a shell or "test," as in the *Foraminifera* and in *Noctiluca*, which subserves purely passive functions of sustentation or defence. It is not certain in such cases whether the structure thus produced is formed by the direct conversion of the protoplasm or by an exudation on the surface which subsequently hardens. But portions of the protoplasm may be set aside for the performance of *active* functions. We see this in its production in the form of locomotory organs, either temporary (pseudopodia) or permanent (cilia). But in neither of these can any actual change in the minute structure of the protoplasm be observed. A differentiation does, however, occur in one remarkable instance—the flagellum, namely, of the *Noctilucidæ* (fig. 1), which exhibits as definite a transverse striation as does the cross-striated or voluntary muscular tissue of the higher animals, in which structural peculiarity it is impossible not to infer a relation to its contractile functions; and similarly, in the *Vorticellidæ*, there is a differentiation of the protoplasm of the rapidly contractile stalk.

Whereas in the more highly organized unicellular animals portions of the single cell are thus set aside for the performance of special functions, and modified in structure accordingly, in multicellular animals, on the other hand, we find whole cells and sets of cells set apart and differentiated. It is to such modifications in sets of cells in multicellular organisms, rather than in portions of the protoplasm of a unicellular organism, that "histological differentiation" is commonly restricted; and each such set of cells, destined for the performance of a special function, and modified accordingly in structure, is denominated a "tissue."

The animal tissues may be classed under the four heads of *Epithelium*, *Connective Tissue*, *Muscular Tissue*, and *Nervous Tissue*.[1] Of these four classes of tissue the epithelium is the most primitive and least altered. In the development of the *Metazoa* the numerous embryonic cells which result from the division of the single cell—the ovum—tend in nearly every case to arrange themselves as a single layer surrounding a central cavity (unilaminar condition of the blastoderm), (fig. 2, A).[2] Presently a part of the wall of the hollow sphere becomes invaginated, so that, instead of a vesicle enclosed by but a single layer of cells, a cup (*Gastrula*, Haeckel), is produced (fig. 2, B), the wall of which is formed by two layers derived from the original single layer, and separated from one another by a narrow interval (which is all that remains of the original cavity of the vesicle) except at the orifice of the cup, where they are continuous (bilaminar condition of the blastoderm). At this part some cells become separated from one or both of

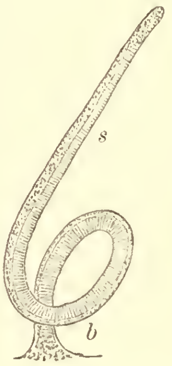

Fig. 1.

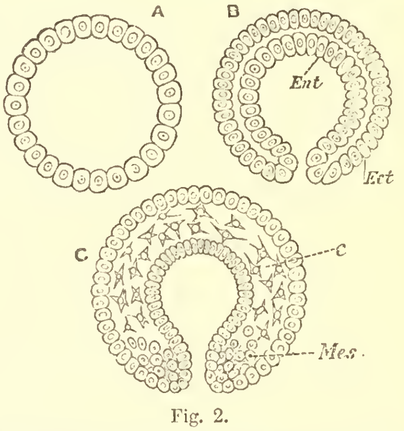

Fig. 2.

Fig. 1.—Flagellum of *Noctiluca miliaris* (highly magnified). *s*, transversely striated substance; *b*, base of attachment to body of animal.

Fig. 2.—Sections through the unilaminar (A), bilaminar (B), and trilaminar (C) conditions of the typical blastoderm. *Ect.*, ectoderm; *Ent.*, entoderm; *Mes.*, mesoderm; *c*, primitive connective tissue.

these two primary layers, and, extending in and occupying the cleft-like space which separates them, become a third layer of cells, which differs from those of the other two in not being arranged into a continuous membrane, and not, therefore, forming an epithelium (trilaminar condition of the blastoderm), (fig. 2, C). Now, of these three layers, the outer one, or ectoderm, and the inner one, or entoderm, give rise to all the epithelial tissues of the body. The nervous tissues are also derived from the ectoderm; whereas the connective and muscular tissues originate in the mesoderm or middle layer. In most of the *Cœlenterata*, however, the mesoderm is not developed at one part only of the embryo as in the higher *Metazoa*. In the hydroid polyps and *Medusæ* it never becomes completely distinct from the ectoderm and entoderm, although a jelly-like sustentacular substance may be formed to a greater or less extent between the two primary layers, and cells may pass into it from one of them, so that a kind of mesoderm is thus produced. In the *Medusæ*, also, the muscular function is performed by

[1] The characters of the several tissues and their varieties are best known as they occur in the Vertebrata, and a description of them will be found in the article on Anatomy.

[2] A layer of cells which thus forms a membrane by the union of the cells, with an inperceptible amount of intercellular cementing substance, would properly fall under the definition of the term epithelium, which was first applied by Ruysch to the cellular membrane covering the lips, and has ever since been used to designate membranes thus composed of cells alone.

cells which either still have their place in the general layer of the ectoderm or are but imperfectly separated from it; and here, again, the commencing separation does not occur at one part only, but over extensive tracts of the surface. Nevertheless these cells are modified in structure precisely in the same way as those which in higher animals are derived from the mesoderm. The nervous functions are also performed by cells and fibres, which, although they show those modifications of structure which in the higher animals are characteristic of nervous tissue, yet remain strictly confined to the ectoderm, and do not, as in the higher animals, penetrate into the mesoderm.

The Epithelial Tissues.—Although, as we have seen (see p. 4, note 2), the layers of cells which are first formed are layers of epithelium, and, therefore, the epithelial tissues are the first to be produced, nevertheless we find that they undergo less modification in structure than any of the other three classes of tissue. As before said, they invariably consist merely of cells cemented together by an imperceptible amount of intercellular substance,[1] and the cells themselves only show minor degrees of modification in shape and structure, at least as compared with the other tissues constituted mainly of cells, namely, the muscular and nervous.

Modifications in Shape of Epithelial Cells.—The cells of this tissue may be either elongated and set like palisades over the surface which they cover, in which case they are termed "columnar" (fig. 3), or they may be flattened out over the surface, and they then appear as thin "scales"; and every variation in shape is met with between these two extremes. In any case where they form a single layer, since the cells are set closely together, the mutual apposition of neighbouring cells produces a flattening of the opposed sides, so that, when the epithelium is looked at from the surface, the cells have a polygonal outline, and collectively present the appearance of a mosaic pavement (fig. 4). In

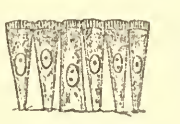
Fig. 3.

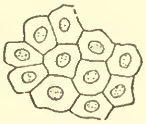
Fig. 4.

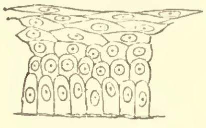
Fig. 5.

FIG. 3.—Columnar epithelium cells.
FIG. 4.—Mosaic appearance of epithelium.
FIG. 5.—Stratified epithelium.

certain cases, especially where there is liability to abrasion of the surface which they cover, the epithelial cells are disposed in two, three, or more superimposed layers (fig. 5), and then the cells of the different layers may vary much in size, shape, and consistence. Such an epithelium is termed "stratified."

It frequently happens that the layer of epithelium which covers a surface is prolonged into depressions, which may be quite simple or may be ramified either slightly or in the most complex manner. The epithelial cells which line such depressions may resemble those of the surface upon which the depression opens, or they may become more or less modified in size, shape, and other particulars, and constitute themselves into a distinct variety of epithelial tissue. Since depressions like those just mentioned are generally for the purpose of forming some special secretion, and are termed *glands*, and since this secretion is elaborated by the agency of the epithelial cells which line the gland, any such special variety of epithelium is termed a "glandular" or "secreting" epithelium.

Modifications in Structure.—The modifications in structure which the cells of epithelial tissue undergo are comparatively slight. One of the most common is the conversion of the external layer of the protoplasm of the cell into a firm membrane, generally of a horny nature, but this membrane is seldom sharply marked off from the substance of the cell, as is the case with the cellulose membrane of the vegetable cell. It becomes formed, moreover, to a very different extent in different cells, according to the function which the particular epithelium has to perform; where, for example, the epithelium is almost purely a protective covering, as in the stratified scaly epithelia, a considerable part, or even the whole thickness of many of the epithelial cells, is thus transformed; but where, on the other hand, the cells have to play an active part in yielding a secretion to moisten the surface, or in protruding a portion of their protoplasm in the form of vibratile cilia to produce currents over the surface, or to move the organism through the water, we find little, if any, of such conversion of the superficial cell-substance. What little there may be is confined to the attached surfaces of the cell, or if there is any such covering on the free surface, it is penetrated by pores which allow of a communication between the protoplasm of the cell and the external medium.

Another common modification of structure which epithelial cells exhibit is the existence of vibratile cilia at the free surface (fig. 6). This, again, is especially frequent with cells of a columnar shape, but it may occur in any. The cilia appear to be protrusions of the more active external protoplasm of the cell, which are in most cases incapable of being again withdrawn, and are in all probability modified in minute structure, although they are always so small that such modification, if it exists, escapes detection even with the employment of the highest powers of the microscope. At their base, however, the cilia are certainly continuous with the unaltered protoplasm of the cell. This may be


Fig. 6.


Fig. 7.


Fig. 8.


Fig. 9.

FIG. 6.—A ciliated epithelium cell.
FIG. 7.—A striated epithelium cell.
FIG. 8.—A ciliated cell with one large cilium.
FIG. 9.—Sense-epithelium cell of *Aurelia*.

seen even where the cilia are small and spring in a bunch from the free surface of the cell, but much better in those kinds of ciliated epithelium in which but a single large cilium is connected to each columnar cell (fig. 8).

Many epithelial cells, especially those of secreting glands, show a differentiation of their protoplasm in the form of fine striæ or rods which pass from the attached border of the cell towards the free end (fig. 7). Cells thus modified are found in the ducts of the salivary glands, in the alveoli of the pancreas, and in the convoluted tubules of the kidney in Vertebrata.

One of the most remarkable modifications which epithelium cells exhibit is found in the organs of special sense. This is the presence of a fine filamentous process or processes springing from the free surface of the epithelium cells, and resembling in their appearance long cilia, but not spontaneously vibratile (fig. 9). Moreover, the cells in question,

[1] Exceptions to this general rule are seen in the layer of cells which underlies the chitinous cuticula of annelids (Claparède), and in the enamel organ of the developing teeth of vertebrates (Kölliker), where the cells, although epithelial, are ramified and united by their branches into a network; and, in a far less degree, in many of the lower cells of a stratified epithelium, where it can be seen with a high power that the edges and surfaces of the cells are provided with numerous short projections which are applied to those on adjacent cells.

which are generally of an elongated columnar form, commonly branch out at their detached end into fine processes which appear to become connected with nerve-fibres. Cells of this character occur even so low in the *Metazoa* as the *Medusæ*, in connexion with the nerve-epithelium to be afterwards mentioned. And, indeed, in many cases where cells of this character enter into the constitution of the sense organs, it is probably most consistent with their true nature to regard them as detached portions of nervous tissue, which also in every case is originally of an epithelial nature.

Modifications in the Cell Contents.—Another chief modification which the cells of an epithelial tissue may undergo consists in the accumulation within the cells of various chemical substances, which may be either taken in bodily as such, or may be formed in the cell from other substances which are supplied to it by the blood. The substances that are thus accumulated and formed within the cells of an epithelium are of very various nature, as, for example, the constituents of special secretions (fig. 10), mucin, pigment, fatty globules, uric acid, &c., &c. These several substances are tolerably constant in an epithelium of the same kind—thus, mucin is a very frequent constituent of columnar epithelium, and in glands which have the same function in different animals, the same substances are found in the epithelium cells of the gland.

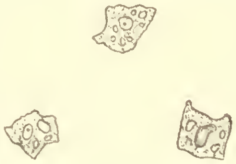
FIG. 10.—Epithelium cells of renal organ of mollusc containing crystals of uric acid. (Boll.)

Exudation from Epithelium Cells. Formation of Cuticular Structures.—In many invertebrates the epithelium which covers the surface of the body, and sometimes also that which lines a part of the alimentary canal, forms an exudation which is generally soft at first, but may afterwards harden into a horny consistency, or may be rendered still harder and at the same time more brittle by impregnation with earthy salts. Any such structure is termed a cuticular formation. It may be composed of a single thin layer, or a number of layers may be superimposed, so that a "shell" of considerable thickness is thus formed. The chitinous or calcareous covering which forms the exoskeleton in many molluscs, arthropods, annelids, and *Hydrozoa* is of this nature. On the other hand, the firm skeletons of sponges, *Actinozoa*, and *Echinodermata* are formed by deposition in the connective tissue.

The Connective Tissues.—The connective tissues are characterized by the great development of intercellular substance in comparison with the cells; indeed in those animals in which connective tissue may first of all be said to appear, there is an entire absence of cellular elements properly belonging to the tissue. This is the case in many of the *Cœlenterata*, in which the connective tissue is represented merely by a layer, more or less thick, of hyaline substance, which undoubtedly performs a sustentacular function, in addition to connecting together the epithelial layers of the ectoderm and entoderm.

The intercellular or ground substance almost invariably takes a prominent part in the formation of connective tissue. It is of a semi-fluid nature, and often contains in addition to albumen a certain amount of mucin. In most cases the cells of the connective tissue separate themselves from the primary layers before the formation of this ground substance; indeed the mesoderm is at first chiefly formed of these cells. The stages of development are as follows. The mesodermic cells, which are at first in apposition, become separated from one another by the accumulation of intercellular substance, but at the same time maintain a connexion with one another throughout the tissue by their branching cell-processes (see fig. 2, C, *c*). Presently, in the production of ordinary connective tissue, fibres of two kinds make their appearance in the intercellular substance, and to all appearance independent of the cells. Those of the one kind (fig. 11, A) are highly elastic and refracting, not easily affected by reagents, stain deeply with magenta, run singly, always branch, and become united with neighbouring fibres so as to form a network throughout the tissue; those of the other kind (fig. 11, B) are excessively fine and indistinct, never run singly but always in bundles, and generally with a wavy course, are readily affected by reagents, and, in vertebrates, yield gelatin on boiling. In the various kinds of connective tissue the relative proportion of these two kinds of fibres to one another and to the cellular elements of the tissue varies. Thus in the so-called elastic tissue of the Vertebrata the elastic fibres greatly preponderate; in tendinous tissue, on the other hand, they are scarcely to be found, and the ground is almost wholly occupied by the white fibres. It may happen that the intercellular substance is so completely occupied by the fibres as to be entirely obscured, but its presence may be always recognized in consequence of the property which it possesses of reducing silver from its salts when exposed to the light. In certain cases the intercellular substance becomes hardened by the deposit within it either of a substance termed chondrin, which confers upon it the well-known toughness and elasticity of cartilage, or by a deposit of earthy salts imparting to it the firmness of bone. These several changes in the intercellular substance are accompanied by special modifications in the form and relations of the cells (by whose agency they are in all probability effected). In comparatively rare cases the intercellular substance which is found occupying the meshes of the network formed by the branched cells of the developing connective tissue may disappear entirely, and the meshes may be occupied either by blood or by the lymph or plasma of the blood (spleen and lymphatic glands of vertebrates).

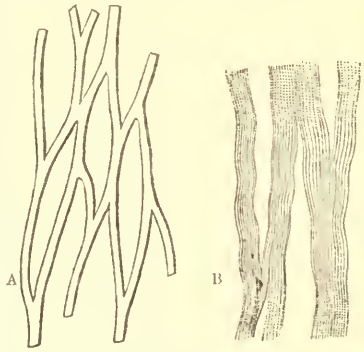

Fig. 11.

It frequently happens that the connective tissue presents the consistence of jelly, and this is generally ascribed to the characters of the intercellular substance. It may, however, be due in many cases to the entanglement of fluid in the meshes of the fibres, and not to a gelatinization of the ground substance. This is shown by the fact that the fluid may be drained from out the meshes by means of filter paper. And the possibility of the formation of a jelly in this manner is evidenced in the coagulation of lymph, where the apparently solid gelatinous clot is a tangled meshwork of fine filaments enclosing fluid.

The connective tissues of invertebrates are, on the whole, similar to those of the vertebrate; at the same time it must be admitted that there are not unimportant differences in chemical constitution, such as the absence of a substance yielding gelatin, and the absence for the most part of mucin, both of which are characteristic constituents of vertebrate connective tissue. On the other hand the anatomical characters of the elements, both cells and fibres, are in most cases sufficiently well marked to be recognizable.

In the sponges the bulk of the animal is made up of a jelly which, when examined under the microscope, is found to consist of large branched cells (fig. 12) connected together by their processes into a network. The meshes of this are occupied by clear intercellular substance within which the calcareous or horny matter which forms the skeleton is deposited.

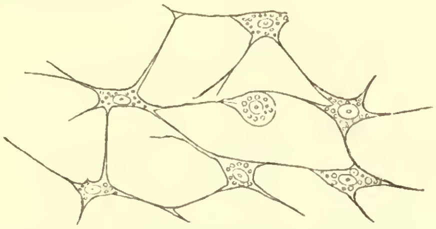

FIG. 12.—Connective tissue of sponge. (F. E. Schulze.)

When the development of the sponge is traced it is found that the first part of the tissue to be seen is the clear intermediate substance, and the skeletal spicules begin to appear in this before the cellular elements. These wander subsequently into it from one of the primary layers. There can be no doubt that this jelly-like tissue of the sponge represents a primitive form of connective tissue, although, so far as has at present been ascertained, no fibres are developed in it.

In the *Cœlenterata*, as in the sponges, the connective tissue makes its first appearance in the form of a clear intermediate substance, which may be so small in amount as to be almost imperceptible, or so large in amount as to form the main bulk of the organism. In the former case, as in the developing sponge, there is an entire absence of both fibres and cells, whereas in the latter case both kinds of elements are found. The fibres are the more constant, and are of the elastic kind (fig. 13); they have for the most part a direction across the thickness of the tissue stretching from entoderm to ectoderm, branching and uniting with their neighbours to form the characteristic network which, enclosing watery fluid in its meshes, produces the jelly-like consistence of the tissue. Fibres of the white variety are also found as low down in the *Metazoa* as the *Cœlenterata*. In some of the acraspedote *Medusæ* they occur in the form of bundles of indistinct wavy fibres situated near the surface of the jelly, and in the *Actiniæ* similar fibres are found forming membranes which bear a strong resemblance to some of the forms of membranous connective tissue of the Vertebrata (fig. 14). As before

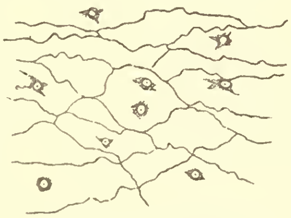

FIG. 13.—Cells and elastic fibres from connective tissue of *Aurelia*.

FIG. 14.—Fibres and cells of connective tissue of an *Actinia*. (Kölliker.)

mentioned, in the lower forms of *Cœlenterata* cells are entirely absent from their jelly-like connective tissue, but in the higher forms scattered cells (fig. 13) of indeterminate shape and position, but generally in the neighbourhood of the entoderm, begin to make their appearance. Some of these cells are amœboid, but others become fixed, and arranged in a network which pervades the jelly.

We see then that the cells, the intercellular substance, the white fibres, and the elastic fibres of the vertebrate connective tissue are represented in these low forms of the *Metazoa* in a perfectly recognizable manner. It is not surprising, therefore, to find in all the higher classes of the Invertebrata that similar elements characterize the connective tissue, although there are undoubtedly certain modifications and exceptions. The most noteworthy modifications occur in the chemical constitution of the ground substance and of the fibres. Thus, as before mentioned, there is for the most part an absence of the gelatin-yielding substance of the vertebrate connective tissue. On the other hand, the intercellular substance may become infiltrated with chemical principles unknown in vertebrate histology, as in the tunic of the *Tunicata*, where cellulose is found.[1] There are modifications also in the appearance of the connective tissue fibres which are often accompanied by modifications in the chemical constitution. For example, in the *Arthropoda* the tissue often undergoes extensive chitinization, and the fibres in it present a straight, stiff appearance, very unlike the soft, wavy look which is exhibited by the fibrous tissue of the Vertebrata.

Although the ramified cell may be looked upon as on the whole the most characteristic form of cell met with in connective tissue, and although this is the first modification in shape which the rounded embryonic cells of the developing vertebrate connective tissue take on, nevertheless it gives place in many parts both in invertebrates as well as vertebrates to other forms. One of the commonest of these is the flat cell, and we almost invariably find cells of this description lying on or in connective tissue membranes, and lining cavities which may have become formed in the connective tissue. In the latter case the flat cells may be and most commonly are spread over the whole inner surface of the cavity which they line, and assume the appearance of a pavement epithelium. Such cells, which are termed epithelioid (or by some endothelial), are found lining the body cavity and the vascular canals and heart (where these exist) of all invertebrates just as they do the similar cavities and canals in vertebrates, and they are derived like the rest of the cells of the connective tissue from the mesoderm, and therefore only indirectly from the primary blastodermic layers. But in the holothurians, and some other animals, the cells in question are derived directly from the entoderm.

In the *Mollusca* (fig 15) a peculiar type of connective tissue cell makes its appearance in addition to the rounded, the ramified, and the flattened forms. This takes the

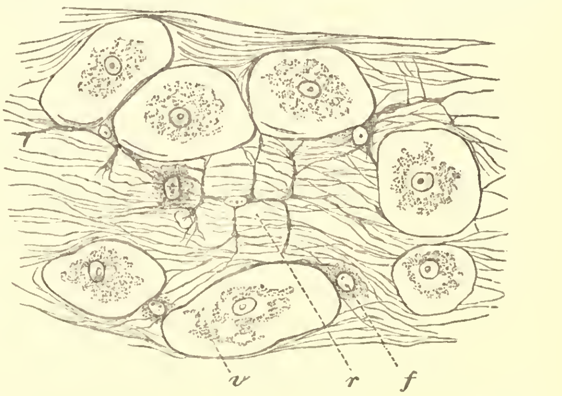

FIG. 15.—Connective tissue of slug. *r*, ramified cell; *f*, flattened cell; *v*, vesicular cell. The fibres in the ground substance are also indicated.

shape of a large clear, vesicular, double-contoured cell-body (*v*) with a relatively small nucleus. Cells of this character are in some cases only to be found scattered here and there in the tissues, but in others they are closely collected masses, and by their aggregation confer an almost cartilaginous consistency upon the tissue. This is

[1] This tunic seems, however, from its development to be an epithelial structure, although resembling in many respects connective tissue.

not due, however, to the accumulation of chondrin—the chemical principle of the cartilage of vertebrates—in intercellular substance. But a true cartilage is met with in some of the higher molluscs (*Cephalopoda*), in which there is a considerable amount of intercellular substance, and the only difference, as compared with ordinary cartilage of most vertebrates, is that the cells are much ramified (as in some fishes).

Bone, or osseous connective tissue, as the word is understood in vertebrate histology, is not met with anywhere amongst the Invertebrata, and this is less to be wondered at since it does not make its appearance even in some of the lowest of the Vertebrata. But hard structures of various kinds serve to supply the place of bone as a sustentacular tissue, and these may be developed either within the connective tissue, so as to form an internal hard skeleton, or on the exterior of the body, so as to form an external skeleton or shell. When external the shell is an epithelial structure, or at least is produced by the formative activity of the epithelium which covers the surface of the body. An internal hard skeleton may either coexist with an external, or the one may be found to the exclusion of the other.

In the cœlenterates the internal skeleton when found is generally deposited in the jelly-like intercellular substance in the form of separate spicules, which subsequently are cemented together by a further deposit of calcareous matter into a continuous skeleton. In the sponges the calcareous spicules often project from the jelly into the external medium, but it is probable that they are covered by an extension of the superficial flattened cells which they seem to pierce; the separate calcareous spicules are in some cases united by calcareous matter, in others by horny substance, or the spicules may be altogether absent and the horny framework constitute the whole skeleton. There is no evidence to show that these calcareous and horny deposits are formed by the direct agency of the cells of the jelly-like tissue. On the contrary, the fact that the spicules make their appearance in the jelly-like substance which accumulates between the two primary layers before there is any trace of cells to be seen in it is a fact pointing in the opposite direction.

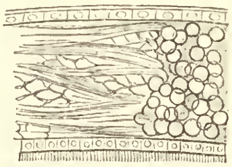

Fig. 16.—Section of the shell of *Echinus*, partly decalcified by acid. (Leydig.) The connective tissue bundles are seen on the left; some are cut transversely; on the right they are obscured by the calcareous globules (*c*). Above and below is seen a layer of epithelium (*e*, *é*).

In the echinids amongst *Echinodermata* the shell is formed by a dense deposit of calcareous substance (fig. 16) in the fibrous connective tissue of the integument, but is not of the nature of bone, as has been sometimes supposed. In other echinoderms the deposition is more scanty, and in some (*Holothuria*) it may merely take the form of isolated spicules, which often present curious shapes.

The Muscular Tissues of Animals.—In the Vertebrata three kinds of muscular tissue are met with—the plain or involuntary, the cross-striped or voluntary, and the cardiac or heart muscle. Undoubtedly the last-named is to be regarded as a transitional form between the other two, for it combines some of the characters of each. This is especially well seen in the lower vertebrates, in which the muscular fibres of the heart (fig. 17) consist of long, tapering, uninuclear cells, in form resembling the plain contractile fibre-cells, but differing from these and resembling the multinucleated voluntary muscular fibres in exhibiting distinct transverse striations. Although these three kinds of muscular tissue thus differ from one another in this respect, they agree in one important character. Whether transversely striated or not, they all exhibit a distinct longitudinal striation of their substance, which is probably indicatory of a polarity which the protoplasm of the cell has assumed at the same time with the faculty of becoming rapidly shortened in the direction of its length and coincidently with the loss of the power of contracting in other directions. Moreover, this longitudinal striation is generally associated with the property of double refraction, which is exhibited to a marked degree by all kinds of muscular tissue.


Fig. 17.—Muscular fibre of Frog's heart.

The voluntary muscular fibres are those in which the protoplasm of the original cell has undergone most differentiation. If we trace their development we find that they originate from mesodermic cells which become elongated in one direction, the nucleus undergoing a corresponding change in shape, and soon becoming multiplied; we next find the external layer of the protoplasm becoming altered and converted into muscular substance, which exhibits from the first both a longitudinal and a transverse striation. The change in question gradually extends inwards, so as to involve more and more of the protoplasm. Up to this time we can distinguish (fig. 18) in the muscular fibre a medullary part composed of unaltered protoplasm, with nuclei, and a cortical part composed of differentiated muscle-substance. Subsequently the nuclei leave their central situation, and either become scattered through the muscular substance or come to lie entirely at the surface. There is always a little of the unaltered protoplasm to be found with each nucleus.


Fig. 18.—Part of developing muscular fibre of a mammal.

In the plain muscular fibres, and in the cardiac muscular fibres, the nucleus does not multiply, and it maintains its central situation. The differentiation of the cell-protoplasm into muscle-substance begins at the periphery and extends towards the centre in the cells which constitute the heart-muscle as in the voluntary muscle, and it is probable that the same is the case in the plain muscular cells.

The muscular fibres of the Invertebrata very closely resemble those of vertebrates. In most cases the differentiation of the muscular substance is not so complete as in the voluntary muscles of vertebrates and especially of mammals, but there is a striking exception in the *Arthropoda*, and especially in insects, where in conformity with the greater muscular activity they possess we find far better marked structural features. On this account the muscles of insects have been especially carefully studied with a view to the elucidation of the structure of muscle generally.

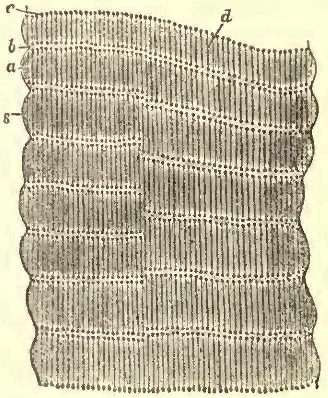

Fig. 19.—Living muscle of Water-beetle (*Dytiscus marginalis*), highly magnified. *s*, sarcolemma; *a*, dim stripe; *b*, bright stripe; *c*, rows of dots in bright stripe, which are seen to be the knobbed heads of *d*, muscle rods.

With a sufficiently high power a voluntary muscular fibre of an insect (fig. 19) is seen to be composed of an external structureless membrane,—the sarcolemma,—a central strand of nucleated protoplasm, and a semi-fluid substance—the proper muscular substance—lying between these and forming almost the whole of the fibre. This proper muscular substance is composed of a clear doubly-refracting material, in which are embedded a number of minute rod-shaped particles, which are so arranged side by side and end to end as to cause the muscular substance to present both a transversely and a longitudinally striated appearance. Sometimes (as in the fibre shown in the figure) the substance of each muscle rod is partly collected into a swelling or knob at either end, and these knobs so act singly and collectively upon the light which passes through the muscular substance as to cause a brighter appearance in their neighbourhood. In this way bright bands seem to cross the muscular substance alternating with the dimmer intermediate portions, and the appearance of transverse striation is much intensified. This is still more the case when the muscle contracts, for the contraction is accompanied by an accumulation of the substance of the rods towards their ends, and an apparent blending of these into a dark transverse band or rather a series of dark transverse bands, which, reflecting from their surfaces the light which is passing through the muscle, cause the whole of the substance between them to appear much brighter than they are themselves. There are other muscular fibres in the insect which present an entirely different appearance. In these (fig. 20) the fibres, which are very fine, are wholly made up of alternating bands of dark and light substance. They are far less like the voluntary muscular fibres of mammals than are the others, and there are no rod-like structures to be seen in them.

FIG. 20.—Fibre of wing-muscle of an insect.

We find muscular tissue, like the other tissues, appearing already in the lowest of the *Metazoa*. In sponges the orifices of the water canals are in many cases capable of being closed partially or wholly when the organism is irritated. The researches of F. E. Schulze have shown that these orifices are encircled by long fusiform cells which appear to be modifications of some of the ordinary ramified cells of the jelly-like tissue. The substance of these cells seems to be undifferentiated, and it cannot be conclusively affirmed that they are of muscular nature, but at least they seem to subserve the function of muscular tissue. But in the very next division—the *Hydromedusæ*—the muscular cells are already so much differentiated as to exhibit both longitudinal and transverse striation. Thus many of the cells which form the muscular layer of the sub-umbrella of the *Medusæ* are long fusiform cells (fig 21, A) with an elongated nucleus in the centre, and gradually tapering ends, and their substance is striated, as just remarked, both transversely and longitudinally. Sometimes there is a considerable amount of unaltered protoplasm in the middle of the fibre around the nucleus (fig 21, B), and this nucleated protoplasm may then project between the epithelial cells

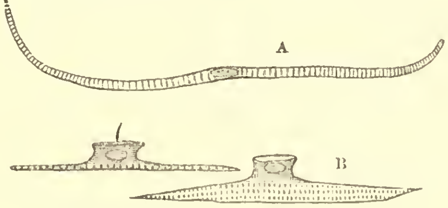

FIG. 21.—Muscular cells of Jelly-fish. (Hertwig.)

of the ectoderm. In every case the muscular fibres are in close contiguity with the attached ends of the ectodermal epithelium, and are with justice reckoned as a part of the ectoderm. In the higher cœlenterates the muscular tissue tends to lose its connexion with the ectoderm and to become embedded in the jelly-like mesoderm, but the connexion is not wholly lost in any. In *Hydra*, on the other hand, the muscular tissue is represented only by simple longitudinal fibres, which are either direct prolongations of the tapering ends of some of the ectoderm cells (Kleinenberg) or are embedded in the enlarged attached end of the cells (Kölliker, Korotneff). In other invertebrates the muscular tissue is nearly always in the form of long cylindrical or flattened, tapering or uniform, uninucleated, longitudinally-striated fibres, which may possess a membrane, and a central strand of undifferentiated protoplasm (fig. 22, B). In some cases a transverse striation may be detected (fig. 22, A), but more commonly the muscular fibres, especially in echinoderms, worms, and molluscs, exhibit a peculiar double oblique striation (fig. 23), so that an appearance of intercrossing lines is thereby produced. The obliquely striated fibres seem to take the place, in many of these comparatively sluggish animals, of the more active, transversely striated tissues. With the exception of the appearance mentioned, they resemble the plain muscular fibres in structure, but they are capable of more energetic contraction than the latter.

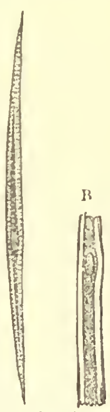

FIG. 22.—Muscular fibres of molluscs.

The Nervous Tissues of Animals.—The nervous tissue of vertebrates is composed firstly of cells—the nerve-cells or ganglion-cells,—and secondly of nerve-fibres. Most of the nerve-fibres possess a sheath formed of nucleated cells wrapped around the fibre, and in this sheath a peculiar white fatty so-called medullary substance is accumulated in some fibres, so that they are distinguished from the others as the white or medullated fibres. There is reason to believe that every nerve-fibre is connected with at least one nerve-cell, and conversely, that every nerve-cell is connected directly or indirectly with one or more nerve-fibres. Nerve-cells are generally comparatively large solid-looking corpuscles, with a relatively large nucleus and nucleolus, and every developed nerve-cell has either one or two or a greater number of processes, which may or may not be ramified. It is certain that from many nerve-cells one process of the cell passes into and becomes a nerve-fibre.[1] Nerve-cells are always traversed by exquisitely fine fibrils,—nerve-fibrils,—and these pass out from the cell into its processes. Apart from any sheath which it may possess, a nerve-fibre is composed of one or more nerve-fibrils, which are embedded in a soft interfibrillar substance. The nervous tissue of vertebrates is developed from that part of the ectoderm which occupies the middle of the dorsal surface of the embryo. In the bird and mammal the epithelial cells in this situation become cut off from the general ectoderm by the formation of a groove which subsequently closes over and forms a canal—the neural canal. The innermost ectoderm cells (fig. 24, B) which form the wall of this canal acquire cilia at the end which is turned towards the cavity, while the other end of each cell is prolonged into branching processes which collectively form a network amongst the deeper lying cells of the wall. The latter multiply considerably, and moreover groups of them grow out from the sides of the neural canal as the roots of the nerves. The nerve-fibres themselves seem to be formed either by the outgrowth of undivided processes from these cells of the neural canal, or by the junction of one elongated

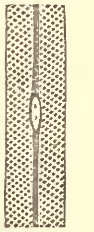

FIG. 23.—Part of an obliquely striated muscular fibre. (From Schwalbe.)

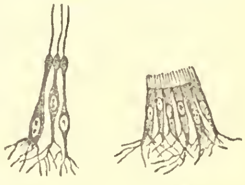

FIG. 24.—Nerve-epithelium cells—A, of *Medusa*; B, from central canal of spinal cord of vertebrate.

[1] The term nerve-fibre is here employed to denote the essential part of the nerve, corresponding to the "axis-cylinder" of vertebrate histology

cell with others. At any rate the fibres are to be looked upon as outgrowths or prolongations of nerve-cells. But some of the outgrowths of the nerve-cells, instead of passing into nerve-fibres, become ramified, and eventually break up into fine twigs, each of which is occupied by a nerve-fibril, and these form by their interlacement a network which joins that of the branched processes of the ciliated epithelium.

With the exception of the formation of the medullary substance in the sheath, the nervous tissue of the invertebrate *Metazoa* agrees precisely, so far as the minute structure is concerned, with that of vertebrates. The lowest forms in which nervous structures have been found are the *Medusæ*. In these the tissue exhibits itself under two modifications. The first of these is a so-called nerve epithelium (fig. 24, A), consisting of a portion of the ciliated ectoderm, the cells of which are prolonged at their attached ends into fine ramified fibres which interlace with one another and form a network of nerve-fibrils underneath the epithelium. This form seems to correspond with the ciliated epithelium of the vertebrate neural canal. The second modification occurs in certain cells of the ectoderm, which have become sunken singly here and there below the general epithelium of the surface, and between it and the muscular layer of the sub-umbrella. These cells become enlarged, and their nucleus takes on the characteristic appearance of the nucleus of a nerve-cell. Then generally from opposite ends of the cell (fig. 25) two processes grow out into long fibres,

FIG 25. Nerve cell and fibre of a Jelly-fish (*Aurelia*).

which exhibit all the features of the nerve-fibres of higher animals, and may even possess a nucleated sheath. These fibres, which may be branched or unbranched, seem to be applied to the substance of the muscular fibres, and in all probability serve to convey impulses to the muscle. There can be no doubt of the correspondence of these cells and fibres with the nerve-cells and nerve-fibre prolongations of the Vertebrata. In other invertebrates the nervous tissue is not only more localized than in the *Cœlenterata*, but the original ectodermal epithelium cells from which it is derived become much more extensively developed into well-characterized nerve-cells and nerve-fibres, and tend moreover to be completely separated from the rest of the ectoderm and embedded in the mesoderm. But they are never originally developed in common with connective-tissue cells, as are the cells which form the muscular tissue. (E. A. S.)

II. VEGETABLE HISTOLOGY.

By Vegetable Histology is meant the study by means of the microscope of the texture, web, or tissue of which plants are composed. It may be considered as synonymous with the minute anatomy of plants, and embraces the study of all those points of structure and development requiring the use of the microscope for their elucidation. Histology is, therefore, a modern science of observation and experiment, and it dates its origin from the time when magnifying glasses were first applied to the scrutiny of the organs of plants. All advances in histology have been preceded by some important improvement either in the construction of lenses and microscopes, or by the invention of some new method of research and application of new reagents. In order to prosecute the study of vegetable histology, it is necessary to understand thoroughly the construction and use of the microscope, to be able to manipulate well and dexterously employ the various cutting and other instruments required, and, lastly, to be able to use the numerous reagents now so important in assisting to unravel the more difficult tissues.

Nature of the Vegetable Cell.—If a small portion of the contents of the fertilized embryo-sac of the *Phaseolus multiflorus* (scarlet-runner, or French bean) be examined in a drop of water on a slide, it is seen to consist of protoplasm with a number of small free cells, in different stages of development, floating in it. These cells consist of little rounded masses of protoplasm with a single contour line; they have the protoplasm more or less granular; and each contains a rounded solid body, the nucleus, usually with a small spot, the nucleolus. Other cells in the preparation have a distinct wall with a double contour line, these being older and more fully developed. In examining the cells it is usually best not to employ pure water, but to use instead a solution of sugar or gum (1 part to 50 or 100 of water). Strasburger recommends, for examining the contents of the embryo-sac in phanerogams, a 3 per cent. solution of sugar, to which is added on the slide one drop of a 1 per cent. solution of osmic acid. Absolute alcohol may also be used for fixing the protoplasm in a nearly unaltered state. A longitudinal section of the growing end of the root of *Fritillaria imperialis* will exhibit the different stages of development of tissue cells. Near the apex the cells are more or less hexagonal in shape, and have a marked wall with a more or less distinct double contour. Inside the cell-wall, and in close contact with it, is the protoplasm, a densely granular soft inelastic mass, consisting of a mixture of albuminoids, and having in the centre a round and relatively very large solid nucleus, with one or two nucleoli. In both *Phaseolus* and *Fritillaria*, as the cell enlarges, clear spaces, called vacuoles, but filled with cell-sap, that is, water with substances in solution, appear in the protoplasm of the cell. In some algæ contractile vacuoles are met with. The ordinary vacuoles rapidly increase in number and enlarge, separating the protoplasm into two parts—one in close contact with the wall of the cell, the other forming strings of varying size and thickness separating the vacuoles. Presently the vacuoles all coalesce and form a central cell-sap cavity, the protoplasm forming a completely closed sac inside the cell-wall. The nucleus remains imbedded in the protoplasm, and is pushed to one side, appearing as if in contact with the wall. The vacuoled condition of the protoplasm may be considered as representing the cell at its state of greatest activity: the central cell-sap cavity is usually seen in tissue-cells, as in *Fritillaria*, and may be taken to indicate a condition of diminished activity. Further changes take place in tissue cells. The protoplasm with its nucleus may disappear and the cell-sap remain, or even the cell-sap itself may disappear sooner or later, and the dry cell-walls, as those of cork, be left. The conditions here described in *Fritillaria* may be taken as typical of all young tissue cells.

Natur the ce

The protoplasm is the essential part of the cell, and by it all the other parts are formed, as well as all the substances, such as chlorophyll and starch, that are contained in cells. When the cell contains protoplasm it can grow, multiply, and elaborate new chemical compounds; when the protoplasm disappears it ceases to perform any of these functions, and passively acts as a protection to deeper cells, or permits certain physical processes to take place, as the transport of water through the walls. The substance of the protoplasm seems to consist of a mixture of various albuminoids, and probably of other nitrogenous compounds. It is a more or less granular, soft, inelastic substance, never a true fluid, but varying in consistence in accordance with the quantity of water it contains.

Proto-plasm.

The chemical reactions of protoplasm are those of albumen. It contracts when substances are applied to it which remove some of the water, as glycerin and alcohol. It contracts when heat is applied, a temperature of between 50° and 60° C. completely altering the texture of protoplasm containing a normal quantity of

Chemi of reactio

water. Where the protoplasm contains little water and is very dense, as in some seeds, a higher temperature produces little or no change. A violet colour is given to the protoplasm of young cells by the application first of a concentrated solution of copper sulphate, next washing the preparation carefully to remove all free traces of the copper solution and then applying a solution of caustic potash. Iodine gives a brown colour, sugar solution and sulphuric acid a red; and dilute caustic potash dissolves protoplasm or renders it perfectly transparent. Carmine and other colouring matters do not colour living protoplasm, but impart a brilliant stain to it when dead.

Protoplasm is usually separable into two parts, an inner portion, endoplasm, more or less granular, and an outer more dense layer, the ectoplasm or primordial utricle, which is quite free from granules. A similar layer surrounds the protoplasm of the nucleus.

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ents.

The living protoplasm exhibits movements either when inside a cell-wall or when the protoplasm is free and in the condition of a wall-less or primordial cell. The constant changes in protoplasm must be always accompanied by movements, but these are usually too small to be visible, and it is only in a few cases that the amplitude of the movements renders them visible. The movements are of four kinds, and are distinguished as rotation, circulation, amœboid, and ciliary.

The first is the movement of rotation, as in *Vallisneria* and *Anacharis*, where the whole protoplasmic sac rotates in the interior of the cell. The second is circulation, where portions only of the protoplasm move as indicated by the circulation of the granules hither and thither in the mass, as in the cells of the hairs of *Tradescantia* and the stinging hairs of the nettle. In the third or amœboid movement whole masses of protoplasm not enclosed in walls change their form and position like the *amœba* or white blood corpuscle. These movements have been noticed in the amœboid and plasmodium stage of the *Myxomycetes* or gelatinous fungi. Lastly, a movement of small masses of protoplasm destitute of walls, and having parts of the ectoplasm prolonged to form one, two, or more vibratile cilia is not unfrequent in the zoospores, swarmspores, and spermatozoids of cryptogamic plants. All these movements are dependent on and much influenced by varying external conditions, as light, heat, presence or absence of oxygen, &c.

ell-
all.

The cell-wall is a thin, elastic, transparent and colourless membrane, destitute of visible openings (except in some cells of *Sphagnum* and in bordered pits), but easily permeated by water and gas. It consists of the carbohydrate cellulose ($C_6H_{10}O_5$), isomeric with starch, and in young cells it is present in an almost pure state. During the growth of the cell the protoplasm furnishes material for the increase of the wall in size and thickness, and usually during growth of the wall various chemical and physical changes occur in it.

The increase in the size of the cell is rarely quite regular or general, except in free cells as pollen grains and spores; usually the growth is more or less limited to definite parts of the wall, and the increase in size is accompanied by a marked change in form. Intercalar growth at a ring-like zone on the cell-wall is seen in the genus *Œdogonium*, while growth at the apex of the cell is not uncommon in many unicellular algæ and in hairs, as well as in the peculiar cells (the hyphæ) of fungi.

Growth at several points on the surface of a cell gives rise to the stellate forms seen in the pith of *Juncus*, and a similar but more limited growth is the cause of the "tyloses," or cellular filling-up of vessels seen in many stems, vine, &c. The growth of the cell-wall in thickness may be general or local. Usually it is local, and is either internal (centripetal) or external (centrifugal). Local thickening gives rise to the production of peculiar markings depending on the different optical effects produced by the thickened and unthickened parts. Pitted markings are very common, rounded or variously shaped portions of the wall being left unthickened, while the form of the pits, and their special arrangement, either irregularly scattered or spirally placed, give a characteristic appearance to the walls of the cells. Pits are often elongated, and when very much elongated, and extending the whole width of the cell, form scalariform markings, as seen in ferns. When pits are very narrow, cylindrical, deep, and branching, they form canals. Bordered pits, in which the pit is surrounded by a border, occur in the pines. In other cells the thickening assumes the appearance of rings, spirals, or reticulations, which sometimes become detached from the walls. In some instances, as in the wood of the lime and yew, two kinds of marking occur in one cell. Peculiar modifications of internal thickening are seen in the root-hairs of *Marchantia*, in the cells with cystolithes in the leaf of the india rubber, and in the pith of *Ricinus*, &c. External thickening is seen on the surface (cuticle of the epidermis) of the plant or on free cells, as pollen grains, spores, &c., and produces peculiar and characteristic markings in various plants. By the alternation of more and less watery layers the cell-wall becomes marked by concentric lines or striæ, as if the wall was built up of layers or strata formed one inside the other, which, however, is not the case. A longitudinal striation assuming a ring-like or spiral direction is also met with on the walls of many wood and bast cells, and is, like the stratification just mentioned, due to alternations of more and less watery layers in the cell-wall. The inner layer in the interior of the cell and next the contents is always a dense layer rich in cellulose and with little water, a fact at once negativing the incrustation theory. Stratification can be readily seen in transverse sections of the bast fibres in the leaf of *Hoya*, or the bast of the stems of many *Asclepiadaceæ*; and the longitudinal striation may be seen in the same fibres when dried, or in the dry wood cells of many conifers, as in *Pinus sylvestris*.

The walls of young cells consist almost exclusively of pure cellulose, which is coloured blue by Schultz's solution[1] or by iodine and sulphuric acid, and is dissolved by strong sulphuric acid and by ammoniacal solution of cupric oxide. Iodine solution alone gives no reaction, or more generally a brown tint; rarely the wall gives a blue reaction, as in the asci of some lichens or in the cells of the cotyledons of *Tamarindus indica*. The cell-walls of most fungi do not give a blue reaction with iodine and sulphuric acid, forming the modification generally known as fungus cellulose. During growth changes occur in the nature of the wall, different strata often having different chemical and physical properties. The three most important changes in the cell-wall are (1) the suberous or corky change, the cell-wall wholly or partially becoming cuticularized or converted into cork; (2) the ligneous or woody change, the walls being converted into wood; and (3) the gelatinous change, as seen in many algæ, where the cell-wall swells up enormously by the imbibition of water, and assumes a clear gelatinous appearance. These changes may occur separately, the whole wall being more or less completely changed; or a part remains composed of cellulose; or, in other cases, two or more of these changes may coexist in the same cell-wall.

Reactions of cellulose.

Changes in cell-wall.

The following reagents are useful in distinguishing the different changes. Schultz's solution gives a blue with starch and cellulose, and a yellow-brown with wood and cork. If the cork-cells are previously boiled in caustic potash, and the wood cells touched with nitric acid, the blue reaction may be got with sulphuric acid and iodine. Sulphuric acid dissolves wood cells, but does not touch cork cells. Ammoniacal solution of cupric oxide does not dissolve cork, causes wood to swell up and to become blue, and deeply colours mucilaginous walls. Boiling caustic potash ultimately dissolves cork. Cold caustic potash at first causes it to swell up and become yellow, and when slowly heated the colour deepens and the texture becomes granular.[2] Chlorate of potash and nitric acid (Schultz's macerating fluid) ultimately dissolves cork, like caustic potash, but does not affect wood. When cork-cells are slowly warmed in this mixture the walls of the cork-cells become very distinct, the other cells being very transparent, and, if washed and treated with alcohol and then with ether, they become perfectly transparent. Chromic acid renders cork distinct by rendering other tissues transparent. Bichromate of potash dissolves cork. The following reactions are given by Zacharias for cell-walls which are coloured brown by Schultz's solution in the rhizome of *Acorus Calamus*.[3] Sulphate of aniline and hydrochlorate of aniline, even when the cells are previously treated with hydrochloric acid, give no reaction, but colour the walls of vessels of a golden yellow. An aqueous solution of aniline blue gives no reaction, while an alcoholic solution of aniline red colours the walls of vessels and oil-glands. The red colour is

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[1] *Schultz's Solution.*—1 ounce of fused chloride of zinc is dissolved in ½ fluid ounce of water; then add iodine 3 grains, and iodide of potassium 6 grains, dissolved together in the smallest possible quantity of water. Or dissolve granulated zinc in hydrochloric acid, and evaporate in contact with metallic zinc until a thick syrup is formed. Add iodide of potassium to saturation, then a little iodine, and if necessary dilute with water.

[2] For this and other reactions see Höhnel, *Ueber den Kork und verkorkte Gewebe überhaupt*, p. 16.

[3] "Ueber Secret-Behälter mit verkorkten Membranen," *Bot. Zeitung*, 1879, p. 619.

best seen when thin slices of the rhizome are placed for a few days in the solution, and then dried and observed under water. The addition of caustic potash causes the colour to disappear, but it reappears on washing away the potash. The walls of vessels become coloured blue-violet by addition of hydrochlorate of phenole, and also when use is made of alcoholic solution of cherry-wood and concentrated hydrochloric acid (Höhnel's xylophilin reaction).

Mineral matters in cell-walls.

Mineral matters are often deposited in cell-walls. Calcium carbonate occurs rarely, calcium oxalate frequently, and silica is the commonest of all. Calcium carbonate forms the cystolithes of *Ficus* and of the *Acanthaceæ*, crystals or masses of crystals imbedded in the cell-wall but projecting into the cavity although surrounded by the substance of the wall. In corallines and many algæ, as also in the *Charas*, carbonate of lime is abundant in the cell-walls. Calcium oxalate crystals occur in the cell-walls of many plants, in other cases forming small granules. The crystals of calcium carbonate are soluble in acetic acid, while those of oxalate are not, although soluble in dilute nitric and hydrochloric acids. Silica is abundant in the *Diatomaceæ* and also in the cells of many of the higher plants (*Equisetum*, grasses, beech, &c.).

Products of desorganization or degradation of the cell-wall occur in the form of gum, gum-resins, or resins, examples of which may be seen in the cherry, gum-arabic, gum-tragacanth, myrrh, &c. Gum-arabic consists of arabin, gum-tragacanth of bassorin, and cherry-gum is a mixture of the two. These substances, when formed, are apparently of no further use to the plant, and are produced by the destruction or desorganization of the cell-walls, as portions of the cell-wall can be distinctly traced when gum-tragacanth is examined microscopically.

Molecular structure of cell-wall.

Cell-walls, as those of the wood of Conifers, bast-cells, and cells of ivory nut, and starch granules, are found when examined by polarized light to be doubly refracting. By an elaborate series of researches Nägeli concluded that these structures were made up of crystalline doubly refracting particles or micellæ, each consisting of numerous atoms and impermeable by water, although each of the micellæ is surrounded by a thinner or thicker layer of water. The water may increase or diminish within certain limits without destroying the structure; or under certain conditions as by the application of certain reagents (strong acids and alkalies, ammoniacal solution of cupric oxide), the texture can be destroyed by the swelling up of the part. The water between the micellæ may be removed by drying, when the micellæ themselves come into contact, as the presence of air would destroy the transparency of the membrane. This peculiar molecular composition of the wall at once explains the striation and stratification observed in it, and also enables us to understand growth and nutrition by the intussusception of new particles in the water space between the micellæ.[1]

Certain substances are formed by the protoplasm and separate from it in the form of granules or crystal-like bodies. The most important of these substances are chlorophyll and starch, the less important are aleurone grains and crystalloids.

Chlorophyll.

Chlorophyll or leaf-green is the green colouring matter of plants, and is met with most frequently in the leaves and young stems. The colouring matter is always united with the protoplasm, usually to definite rounded masses, the chlorophyll granules or corpuscles, readily distinguishable from the general protoplasmic mass of the cell in which they are imbedded. Chlorophyll granules never occur separate from the protoplasm of the cell. In a few instances the whole of the protoplasmic mass, with the exception of the ectoplasm, is uniformly coloured green as in *Pleurococcus* and other low algæ; while in other plants the protoplasmic base for the colouring matter is star-like (*Zygnema*), in plates or lamellæ (*Closterium* and *Mesocarpus*), or spiral, as in *Spirogyra*. The chlorophyll grains of the vast majority of plants are rounded corpuscles of varying size with a slightly denser external layer, and frequently containing vacuoles or small starch granules. They grow in size and divide, the grain elongating and being cut into two by the formation of a gradually deepening circular groove. These changes may be seen in the prothallus of a fern or the leaf of a moss. The granules are produced by the aggregation of protoplasmic particles, so as to form a sharply-defined spherical mass. At first these are colourless or of a yellow tinge, and become green by the formation of the colouring matter, the chlorophyll, when exposed to the light, as it is only in a few rare cases, as in the cotyledons of pines and in ferns, that the colouring matter is formed independently of light.

The colouring matter can be removed by means of alcohol, ether, benzole, chloroform, and other solvents, the protoplasmic mass remaining behind unchanged in size and appearance, except in so far that it is now colourless. The solution thus obtained is of a dark green colour by transmitted light, and blood-red by reflected light. Its spectrum shows seven absorption bands, the strongest being between the lines B and C of the solar spectrum. Many modifications of chlorophyll exist in plants, and it also undergoes changes in colour during the ripening of fruits or in the corollas of certain flowers. The chief modifications are—etiolin, in blanched parts of plants; anthoxanthin, in yellow granules of many flowers; xanthophyll, yellow granules in leaves in autumn; the green colouring matter of red sea-weeds; phycoerythrin, the red colouring matter of red sea-weeds; the phycochrome of nostoc, &c.; and the brown colour of diatoms and fucoids.

Starch

Starch occurs in granules of varying size and form, and during the growth of the granule it is always in relation to the protoplasm of the cell. The granules are oval, lenticular, polyhedral, or bone-shaped, as may be seen in the potato, wheat, and maize, and in the milk-sap of certain exotic *Euphorbias* respectively. Each grain usually exhibits a central or lateral spot, the hilum, and a series of concentric striæ, caused like the striation and stratification of the cell-wall by the alternation of more and less watery layers. Sometimes the starch granule has two or more hila, the compound grains, which often separate into their several parts.

Starch has the same chemical composition as cellulose, $C_6H_{10}O_5$, and differs from cellulose in being coloured blue directly by a dilute solution of iodine. Schacht's solution contains 1 grain of iodine and 3 grains of iodide of potassium dissolved in 1 ounce of distilled water; but an aqueous solution of iodine answers quite well. Two substances are generally recognized in the starch grain —(1) granulose, coloured blue by iodine and forming by far the greater part of the granule, and (2) starch cellulose, not coloured blue and only forming a sort of skeleton to the grain. Starch is one of the most widely distributed substances in plants, being absent from comparatively few except the fungi.

Oil globules occur not unfrequently in the protoplasm of plants; and in a few instances they occur in chlorophyll granules. Oil is easily distinguished by its reactions with ether, and by its optical properties.

Crystalloids, globoids and aleurone grains.

Occasionally portions of the protoplasm assume a crystal-like appearance, resembling cubes, octohedra, tetrahedra, &c. These portions are known as crystalloids or protein crystals. They give the ordinary reactions of protoplasm, and differ from crystals in their power of swelling up and changing their angles in certain solutions, as in caustic potash. Crystalloids occur frequently in the cells of the tuber of the potato, in fatty seeds, in red algæ, in petals of many flowers (*Viola tricolor*), and in some fruits. Usually the crystalloids occur in fatty seeds, as in the castor oil and brazil nut, in the interior of rounded grains of albuminoids, the aleurone or protein grains, along with little rounded bodies called globoids consisting of a combination of magnesia and lime with phosphoric acid. In other instances aleurone grains without crystalloids are met with, as in *Cynoglossum*. The aleurone grains are usually soluble in water, and are, therefore, best examined microscopically in strong glycerin, in iodine dissolved in glycerin, or in a solution of corrosive sublimate in alcohol. Aleurone grains form when the seed is nearly ripe, the crystalloids and globoids appearing earlier.

Cell-sap

The cell-sap consists of water with different substances in solution, the substances varying in different cells, and also changing in the same cell from time to time during growth. It saturates the whole wall and protoplasm, and collects in the vacuoles and cell-sap cavity.

The most important substances in the cell-sap are inulin, sugar, tannin, and colouring matters, while the calcium oxalate usually crystallizes out, and forms visible crystals in the cell, or in the wall as already described. Inulin can be separated, in the form of sphærocrystals, by the action of alcohol or glycerin, from the tissues of many of the *Compositæ*, dahlia, sunflower, &c. By keeping the tissue long in absolute alcohol the crystals grow to a large size, and occupy more than one cell. Sugar in solution in the cell-sap may be grape or cane sugar, and can be rendered visible by the copper test, or by the action of glycerin. Glycerin forms drop-like spheres with sugar and inulin; these are very highly refracting and easily

[1] See Nägeli and Schwendener, *Das Mikroskop* (2d ed.), p. 299 *sq.*; and Dippel, *Das Mikroskop*, vol. i. p. 409 *sq.*

distinguished in the cell. When these spheres are of syrup they quickly disappear, no trace remaining in a few minutes, while, as Kraus (*Bot. Zeitung*, 1877, p. 329) has shown, if the substance be inulin the formation of sphærocrystals rapidly occurs. Hesperidin may be obtained from the unripe fruit of orange, &c., in the form of sphærocrystals when treated with alcohol.

Tannin is present in the cells of many plants, and may be seen, when water is applied to the section, in the bark of the oak or birch in the form of fine granules which soon dissolve. A bluish black or greenish colour or precipitate is produced by the action of salt of iron, and a dark red-brown with bichromate of potash. Colouring matter (anthocyan) gives red and blue colours to flowers and a red colour to stems and leaves, and is dissolved in the cell-sap. Lastly, calcium oxalate, which is formed in plants by the metastasis of nutrient matters during growth, is got rid of in many parts of plants, or rendered harmless in others, by crystallizing out, either as large crystals, prismatic or octohedral, or in masses of small crystals, or in the form of long needle-like crystals or raphides belonging to the trimetric system. The two forms differ only in the quantity of water of crystallization present: the raphides have two equivalents, the prisms six of water.

ell formation.

Cytogenesis.—The enlargement of organs of plants is not only accompanied by an increase in the size of the individual cells, but new cells are also formed in the part, these new cells, which are at first small, soon enlarging to their full dimensions. Usually the formation of a new cell takes place by the division of the protoplasm of a pre-existing cell, the mother-cell, into two portions of equal or unequal size, the daughter-cells. These daughter-cells in turn enlarge, and may each become the mother-cells of new daughter-cells. In this way by cell-division the vegetative cells of plants are increased in number. The process of reproduction in plants is invariably associated with the formation of a new cell or cells, and in general the process is very different from that of division, there being often a diminution in the number of cells, instead of an increase.

Four types of Cytogenesis may be distinguished:—(1) Rejuvenescence; (2) Conjugation; (3) Free-cell formation; and (4) Division.

ejuvenescence.

In rejuvenescence, the whole protoplasm of the mother-cell undergoes contraction and rounding; water is eliminated, and an entire rearrangement of the molecules of the protoplasm may be noticed by changes in the contents. As a result of these changes one new daughter-cell is formed from the entire protoplasm of the mother-cell. Rejuvenescence is observed in the formation of the swarm-spores, non-sexual reproductive organs, of some algæ, such as *Œdogonium* and *Vaucheria*, as also in the formation of single spermatozoids. The egg-cell of many algæ and fungi, as well as of the vascular cryptogams, is formed by rejuvenescence, the only difference being that here the daughter-cell remains inside the wall of the mother-cell until fertilization, when it forms a wall and begins to divide.

onjugation.

Conjugation consists in the union of two, rarely more, masses of protoplasm, nearly or quite similar in size and appearance, to form a single new daughter-cell, which then becomes surrounded by a wall and forms a zygospore. The union of the two masses is always accompanied by rounding and contraction of the masses and a complete molecular rearrangement of the protoplasm. Conjugation is seen in the group of the *Conjugatæ* among the algæ, and also in the *Zygomycetes* and *Myxomycetes* among the fungi. In all cases conjugation is a reproductive process. The conjugation in the *Myxomycetes* is very peculiar, the numerous small masses of protoplasm (the myxoamœbæ) fusing into a naked mass of protoplasm (the plasmodium).

'ree-cell ormation.

Free-cell formation consists of the formation of several (rarely one) cells from and in the protoplasm of the mother-cell, the whole of the protoplasm not going to form daughter-cells. Free-cell formation may be typically observed in the formation of the ascospores of the *Ascomycetes*. The nucleus of the large mother-cell or ascus disappears, and two new ones form, which again and again divide, thus forming eight, each nucleus forming the centre of a new mass of protoplasm, which at length becomes surrounded by a wall. In other cases many new masses of protoplasm form after the disappearance of the nucleus of the mother-cell; and these new masses develop a wall and a nucleus, or very rarely no nucleus forms. The endosperm in the embryo-sac of *Phaseolus* and other phanerogams is formed by free-cell formation, the cells after attaining a certain size fusing together and forming a tissue, the individual cells of which divide. In some fungi, *Peronospora*, *Cystopus*, &c., only one daughter-cell is formed in the protoplasm of the mother-cell.

ivision.

The last variety is cell-division, the whole of the protoplasm of the mother-cell going to form two, rarely more, daughter-cells. The process may be observed in the cells of *Spirogyra*, in the cells of the hairs of *Tradescantia*, or in the cells near the growing points of the roots or stems of plants. *Spirogyra* and *Tradescantia* may be observed in a hanging drop of fluid,—water in the case of *Spirogyra*, a dilute sugar solution (1 per cent.) in the other. In *Spirogyra* a ring-like groove forms round the protoplasm in the centre of the cell, gradually deepening until the nucleus divides, and the two portions of protoplasm become separate. As the separation of the protoplasm goes on, the wall forms a ring-like projection of cellulose, which gradually extends inwards until only a small central hole is left; this soon fills up, and the mother-cell is separated into the two daughter-cells.

Cell-division can be seen in the hairs of the young stamen of *Tradescantia virginica*. A small unopened bud about one-fifth of an inch long is recommended by Strasburger.[1] The entire stamens are removed, and one, with the small hairs attached, is to be placed in the 1 per cent. sugar solution in a hanging drop. The cover glass on the under side of which the hairs are arranged must be very thin, to permit of observation with an immersion object-glass magnifying about 600 diameters. The cell-division in the last three cells of the hair can be readily observed, as well as the peculiar behaviour of the nucleus, its solution, and the formation of the barrel-like body "Kerntonne." These and other changes, which had been fully described by Strasburger (*Ueber Zellbildung und Zelltheilung*) in *Spirogyra* and other cells from specimens hardened and fixed in absolute alcohol, can be seen in the living cell of *Tradescantia*.

In the pollen of monocotyledons and the tissue cells of many dicotyledons, as in the pith and epidermis, the division of the cell differs slightly from that seen in *Spirogyra*. The nucleus of the mother-cell divides into two sister nuclei, and the protoplasm separates into two portions, the wall forming at once as a plate stretching right across the mother-cell and cutting it into two daughter-cells. The process of division can rarely be observed in living cells; hence it is necessary to make use of specimens killed during the process of division by immersion in absolute alcohol, or in a 1 per cent. solution of osmic acid.

Special modifications of the process of cell-division may be observed in yeast (*Saccharomyces*), in the formation of styloconidia as in *Penicillium*, and of the basidiospores of the *Basidiomycetes*, as also in *Œdogonium*, in the sporangia of *Saprolegnia*, and in the spores of the higher cryptogams. In yeast a portion of the cell-wall enlarges in a sac-like manner, and into it a portion of the protoplasm of the mother-cell passes, thus forming two daughter-cells of very different sizes; when the smaller cell is full-grown a wall separates the two, and they become detached. In *Penicillium*, and in the formation of basidiospores, a very similar process is seen. In *Œdogonium* division of the cells is preceded by the formation of the curious cap-like structures at the apex of the cell due to local intercalar growth of the wall.[2] In *Saprolegnia* the protoplasm of the mother-cell divides into a large number of daughter-cells, which are liberated as ciliated swarm-spores, and afterwards form a cell-wall. Lastly, in the spores of the higher cryptogams the division of the mother-cell into four daughter-cells is observed.

Tissues true and false.

Union of Cells to form Tissues.—Cells are usually united together to form an aggregate governed by some common law of growth. Such an aggregate of cells is called a tissue. Tissues are formed in different ways, and in accordance with their mode of formation are distinguished as true and false. A true tissue is formed by cell-division. In the young growing part of the plant the young active cells are all capable of dividing, a transverse wall cutting the mother-cell into two daughter-cells, the process being repeated for some time. In this way the tissues of the higher plant are formed, either originally from a single cell (apical cell) at the apex of the part, or from several cells (initial cells) situated at the growing point. In some of the lower plants false tissues are formed, rarely in some of the higher ones. The first mode of formation of a false tissue is noticed in some of the algæ, as in *Pediastrum* and in *Hydrodictyon*, as well as in the formation of the endosperm in the embryo-sac of many plants, as in *Phaseolus*, *Gnetum*, &c. Here the cells are at first separate and distinct, but these loose cells become aggregated together, often, as in *Pediastrum* and *Hydrodictyon*, to form a beautiful and regular figure. In such instances the wall separating two cavities is a double structure formed by the union of two distinct walls. In the endosperm of the higher plants, when the false

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[1] "Ueber ein zu Demonstration geeignetes Zelltheilungs-Object," *Sitzungsberichte der Jenaischen Gesellschaft für Medicin und Naturwissenschaft*, July 18, 1879.

[2] Fully described by Strasburger, *Ueber Zellbildung und Zelltheilung* (2d ed.), p. 73.

tissue is formed, the cells divide in the ordinary way, and at length give rise to a true tissue, as different modes of cytogenesis may occur in the same plant, either in different parts or at different times. The second mode of formation of a false tissue is seen in the fungi and lichens, in the peculiar hyphæ tissue so characteristic of these plants. The cells form long narrow rows or filaments, which branch and interlace, producing a network of interlacing fibres, but without the walls becoming fused firmly together as in *Pediastrum*. In some cases the hyphæ cells swell up and come into such close contact by mutual pressure that they form a tissue so like ordinary cell-tissue that it has been denominated pseudo-parenchyma. This variety of tissue occurs commonly in the higher fungi, as in the mushroom.

Mode of union of cells.

Cells are united in various ways, the modes of union being often very characteristic of certain of the lower groups of plants, although the same modes of union repeat themselves in the higher plants. The following are the chief varieties. (1) Cell-rows have the cells united by their ends to form a long filament, formed by the repeated division of the cells. Examples of cell-rows are seen in *Spirogyra*, *Conferva*, *Œdogonium*, the hyphæ of fungi, the moniliform hairs in *Tradescantia*, and in many others; not unfrequently these cells branch in various ways. Cell-fusions or vessels are cell-rows occurring in the higher plants, but having the transverse walls separating the original cells either partially or completely absorbed. They occur in the fibro-vascular bundles of plants, both in the wood and in the bast. Laticiferous vessels are examples of branching and anastomosing cell-rows. (2) Cell-surfaces have the cells united to form a single layer, and are thus in contact by the ends and sides, having an upper and under (rarely only one) free surface. Examples are afforded by some of the sea-weeds, as *Ulva*, and by the leaves of liverworts. In the higher plants cell-surfaces occur not unfrequently, as in the epidermis, a layer of distinct cells, free on one surface, but in contact with other cells below. Many flat, scale-like hairs are also cell-surfaces, as well as the thin plates of cells separating the remarkable air spaces in the petioles of *Nuphar* and *Musa*. (3) Cell-bundles are bands or bundles of similar cells either occurring separately or running through the other tissues of plants, and when doing so easily recognized in a transverse section of the part, as the bast-bundles in the stem of flax. Other examples occur among the red sea-weeds, and in the bundles of sclerenchyma in the stems of ferns. (4) Cell-groups are small masses of similar cells, either forming the families or colonies (cœnobia) of many thallophytes, as *Chroococcus*, *Glœocapsa*, *Pandorina*, &c., or forming the curious groups of sclerenchyma producing the gritty particles in the pulp of the pear or the hard masses in cork. (5) Cell-masses are formed when the cells are united in all directions of space, the whole not having necessarily any definite external shape. Examples are numerous, but we may cite the tissues of large fungi, the ground tissue of the higher plants, and the pulp and hard endocarps of fleshy fruits. (6) Lastly, separate cells occur, either distinguished from the cells in the neighbourhood by their peculiar form and development (idioblasts), or the originally united cells separate themselves, as in pollen-grains and spores, and form eremoblasts.

Prosenchymatous and parenchymatous cells.

By the form and connexions of the cells aggregations of cells may be described as parenchymatous tissue and prosenchymatous tissue, both these forms occurring very commonly in plants, and usually shortly designated by botanists parenchyma and prosenchyma. Parenchymatous cells are usually thin-walled, and have a correspondingly large cavity; their length is generally not very much greater than their breadth, the form frequently being rounded or polyhedral; the walls are broad and flat, the cells, if elongated, not having pointed and overlapping ends. At the places where neighbouring cell-walls meet triangular or quadrangular intercellular spaces are formed, by splitting of the wall during rapid growth. Sometimes these spaces are very minute, in other cases they are largely developed, and if irregular growth of the wall occurs a very loose form of parenchyma may be produced, as in the pith of *Juncus*. In other cases tolerably large intercellular spaces occur, as in the spongy parenchyma of the mesophyll of leaves. In prosenchyma the individual cells are greatly elongated and fibre-like, the walls are very thick, and the cavity small or even nearly obliterated; the ends of the cells are elongated, pointed, and overlapping those above and below; and lastly, no intercellular spaces are developed. Wood-fibres and bast-fibres are examples of prosenchyma; the young cells of stem or root, and the tissues of pith, leaves, flowers, and many fruits, of parenchyma.

Meristem and permanent tissue.

By the power possessed by the cells in a tissue of dividing and forming new cells such a tissue is distinguished as meristem or the formative tissue of plants, all the other tissues being permanent tissues, or incapable of further enlargement by the formation of new cells. Meristem is observed forming the whole of the tissue of the young embryo plant, as also the whole tissue at the apex of a stem and root. All the other tissues of the plant are formed by the gradual differentiation of the originally similar cells of the meristem. Generally meristem tissue differentiates into special layers, each capable of forming cells which will ultimately form some definite portion of permanent tissue, not necessarily of the same value, however, in different groups of plants. The meristem of the embryo and of young stems and roots is distinguished as primary meristem, because occasionally a zone of cells forms in the permanent tissue having the characters of meristem, and secondary meristem, which either originates from the permanent tissue or is partly connected with the primary meristem. The cork-cambium or phellogen in the cortical tissues of dicotyledons is a layer of secondary meristem, while the cambium layer between the wood and bast portion of the bundle is partly (the fascicular cambium) derived from the primary meristem (the procambium) of the fibro-vascular bundle.

Walls of tissue cells.

Walls of Tissue-Cells.—The cell-wall separating the contiguous cavities of two young cells appears as a simple homogeneous plate or lamella of pure cellulose, giving the usual reaction with Schultz's solution and iodine and sulphuric acid. As the tissue grows older and the wall thickens, it apparently separates into distinct layers having different chemical and physical properties, so that in some cases it appears as if each cavity had its own special wall separated from the neighbouring wall by a thin or thick layer of material, to which the older botanists gave the name of intercellular substance. The thickening layers usually exhibit a well-marked stratification, the strata often differing in chemical composition, as in pine-wood, in the bast of laburnum, or in the epidermis of *Viscum*, *Ephedra*, *Nerium Oleander*, &c. The application of Schultz's solution usually brings out the differences very well. In a few instances the middle lamella becomes gelatinous, and swells up enormously in water. Examples are afforded by the stems of many algæ, and by the endosperm of *Ceratonia*, where the so-called intercellular substance separates the cell-cavities widely one from the other. The middle lamella or intercellular substance and the thickening layers in the stratified cell-wall vary much in composition, but generally it is found that the incrusting layers are soluble in sulphuric acid, while the middle lamella is dissolved by nitric acid and chlorate of potash. These two substances, just mentioned under the name of Schultz's maceration process, are constantly employed to separate cells from their connexions, as the markings in the thickening layers are not injured by the solution of the middle lamella in the chlorate of potash and nitric acid.

Classification of Tissues.—In classifying vegetable tissues it is necessary first to distinguish the different kinds of tissue depending on the characters of the individual elements composing it, and, secondly, to consider the various grouping of these kinds or species into systems more or less homogeneous and obeying certain common laws of growth. It is necessary to distinguish the kinds of tissue, because different kinds may occur in the same system, and it is further necessary to distinguish the systems, because the same form of cell may be repeated in different systems or in different parts of the same system and yet be of very different morphological and physiological value. In classifying the different kinds of tissue we shall follow De Bary (*Vergleichende Anatomie der Vegetationsorgane der Phanerogamen und Farne*), and in the systems we shall adopt the threefold divisions of Sachs (*Lehrbuch der Botanik*), now generally used.

I. Kinds of Tissue.
- (A.) *Meristem Tissue.*
  - 1. Primary. 2. Secondary.
- (B.) *Permanent Tissue.*
  - 1. Cell Tissue. *a.* Epidermis. *b.* Cork. *c.* Parenchyma proper.
  - 2. Sclerenchyma.
  - 3. Gland Cells.
  - 4. Tracheal Tissue.
  - 5. Sieve Tubes.
  - 6. Laticiferous Tubes.
  - 7. Intercellular Spaces.

II. Systems of Tissues.
- (A.) *Epidermal or Limitary System.*
- (B.) *Fibro-vascular System.*
- (C.) *Ground System.*

Primary meristem. (A.) *Meristem Tissue.*—Primary meristem can be observed in the embryo in its young stages, and at the apex of the stem and root. In the embryo at an early stage, as described by Hanstein (*Botanische Abhandlungen*, i.), the meristem becomes separable into three zones, differing in the appearance and arrangement of the cells and in the mode of dividing. Dermatogen, periblem, plerome. These zones were called by Hanstein (1) dermatogen, or primary epidermis; (2) the plerome or central series of more elongated cells with marked longitudinal division of the cells; and (3) a series between the plerome and dermatogen, dividing more or less irregularly or transversely, the periblem. These three zones remain distinctly marked at the apex of the stem, and in *Hippuris* the three can be easily seen, while as the stem elongates new cells continually form, the initial cells or cell, as there may be one or more for each zone. Usually the dermatogen layer is the most constant in angiospermous plants, the separation into periblem and plerome being sometimes a little obscure. In the root a fourth zone of meristem has to be distinguished, called by Janczewski the calyptrogen layer, from which the calyptra, pileorhiza, or root-cap is formed. Various modifications of the arrangement of the different layers in the meristem of roots have been described. Very rarely, as in *Hydrocharis* and in *Pistia*, four distinct layers are formed Calyptrogen. —the plerome, periblem, dermatogen, and calyptrogen. In *Cucurbita*, *Pisum*, and a few others there is a common mass of meristem at the apex, from which the others are all differentiated. In *Zea Mays* and most monocotyledons two distinct zones are seen, the plerome and the calyptrogen, while between them a short distance from the apex the initial layer forms, which separates into the periblem and dermatogen. In *Fagopyrum* and most dicotyledons the plerome and periblem are sharply separated, but the periblem above the apex of the plerome passes into a common layer with the initial cells of the dermatogen and calyptra, the dermocalyptrogen. In gymnosperms the root possesses a sharply-defined plerome with a periblem mantle, in *Thuja* formed by from 12 to 14 regular concentric layers; there is no trace either of a calyptrogen or dermatogen layer, the outer cells of the periblem serving as a calyptra. In the stems of gymnosperms the condition of the layers is somewhat intermediate between those formed in the angiosperms and lycopods. In *Araucaria* and *Dammara* the dermatogen, periblem, and plerome are separate and distinct, but in *Abietineæ* and in *Cycas* they run into a common initial group, and it is only at some distance from the apex that in the *Abietineæ* the separation becomes very marked, and in *Cycas* only slightly marked. In lycopods the end of the stem shows a series of cells, the initial group from which the periblem and dermatogen (or the external layer representing it) arise. Further down the initial cells of the plerome are developed from the side of the periblem. In the root of lycopods the arrangement of the layers is exactly the same as in *Hydrocharis* and *Pistia*. In the *Ligulatæ* and the remaining *Pteridophyta* there is a single cell at the apex of root and stem which divides into two. The one daughter-cell forms the new apical cell, the other is the segment cell. The segment cell divides still further, and forms a meristem from which at a later stage zones corresponding more or less accurately to dermatogen, periblem, and plerome are produced. In the roots a segment is cut off in front of the apical cell, which is the first cell of the calyptra, and from which, by repeated divisions, that structure arises.

Secondary meristem is intimately connected with the secondary circumferential growth of stems and roots in gymnosperms and dicotyledons. Secondary meristem. One of the zones of secondary meristem arising from permanent cells is the cork-cambium or phellogen layer, which is described under the epidermal system of tissues. The other example of secondary meristem is the cambium layer separating the wood and bast in the stems and roots of gymnosperms and dicotyledons.

When the fibro-vascular bundles first appear, either in the periblem or plerome, the cells become distinguishable by Procambium. their form and arrangement, and as the cells are still in the condition of meristem, the term procambium has been given to the whole. The cells of the procambium are gradually converted into permanent tissue, generally changing their appearance completely, although in some cases the change is but slight, the cells being *cambiform* and hardly differentiated into the two parts of the fibro-vascular bundle, the wood and bast, to be described under the fibro-vascular tissues. In some plants all the procambium is converted into permanent tissue, while in others a small zone between the wood and bast remains in the condition of meristem. If the bundles are separate, secondary meristem forms in the ground tissue between the bundles, bridging over the space between the bundles, but uniting so as to form the cambium-ring, Cambium ring. which consists of fascicular cambium in the bundle, derived from the procambium, and interfascicular cambium, a secondary meristem formed in the ground tissue. It is by the growth of this cambium ring that the secondary circumferential growth, so marked in our ordinary forest trees, takes place.

(B.) *Permanent Tissue.*—It will be sufficient to give only Permanent tissue. a general sketch of the seven kinds of tissue described by De Bary, and to refer for full details to his *Vergleichende Anatomie* above mentioned.

1. *Cell-tissue* is permanent tissue, the cells of which are little if Cell-tissue. at all altered in form and appearance from their meristem stage. In some cases the cells are short, in others elongated. The wall may be thin, and enclose the protoplasm and other contents, the chlorophyll, starch, sugar, inulin, &c. In others the wall is thick and changed in composition. As varieties of cell-tissue De Bary includes (1) epidermis and its appendages, equivalent to the epidermal system of Sachs, and to be considered below; (2) cork, parenchymatous cells chemically altered, and forming usually a part of the secondary epidermal system; and (3) parenchyma proper, all the cell-tissue inside the epidermis and cork cells, a division almost but not quite equivalent to the ground tissue of Sachs.

2. *Sclerenchyma.*—De Bary includes under the name of scleren- Sclerenchyma. chyma all the hard thickened cells of plants, whether long or short, which have become greatly thickened, and whose cavity is nearly if not quite obliterated,—the cell-contents also, as a consequence, having entirely disappeared, or left only slight traces. In this state these cells act in conveying water through their walls, and also serve to give rigidity to the plant, forming the mechanical system of Schwendener. Two forms are distinguished: (1) the short sclerenchymatous cells, and (2) long sclerenchymatous fibres. Of the former, examples are met with in the flesh of the pear, in the root-tubers of *Dahlia*, in the rhizome of *Dentaria*, the pith of *Hoya carnosa*, and

many others. Such cells are rare in monocotyledons, and the typical form (like the cells in the pear) does not occur in cryptogams. A variety of the short cells is described under the name of stegmata. The long sclerenchymatous fibres are pointed, with overlapping ends, and occur commonly in dicotyledons. They are either simple or branched. The best examples are the bast fibres of the fibro-vascular bundles, and the libriform fibres of the secondary wood. The wall of the sclerenchym fibre often exhibits peculiar split-like pitted markings (*Pteris aquilina*). Not unfrequently the sclerenchym fibres have numerous small crystals of calcic oxalate imbedded in the wall, a very beautiful example of which is afforded by *Welwitschia mirabilis*. Sometimes the cavity in the interior of the fibre is divided by transverse partitions forming chambered fibres, as seen in the bast of the vine, *Platanus*, *Tamarix*, &c.

lands. 3. *Gland Cells.*—Gum, resin, ethereal oils, balsam, and gum-resins are usually met with in peculiar elongated cells, which develop from special meristem-cells. Sometimes they are isolated, in other cases they occur in rows; they are considered by De Bary as a special kind of tissue, the cells being at once distinguished from the others in the neighbourhood by their contents. In many ways these gland-cells exhibit intermediate transition forms to laticiferous tubes on the one hand, and to intercellular spaces containing special secretions on the other. De Bary distinguishes four varieties. (*a.*) Cells with the cavity nearly filled with raphides or with single crystals or groups of crystals, *e.g.*, *Aloe*, *Scilla*, and many monocotyledons, as also many dicotyledons. Groups of crystals occur in petiole of aroids, pith of *Ricinus*, and others, large crystals in leaves of *Citrus*, and in the bast of *Acer*, *Robinia*, *Ulmus*, *Berberis*, &c. (*b.*) Cells with the cavity filled with mucilaginous and gummy substances, root of *Symphytum*, *Orchis* tubers, and in the parenchyma of *Malvaceæ*, *Tiliaceæ*, *Ulmaceæ*, &c. (*c.*) Cells containing resin or gum-resin. Two modifications occur, the cells being either short or long, and frequently, as Zacharias (*Bot. Zeit.*, 1879, p. 167) has pointed out, the walls are corky. Short cells occur in *Acorus*, *Canella*, *Zingiberaceæ*, &c., while long ones occur with milk-like juice, the laticiferous cells of some authors. As examples De Bary gives *Allium*, aroids, *Musaceæ*, *Convolvulaceæ*, *Sapotaceæ*, *Sambucus*, *Acer*, and doubtfully *Sanguinaria*, *Glaucium*, &c. (*d.*) Cells containing tannin, occurring in rhizocarps, ferns, monocotyledons, and dicotyledons.

Vessels nd essel- ike ells. 4. *Tracheal Tissue.*—Under this head De Bary distinguishes all those cells which become more or less lignified, and in which the thickening of the wall assumes the form of spirals, rings, reticulations, or pits, and which as soon as these markings are formed either lose their contents completely and become filled with air, or contain clear watery fluid. Usually these form long cell-fusions, the vessels of plants, or else they form elongated or shorter cells not united into a vessel. The former are the vessels, the latter the tracheides. The markings in the two forms correspond, and there are intermediate varieties. The markings are spiral, annular, reticulated, pitted, and trabeculate (juniper and lycopod), with the varieties of bordered pits and scalariform markings. Short tracheides form the velamen or outer modification of the epidermis of the aerial orchid roots, also the outer tissue of the stem of *Sphagnum*. In *Nelumbrium speciosum* the tracheides are 12 centimetres long. Many of the structures usually called vessels are tracheides. Large vessels frequently exhibit tyloses or cells filling up the cavity of the vessel. They have been observed in many monocotyledons and dicotyledons, both in stems and roots, and in herbaceous as well as in woody plants.

ieve- ubes. 5. *Sieve-tubes.*—These resemble vessels in being elongated cylindrical or prismatic cells joined in long rows, the individual cells always remaining distinctly marked. The transverse wall separating the two cavities becomes perforated at the unthickened parts, forming the sieve-plate perforated by the sieve-pores. The contents of the sieve-tubes are colourless and transparent, and the wall is coated with a thin layer of protoplasm-like substance, not unfrequently with small starch granules. Sieve-tubes form a special part of the bast of plants, and are met with in pteridophytes, gymnosperms, and angiosperms, exhibiting occasionally in different groups slight structural differences.

Iilk- earing ubes. 6. *Laticiferous Tubes* are tubes containing the peculiar milky sap or latex occurring in special groups of plants. These run through the plant usually for very long distances, and when a portion is injured the milk-sap flows out at the opening. The walls are always soft, of pure cellulose, and readily giving the characteristic reaction with iodine and sulphuric acid. The tubes contain no protoplasm and nucleus; but a quantity of a rarely watery, usually milky juice, occasionally, however, orange or yellow, and sometimes containing peculiar starch granules. The tubes are either simple or segmented. Segmented tubes occur in *Cichoraceæ*, *Campanulaceæ*, *Lobeliaceæ*, *Papayaceæ*, many *Papaveraceæ*, as *Papaver*, *Argemone*, and *Chelidonium*, but not in *Glaucium* or *Sanguinaria*, many aroids, and *Musaceæ*. Simple tubes are met with in *Euphorbiaceæ*, *Urticaceæ*, *Apocynaceæ*, and *Asclepiadaceæ*. These latter do not exhibit the net-like anastomoses of the segmented forms, and usually have the branches terminating in blind extremities.

7. *Intercellular spaces* are the cavities between the elements of full-grown tissues, the cells in the meristem stage being in uninterrupted continuity. Some of the intercellular spaces are produced by the splitting of the cell-wall between three or more cells, others are formed by the destruction of the walls of a cell or group of cells during the formation, by desorganization, of some secretion. Lastly, large cavities appear in plants as the result of mechanical rupturing and tearing of the inner tissues during rapid growth of the part. De Bary distinguishes all these by separate names, viz., schizogenous when formed by splitting of the common wall between cells, lysigenous when formed by the destruction of certain cells and cell-groups, and rhexigenous when produced by mechanical disruption. From the nature of the contents, the intercellular spaces can be divided into two groups, the one containing substances or mixtures similar to those contained in gland-cells, the other containing air, or rarely water. Of the intercellular glands, spaces, or canals the following varieties may be distinguished:—(*a.*) mucilage or gum canals, of which examples may be seen in *Marattiaceæ*, *Lycopodiaceæ*, *Cycadaceæ*, *Canna*, *Opuntia*, and some *Araliaceæ*; (*b.*) resin, ethereal oil, or gum-resin canals, either in long canals, as in *Coniferæ*, *Alismaceæ*, aroids, *Compositæ* (*Tubulifloræ*), *Umbelliferæ*, *Araliaceæ*, &c., or short spaces as in *Rutaceæ*, *Hypericum*, *Oxalis*, *Myrtaceæ*, *Lysimachia*, &c. Of the intercellular air or water spaces there are several modifications. First there are the minute spaces between the walls of parenchymatous cells, the interstitial air spaces; and when the spaces are larger and accompanied with irregular growth of the wall, lacunæ are produced, as in the root of *Sagittaria sagittifolia*, or in the pith of *Juncus* or petioles of *Musa*, &c. Large schizogenous air-spaces with smooth walls are met with in *Isoetes*, *Potamogeton*, *Hippuris*, *Trapa*, *Nymphæaceæ*, and many others. Lysigenous spaces having the remains of the destroyed cells more or less marked on the walls are seen in *Equisetum*, *Cyperaceæ*, *Gramineæ*, *Typha*, *Iris*; while the large hollow stems of *Umbelliferæ*, *Compositæ*, grasses, and the leaves of *Allium*, &c., are rhexigenous. Occasionally flat cell-surfaces or diaphragms interrupt the continuity of long air-spaces, and not unfrequently internal hairs or peculiar hair-like idioblasts are formed, projecting into the intercellular spaces as in *Nuphar* and *Monstera*. It is only in the neighbourhood of water stomata that the spaces contain water for a short time. Cavities in tissues.

Systems of Tissues.—Sachs describes three systems of tissues, complex aggregations consisting of different kinds of tissue, but all so combined as to form readily recognizable parts of the root, stem, or leaf of a plant. Externally there is the epidermal or limitary system equivalent to De Bary's first division, excluding his parenchyma. This system is taken to include the epidermis of plants, with its cuticle, stomata, and hairs, and also to include the secondary modifications produced by the development of cork and bark. In the interior of most parts of the higher plants, and following in the direction of the long axis of growth, separate or united strings or bundles are seen running and usually branching or anastomosing. Generally these bundles are harder than the surrounding tissues and readily separable from them. Consisting as they do of many kinds of tissue of vessels, cells, and sclerenchyma, these structures are known as fibro-vascular bundles. Lastly, there exists a quantity of parenchyma or a mixture of parenchyma with other forms, packing up all the space between the fibro-vascular bundles on the one hand and the epidermal system on the other. This forms the ground tissue, and includes the parenchyma proper of De Bary.

1. *The Epidermal or Limitary System.*

The epidermal system takes its name from the chief member of the group, namely, the epidermis or outer skin of the plant. It is the superficial layer, and is variously developed in the higher and lower plants. In the lower forms, algæ, fungi, lichens, the external cells are usually smaller than those below, or the walls are thicker and coloured; while in many mosses and liverworts a true separable epidermis is only slightly indicated. In others, as in *Marchantia*, capsules of most mosses, and in *Sphagnum*, a specially differentiated epidermis appears, resembling that in the higher plants. The nature of the epidermis varies in accordance with the conditions to which it is exposed, as to air and light, or in water, or in the soil, and in darkness. The nature of the limitary tissue also varies with the stage of growth in such parts as are of perennial duration. Epidermal tissues.

Usually the epidermis is a single layer of cells producing stomata and hairs. In many plants the epidermis is strengthened by the formation of a corky outer layer, the cuticle, which develops wax; or in other cases a new formation takes place below the epidermis, usually in the ground tissue, and by the formation of layers of cork a secondary epidermal or limitary tissue is produced. Other parts of the ground tissue assist in forming the outer covering of plants, and may be considered physiologically to belong to the epidermal system. These will be described as hypoderma and collenchyma under the ground tissue.

Epidermis. *Epidermis.*—The cells of the single layer forming the epidermis vary in shape, but usually the form is determined by the shape of the part on which they are developed, being elongated on long leaves, broad with straight or wavy margins on broad leaves. Usually the cells of the epidermis, although parenchymatous, have no intercellular spaces, except in *Osmunda* and *Todea*, and a few other rare instances. The only openings are those in the stomata, schizogenous intercellular spaces, between the special cells (guard cells) of the stoma. In many plants, as monocotyledons and needle-leaved conifers, the epidermal cells contain no chlorophyll; but in ferns and in many dicotyledons, as has been shown by Stoehr (*Bot. Zeit.*, 1879, p. 581), chlorophyll is present. Not unfrequently anthocyan fills the epidermal cells, and completely obscures the green colour of the chlorophyll-bearing cells below. The outer wall of the epidermal cell is usually greatly thickened and corky, forming the cuticle, which generally forms a continuous sheet separable by the action of caustic potash from the rest of the wall below. In applying Schultz's solution to a thin section of an epidermal cell, the outer layers become brown, while the inner give the reaction of cellulose. The outer layers are soluble in boiling caustic potash and in nitric acid and chlorate of potash, but insoluble in sulphuric acid and in ammoniacal solution of cupric oxide. Many of the cells have a marked deposit of mineral matter, more particularly silica (*Equisetum*), in their walls. See Nageli and Schwendener, *Das Mikroskop* (2d ed.), p. 489.

Wax. Wax is frequently produced: either it is on the surface of the cuticle forming a variously constructed coating, or minute particles are embedded in its texture. The chief modifications are described by De Bary (*Vergleichende Anatomie*, p. 86):—(1) a layer or crust, either thin, homogeneous, and transparent, or thick and striated, the former seen in *Sempervivum*, the latter in the waxpalm (*Klopstockia*); (2) a coating of rod-like particles placed perpendicularly to the surface, either closely placed or somewhat loose and irregular (*Saccharum*, *Musa*, and *Scitamineæ*); (3) a layer of granular particles, close or widely separated, and not placed one over the other (*Allium*, *Acer*, *Vitis*), &c.; and (4) irregular granules piled up one over the other in several layers, as in *Eucalyptus*, *Ricinus*, *Abies pectinata*, &c.

Stomata. Stomata (De Bary, *Vergleich. Anat.*, p. 36 *sq.*) are the openings in the epidermis which permit the entrance and escape of gases. They are formed by two semilunar cells, the guard cells, with the pore or intercellular space between them, the pore opening into a large air-space in the tissue below, and in communication, by means of the small intercellular spaces of the parenchyma, with most of the tissues of the plant. The stomata are found on those parts above ground exposed to air and light, hence chiefly on the leaves and tender green stems of plants. On leaves they are most abundant on the under side, and are generally absent from the upper surface. In many leaves, however, especially of monocotyledons, they are equally distributed on both sides, and in water-plants with floating leaves they are abundant on the upper side but absent from the lower. They rarely occur on submerged water-plants and never on roots. As a rule the stomata are irregularly scattered, but in some plants, as in *Equisetum*, they occur in tolerably regular longitudinal rows on the stem. Usually the stomata consist of only two cells, the guard cells, or of two pairs of guard cells (*Equisetum*) one over the other, or there are many, as in the peculiar stomata of *Marchantia*. In some plants two or more additional cells, the accessory cells, are formed. These accessory cells differ from those of the epidermis on the one hand, and from the guard cells on the other. The position of the stoma varies. It is sometimes at the end of the long epidermal cells, as in the hyacinth, or at the side, in a few cases free in the centre of the epidermal cells (*Anemia*, &c.). The guard cells may be on a level with the epidermis; rarely they project slightly; but frequently they are depressed below the surface. The guard cells often contain chlorophyll and starch, the outer wall is often thickened, and occasionally even wax forms on their surface; but as a general rule no wax forms, and thus, when a thick coat of wax is developed, narrow canals through it indicate the position of the stomata.

Development of Stomata.—In long epidermal cells (hyacinth) a portion is cut off at one end by cell-division, and forms the mother-cell of the stoma. It then divides into two daughter-cells, each forming one of the guard cells. The lamella between the two splits, either from without inwards or within outwards, and forms a schizogenous intercellular space. When the epidermal cells are not elongated (*Œnothera*, *Silene*, &c.), a portion of the epidermal cell is cut off at one part by a bent wall. This is the mother-cell of the stoma, and either forms the daughter-cells immediately, or may divide by segments cut off at one side and then at the other side, either one, two, or more times before the central cell divides to form the daughter-cells which form the guard-cells of the stoma. The other cells cut off on each side are the accessory cells. In other cases the accessory cells have a different origin, being cut off from the neighbouring epidermal cells after the guard-cells are formed. Instances of the former may be seen in *Crassulaceæ*, *Cruciferæ*, and *Papilionaceæ*; of the latter in *Juncaceæ*, *Cyperaceæ*, and *Gramineæ*. In *Anemia* and some other ferns a cell is formed inside the epidermal cell, cutting a cylindrical piece out of it. This divides and forms the guard-cells of the stoma.

Water stomata. Two kinds of stomata exist in many plants. The one kind, already fully described, are the air-stomata, to distinguish them from the second kind, the water-stomata. The latter occur in many plants on the leaves, immediately over the ends of the fibro-vascular bundles, near the margin on the upper surface, and often on the serrations of the margin itself. They give off water, during a portion of the life of the leaf, which appears on the surface in the form of drops, under the action of root-pressure. They are at once distinguished by their large size, and by their not opening and closing like air-stomata.

Hairs. Hairs (De Bary, *Vergleich. Anat.*, p. 58) are usually out-growths of single epidermal cells; but occasionally some of the cells below the epidermis assist in the construction of large massive hairs or emergences, as they are called by Sachs. Hairs vary very much in construction, size, and appearance, and not unfrequently different kinds of hairs occur mixed together on the same part of the plant, although in many instances only a single characteristic variety of hair may be developed on the epidermis. De Bary distinguishes several typical varieties of hairs:—(1) hairs proper; (2) papulæ, short rounded sac-like structures; (3) scales; (4) villi; and (5) warts or prickles. The simplest hairs are outgrowths of single epidermal cells, having the cavity either continuous with that of the epidermal cell, or cut off by a wall. Long cylindrical unicellular hairs occur in cotton; and on most roots root-hairs, with thin or sometimes with peculiarly and irregularly thickened walls (*Viola tricolor*). The cells may divide and form a moniliform hair, as in *Tradescantia*, or much more complex branched (*Verbascum thapsus*) or club-shaped and glandular hairs may be produced. Flat, dry scales, either unicellular or multicellular, are seen in *Deutzia*, *Elæagnus*, and in many ferns. Papulæ are mentioned by De Bary as occurring on *Rochea*, *Begonia*, *Piper*, *Ampelopsis*, and others. The villi or colleteres occur on bud-scales and buds, while spiny hairs or warts occur frequently as the prickles of the rose and bramble, and in *Dipsacus*, *Smilax*, &c. The walls of hairs are often thin, and composed of nearly pure cellulose, or thickened and stratified in various ways, with an outer cuticular layer. The thickening is either general or local, and may assume the form of pores or spiral striation (hairs on stamen of *Bulbine aloides*), or may form peculiar warts or nodules. Silicious hairs (*Deutzia*), or hairs containing lime, sometimes occur. In some cases the hairs (nettle) are supported on cellular elevations of the epidermis. These may be distinguished as the accessory cells of the hair. Glandular hairs are of frequent occurrence, the end cell or cells secreting some ethereal oil or resin; the secretion collects below the cuticle, and either it remains there, causing the absorption of the secreting cells, or the cuticle ruptures. The villi or colleteres are peculiar many-celled glandular hairs on young leaves, stipules, or bud-scales (*Ribes*, *Viola*, *Polygonum*, *Æsculus*), and secreting a gum or resin. Frequently the secretion of these colleteres is supplemented by the formation of a resin from below the cuticle of the epidermis, forming the gelatinous secretion covering buds, termed blastocolla (horse-chestnut). In some plants, as *Populus*, the blastocolla is formed by the epidermal cells alone, in others both by the colleteres and epidermis.

Secondary epidermal tissue. Beneath the epidermis the cells are often peculiarly modified to form the hypoderma and collenchyma; but as these belong to the ground system of tissues they are described below. The secondary epidermal tissues, or the covering that replaces the epidermis on the perennial parts, consists largely of cork, either in the form of a thin layer or in repeated layers developing deeper and deeper in the tissues of the stem or root and forming the massive bark or rhytidome. Cork cells arise usually from the cortical cells, *i.e.*, those of the ground tissue placed a short distance below the epidermis (*Populus*, *Sambucus*). In other cases the cork forms still deeper, among the green chlorophyll-bearing cells of the cortex, as in *Rubus Idæus*, *Ribes*, &c. Rarely the cork-cells arise from the epidermis itself (*Salix*). In all cases cork is formed by the division of the cells of the cortex or epidermis by a tangential wall, separating the mother-cell into two daughter-cells. The outer cell becomes corky, rapidly losing its contents and becoming filled with air; while the inner one retains its protoplasm and forms new cork-cells by division. The formation of cork does not necessarily begin at all parts of the circumference simultaneously, but sooner or later a complete layer of cork is formed. When the layer has become a few cells thick, it is known as the periderm; while the active cells from which it arises are distinguished as the cork cambium or phellogen. Inside the cork cambium new cells are often formed, which contain chlorophyll, and are known as the phelloderma (*Fagus*, *Salix*), such cells being also formed by division of the cork cambium. After the formation of the periderm, as is easily seen in the stem of the black currant, the whole of the epidermis and of the ground tissue immediately below becomes withered, and is thrown off. In the formation of bark, the layers of cork form repeatedly in the cortical tissue of the stem, and even in the bast portion of the fibro-vascular bundles. The layers of cells between the plates of cork, being cut off from a supply of nourishment, soon wither; and thus occasionally the dead parts scale off, as in the *Platanus*, cherry, &c. The bark or rhytidome is thus a very complex structure, consisting of the secondary epidermal tissues either formed in the primary cortex alone or deep in the other tissues, and popularly it includes all the tissues outside the cambium layer, that is, the bast part of the fibro-vascular bundles and secondary epidermal tissues. Lenticels are special structures connected with the epidermal tissues, and are common on dicotyledons (*Sambucus*, *Populus*, *Juglans*, &c.), and on some monocotyledons, being formed on stems, branches, petioles, and roots. Below a stoma or group of stomata a few cells enlarge and divide, and form numerous colourless thin walled cells, which arise from the bent layer of lenticel cambium below. The epidermis becomes ruptured and the cells appear on the surface, forming a brownish wart-like marking. These lenticels are probably to be considered functionally as secondary stomata, as the cells have large intercellular spaces and readily permit the passage of air into the interior. Lenticels have the marked peculiarity of being sometimes closed in autumn by the formation of cork cells, but open again in spring.

enticels.

2. *The Fibro-vascular System.*

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ascular
undles.

String-like bundles, the fibro-vascular bundles, are common in vascular cryptogams, gymnosperms, and angiosperms, and are familiar in the leaves of plants as the veins. They run in the ground tissue either separately or united, as in many dicotyledons, and in most roots, &c., to form a central or hollow cylindrical vascular mass. When the bundles are separate they often branch and anastomose as in leaves, or they may only anastomose at the nodes of stems. The bundles are easily separable by maceration, except in water plants, and a few others, in which the bundles are very soft; or they may be examined in transverse and longitudinal sections of the part, more particularly in the latter case when the tissues have been rendered transparent by boiling in dilute caustic potash, or by being previously boiled in strong nitric acid. (See Nägeli and Schwendener, *Das Mikroskop*, p. 632.)

Vood
ylem)
id bast
hloem).

Each bundle in its perfect state consists of two groups of cells, the wood or xylem portion, and the bast or phloem. Bundles are either closed or open. In the former the procambium cells, the meristem, from which the permanent tissue of the bundle originates, entirely passes over into permanent tissue; while in the latter the cambium remains between the xylem and phloem, and is capable of forming new cells for an indefinite period. Closed bundles thus rapidly assume a permanent form, while open bundles go on growing. Fibro-vascular bundles are divided by De Bary into four groups by the mode of arrangement of the xylem and phloem. The first and commonest form is the "collateral" bundle, where the xylem and phloem are placed side by side with or without cambium between them, the xylem being always towards the pith or the central part of the stem, the phloem external. In *Cucurbita*, *Solanum*, and others the bundles are "bicollateral," there being an additional phloem portion inside the xylem. "Concentric" bundles occur in many vascular cryptogams, the central xylem being completely surrounded by the phloem. The last form is the "radial," where the bundles of phloem and xylem are arranged alternately in the central fibro-vascular axis, as in most roots. Irregular bundles also occur, and numerous intermediate forms connect the different types.

tructure
f xylem.

In each of the portions of the bundle different kinds of tissue occur; but there is a marked similarity in the construction of the phloem and xylem, at least in separate bundles and before circumferential growth takes place. In the wood, distinguished by the lignified hard brittle walls of the cells, there are four elements usually present:—(1) the wood vessels or cell fusions filled with air, having the transverse walls more or less completely absorbed, and having thickened walls marked with rings, spirals, reticulations, or pits of different kinds; the ends of the cells sometimes are more or less pointed and overlapping, with pitted markings, having, however, a free communication from cell to cell through the absorbed thin part of the pits; (2) tracheides, or vessel-like wood prosenchymatous cells, having walls marked like the vessels, and with the cavity containing air, but never showing any absorption of the end walls and fusion into vessels; (3) wood prosenchyma or libriform fibres, elongated, pointed, and overlapping cells, exactly resembling bast fibres, often with greatly thickened walls, these walls never having spiral or annular markings, but only small simple or occasionally exceedingly minute bordered pits; they are very common in the wood of dicotyledons, and may either be simple or have fine transverse partitions forming chambers in the long cell; (4) wood parenchyma, wood cells with thin walls, and simple pits; these in winter contain starch, and other reserve materials, along with the cells of the medullary rays, and at other times may contain tannin, chlorophyll, or crystals of calcium oxalate. In the bast or phloem portion of the bundle there are three elements only, as there are no cells equivalent to the tracheides. These are—(1) the sieve tubes or bast-vessels, cell-fusions like the wood vessels, but having the transverse portion forming the remarkable sieve plate perforated by the sieve pores, while occasionally such plates or similar markings occur on the side walls: the walls are soft and delicate, giving a cellulose reaction, and the cavity contains abundant protoplasmic contents with excessively minute starch granules; (2) bast prosenchyma or bast vessels, elongated prosenchymatous cells, with pointed and overlapping ends, the walls so thick as almost to obliterate the cavity; the walls are soft and flexible, often marked with fine pits; like the libriform fibres of the wood, they have occasionally the cavity chambered with thin transverse walls, and not unfrequently they branch; (3) bast parenchyma, repeating the wood parenchyma; but occasionally the cells are long and narrow, exactly like those of only slightly modified procambium, which they really are; in this state they are often called cambiform cells. The sieve-tubes and bast parenchyma or cambiform cells form the soft bast. These different elements of the wood and bast are not always present, and the secondary wood and bast developed from cambium are often very different from the primary portions developed from procambium. Thus in *Cucurbita* there are no bast fibres, while in most coniferous woods the tracheides alone are present in the xylem. At the ends of the fibro-vascular bundles in the leaves the different elements gradually disappear until one or two spiral vessels and a few cambiform cells alone remain. In most roots the fibro-vascular bundles form a central mass with the phloem and xylem in separate groups and arranged alternately; the xylem masses generally project into the centre, and the oldest vessels are nearest the centre. The whole mass, which is either a single bundle or a group of bundles, is usually surrounded externally by a peculiar layer, the pericambium, in contact with the endodermis or sheath, the inner layer of the ground tissue, which in roots forms the massive cortical portion.

Structure
of
phloem.

3. *Ground System of Tissues.*

The ground tissue comprises all that remains after the formation of the epidermal and fibro-vascular systems, and is usually composed of parenchymatous cells, not in any way distinguishable except by their position from parenchymatous cells in the other systems. In other cases the ground tissue contains prosenchyma, or the cells in certain regions are more or less thickened. When the part contains closed fibro-vascular bundles, as in monocotyledonous stems and in leaves, the ground tissue forms the chief bulk of the part; but in other cases, as, for instance, in the stems of conifers and dicotyledons, with circumferential growth, the ground tissue is very feebly developed. In such stems the ground tissue forms the pith and cortex, with the primary medullary rays joining the two. In roots with a central fibro-vascular mass, the cortex is the only part of the ground tissue represented. The ground tissue immediately below the epidermis may be simply parenchymatous, or it may exhibit certain modifications. Either the cells form collenchyma, as in many stems and petioles, a tissue consisting of mere elongated cells without intercellular spaces, and having special masses of thickening matter developed on the walls where neighbouring cells meet. These masses readily swell up in water, and probably act as a sort of erectile tissue. In other cases a greater or less development of hypoderma is observed in leaves and stems, the cells being elongated and greatly thickened and sclerenchymatous, resembling in most points the bast-fibres of the fibro-vascular bundles. In some plants, as in ferns, separate, often dark-coloured, bundles of sclerenchyma occur in the ground tissue. These different elements form part of what has been distinguished as the "mechanical" system of tissues, hardened cells giving rigidity to the different parts of the plant, and although such cells occur in very different parts of plants, as in fibro-vascular bundles and in the ground tissue, still they have a marked external resemblance, and are closely related physiologically. Thick, short, sclerenchymatous cells occur in the ground tissue, as in the pulp of the pear; in other cases the parenchyma is unthickened, and contains either colourless contents or develops chlorophyll. The part of the ground tissue next the fibro-vascular bundles forms the sheath or endodermis, a layer of cells often thickened or cuticularized, and surrounding either single bundles or the whole vascular mass or series of fibro-vascular bundles. In some cryptogams the endodermis is strengthened by numerous sclerenchymatous cells surrounding it either partially or completely. The ground tissue of tree *Liliaceæ*, and even in some abnormal dicotyledons, forms a layer of secondary meristem cells capable of developing both new ground tissue and new fibro-vascular bundles; and it is in this way that the secondary circumferential growth in the stems and roots of *Dracæna*, and probably of the fossil vascular cryptogams, took place. The secondary circumferential growth of gymnosperms and dicotyledons is the result of the activity of the cambium ring formed by the fascicular cambium and the interfascicular cambium in the ground tissue, as already described. The changes produced by secondary circumferential growth are very numerous, and are fully described by De Bary (*Vergleichende Anatomie*, chaps. xiv. and xv.).

Ground
tissue.

Collenchyma.

Hypoderma.

Endodermis.

Bibliography.—The chief works to be consulted on the subject of vegetable histology are—Beale, *On the Microscope*; Carpenter, *On the Microscope*; De Bary, *Vergleichende Anatomie* (Hofmeister's *Handbuch der Physiologischen Botanik*, vol. iii.); Dippel, *Das Mikroskop*; Lürssen, *Grundzüge der Botanik* (2d ed.); Nägeli und Schwendener, *Das Mikroskop*; Pelletan, *Le Microscope*; Sachs, *Text-Book of Botany*, or *Lehrbuch der Botanik* (4th ed.); Sachs, *Geschichte der Botanik*; Strasburger, *Ueber Zellbildung und Zelltheilung*; Strasburger, *Die Angiospermen und die Gymnospermen*; Van Heurck, *Le Microscope*. (W. R. M'N.)

HISTORY, in the most correct use of the word, means the prose narrative of past events, as probably true as the fallibility of human testimony will allow. This definition takes no account of chronicles in verse which were not uncommon in the Middle Ages. With this exception the definition is fairly exact, both in what it comprehends and what it excludes. Obviously prose narrative is not history when it deals with fictitious events, as in the case of the novel; and verse narrative, even when it deals with true events (as in the account of the battle of Salamis in the *Persæ* of Æschylus, or Guillaume le Breton's metrical chronicle of the reign of Philip Augustus), is either more or less than history, and in any case a sub-species by itself.

In practice, the line between history and mythus is often not easy to draw; but the theoretical distinction is plain. History reposes, however remotely, on contemporary witness to the fact related. Written records are not absolutely indispensable, as tradition *may* supply their place and represent authentic contemporary testimony. But tradition is very insecure and apt to be equally inventive and oblivious. It is in the half light of tradition that mythus is born of the creative fancy of man, and the difficulty of separating fact from fiction in this border-land of mingled fable and reality very often amounts to impossibility.

But even authentic facts alone are not sufficient to constitute history. Many facts and dates are recorded with reference to China, Egypt, and Assyria in olden times, which in all probability are true; but these facts and dates are not enough to give those countries a history. The bare fact that a certain king reigned in a certain year, and conquered or was defeated in battle with a neighbour, is perhaps chronologically valuable, but it is not history. History only attains its full stature when it not only records but describes in considerable fulness social events and evolution, when it marks change and growth, the movement of society from one phase to another.

The field of history is in consequence very limited, both in time and space, in proportion to the length of human existence and the area of the earth's surface occupied by man. Primitive and savage man has no history, because the struggle for existence consumes all his energies, and he has neither time nor faculty to think of himself as a social being, much less to make record of social events. But even when partially civilized, mankind is often incapable, not only of writing history, but of furnishing the materials of it. Under a system of caste, or conservative theocracy, or oppressive tradition, as in India, Egypt, and China respectively, the social evolution is so slow that it hardly seems to move at all. The grandson lives among conditions hardly differing from those of the grandfather. In such a state of things the very subject-matter of history is wanting. Nothing attracts less notice than immobility, and large populations have often lived under conditions which for whole generations did not seem to vary. The vast and vacant annals of the East show that the arts of peace and war may attain considerable development without history or its materials being produced in consequence.

If these views be correct we can only allow a period of about 4000 years as the limit of genuine history in point of time. The beginning would be with the historical books of the Old Testament. Before the Jewish records fail us the Greek have begun. The Romans follow in immediate succession, and the historical thread has never been broken since, though thicker and stronger in some epochs than in others. As regards area, history long dwelt exclusively on the shores of that inland sea which, if not the birthplace of the human race, have at least been the chief training-ground of its early youth and vigorous manhood. Civilization subsequently spread from the Mediterranean to remote islands and continents unknown to the ancients, and history has followed it. No doubt in time both will be coextensive with the globe; but that time has not yet come. It is still useful to remember that the materials of history now rapidly accumulating in the far West, the far South, and even the far East, owe their origin to that antiquity of which we are the heirs, to the civilization which took its rise in those ever memorable centres named Rome, Athens, and Jerusalem.

Early history is never critical and painstaking in the investigation of facts. Neither the historian nor his readers or hearers have reached a stage of culture in which accuracy is highly valued. Early history is essentially artistic, its object is much more to charm the fancy and warm the emotions than to instruct the understanding. A good story, pathetic or humorous, is appreciated for its own sake independently of its truth. Striking pictures, dramatic situations, often told in dialogue, scenes in which virtue and vice are depicted on a colossal scale—these are the chief objects of the early historical writer, who mingles fact and fiction with the same naiveté as his brethren, the writers of the early epos and drama. Indeed, their subjects are often the same,—the heroes whose prowess saved or achieved the national existence, the odious foreign foe who was beaten back; in either case characters appealing strongly to the imagination and the feelings, which would resent cold criticism, but gladly welcome eloquence and passion. History written under these circumstances has much of the character of the prose poem,—*carmen solutum*, as Quintilian called it. The artistic or imaginative element predominates in it rather to excess. Such is history as written by Herodotus and Froissart. The growth of accurate knowledge in other departments, the increased practice of affairs, the substitution of the political for the heroic and chivalrous sentiment, lead to a more sober and scrutinizing style of history without sacrifice of artistic form. Such is history as written by Thucydides and Tacitus.

Even a most hasty survey of so vast a subject as the historical literature of the world will be helped by its division.

History is of two kinds,—the old or artistic type of history, and the new or sociological type. The artistic type, invented by the Greeks, remained the ideal of history till comparatively recent times. Its aim was perfection of literary form, weight and dignity of language, depth of moral and sagacity of political reflexion. It was habitually careless and indifferent as regards research. But its chief distinction from the new history was a negative one; it had no conception of society as an organism, no suspicion of the depth and variety of the social forces which underlie and originate the visible events which it describes, often with admirable power. The new history is to a great extent characterized by opposite qualities. Its preoccupation about literary form is secondary, moral reflexion it rather avoids, but it is laborious beyond precedent in research, and above all it is pregnant with the notion that society is a great aggregate of forces moving according to laws special to it, and similar to those producing evolution and growth analogous to what we see in other forms of life. The remainder of this article could not perhaps be better employed than by a short examination of these two types of history, including some reference to the causes which brought about a transition from one to the other.

The Greeks were the inventors, and remain the unsurpassed masters, of the artistic form of history. That extraordinary insight into the true conditions of harmony, proportion, and grace which guided them in other departments of literature and art did not forsake them in this. As in the drama a few tentative and experimental essays soon led to the master works of Æschylus, Sophocles, and Aristophanes, so a few precursors were sufficient to direct Herodotus to the main outlines of historical composition. By one of those mysterious accidents, not to be accounted for, which produce genius, Herodotus was closely followed by the greatest mind that ever applied itself to history. Thucydides remains the unsurpassed ideal of artistic history. As the famous statue of Polycletus, called the Doryphorus, represented the proportions of the human body in such complete beauty "that it was regarded by the ancient artists as a canon of the rules on this point," so the history of the Peloponnesian War may serve, as its author seemed to know it would, as a model which all may copy but none may equal. Art, differing from science, allows of something like final perfection. Scientific work, however admirable, is always speedily superseded. Great artistic works remain perfect in their kind, and such was the work of Thucydides. History never deviated from the lines laid down by the Greeks till the advent of the modern school towards the end of the last and the beginning of this century. Between Thucydides and Gibbon there is no change of the ideal plan on which history should be written, though of course there is every degree of success and failure in striving after its realization.

A history of history is a desideratum in literature. The merit of such a work, if properly done, would consist, not only in the criticism of particular authors, but in a comparison of their epochs and social surroundings, and a pointing out how these influenced the character and quality of their historical writing. It is, for instance, worthy of notice that history is far more sensitive and dependent on public freedom than either poetry, science, philosophy, or jurisprudence. All these have flourished under governments more or less despotic, but history never. Tacitus seems to have felt this in the depth of his heart when he said that he was able to write as he did because of the "rara temporum felicitas ubi sentire quæ velis et quæ sentias dicere licet." Again, certain epochs are favourable to great historians, as periods of war are favourable to great soldiers. Rating the genius of the Greek historians as high as we please, and it is difficult to rate it too high, it is still manifest that they enjoyed exceptional advantages. The political condition of the Greek world in the 4th and 5th centuries B.C. was beyond measure stimulating to men of genuine historical power. That extraordinary collection of small states, full of the most active political life, full of wars, alliances, and brusque revolutions, was a scene of interest, of which no subsequent historian has ever seen the like. In this respect the Greek historians had a privilege similar to that enjoyed by the Greek sculptors. As the gymnasia displayed the finest type of manly beauty and strength ever seen, so the fervent energy and activity of the Greek states presented in unparalleled variety and fulness the features of political life most capable of interesting an historical mind. And it is perhaps hardly too much to say that what the palæstra was to Phidias, that the Peloponnesian War was to Thucydides.

Continuing this vein of reflexion, we might remark that it is a noteworthy fact that in history alone the Romans came nearest to their Greek models. Copyists in everything else, and inferior copyists, in history they equalled if they did not excel their masters. It is a moot point with many whether Tacitus should not be placed above Thucydides. In any case that steep inferiority which marked Roman imitation of Greek models in every other department was excepted in the case of history. Why was this so? Obviously because the Romans possessed a robust national life in many respects more lofty and inspiring even than that of the Greeks. The genius of individual men was kindled by the propitious *milieu*. And a disastrous *milieu*, injurious to all productions of the mind, is peculiarly fatal to history. The decay of historical writing in the later period of the declining Roman empire is a sufficient proof. Nothing so debased as the Augustan History can be found in any other province of Latin literature, and when a man of real power like Ammianus Marcellinus appears, if we compare him with Claudian in another department, we perceive that the muse of history is more austere than her sisters. The Middle Ages would offer the historian of history ample scope for connecting the quality of historical writing with the social surroundings of the authors. The great monastic houses, such as Malmesbury, St Albans, Eu, and many more, would be shown to have been such schools of history as they were, for very efficient reasons. The appearance of the modern Herodotus, Froissart, would seem meant expressly to show the union of opportunity and genius needed to produce great historical work. It was no accident which gave us the immortal chronicles. The first instalment of the Hundred Years' War between France and England, the grand but abortive outburst of Parisian democracy under Étienne Marcel, the energetic action of the first serious States-General of France—these were subjects to arrest a real historical eye, such as Froissart had, in spite of his many shortcomings. The dramatic struggle between feudalism and monarchy in the 15th century found a competent if somewhat rustic Tacitus in Comines, more friendly but on the whole not less severe to his bourgeois Tiberius, Louis XI. In the stirring times of the 16th century historians abound—Italians, Frenchmen, Dutchmen—too numerous to mention and too distinguished to be passed over with perfunctory notice here. But how much would an historian of history have to say of Fra Paolo, Davila, De Thou, Grotius, to name only the chief? And then occurs a really surprising phenomenon. History disappears from the continent of Europe for a century and a half. Between the Thirty Years' War and the Seven Years' War the Continent produced no historians whom the world cares to remember, for Mézeray is remembered, though hardly read, on account of his quaint and occasionally graphic style. Yet this was the great age of Louis XIV., the classic age of French literature and philosophy, and the commencement of French science. But history withered under the blight of the Catholic and monarchical reaction. History was indeed being written in France, the most witty, profound, and graphic since the days of Tacitus; but it was history which the author kept for himself and a remote posterity; not for a hundred years was the world to be permitted to gaze with wonder and admiration on the incomparable memoirs of St Simon. But Rebellious and Revolutionary England gives us Clarendon and Burnett—cause and effect as usual. A review of the 18th century and its performances in history would conclude this interesting retrospect. But it is time to return from this digression to our more immediate subject.

The old type of history, one might say, was a species of portrait-painting which had often every merit except that of close likeness to the original. Whether it is quite just to say this will be presently considered. But it cannot be denied that the old writers generally thought more of the brilliancy of their colours and the effectiveness of their pictures than of their exact truth. "My siege is finished," said Vertot, when offered new documents which stultified his narrative. The old masters of history resembled, it is to be feared (if so honourable a comparison can be considered derogatory), the old masters of painting. Both thought little of what we call "local colour," of close conformity to the scene or object delineated, provided they produced striking compositions with grand outline and rich tints which were attractive and beautiful for their own sake. When to this conception of their art we add their general apathy in research, the measure of their sins appears to be filled up in the eyes of a generation like ours, which has brought historical evidence under conditions nearly as stringent as those which regulate the depositions of a court of justice. Still it may occur to some persons that there is another side to this matter, and that the great men of old are not wholly without defence. They were indolent in research no doubt, or rather they did not attach the value that we do to it (if they had, they were not men to have spared their pains), but they were large, sympathetic, and humane. They wrote for a public composed of men of the world and not of specialists. Their manner is somewhat off-hand, but they are neither prigs nor pedants. After all, the most important facts of history, as Auguste Comte has weightily remarked, are the best known and the least dependent on minute rectification for their true appreciation. History has an ethical and psychological side as well as a documentary side supported by elaborate citation of chapter and verse for every statement. Chapter and verse, important as they are, are sometimes a little oppressive and overbearing. The most exhaustive knowledge of authorities will not give a dull man insight into character, or enable him to realize and paint a great historic scene, or teach him to use with skill the mass of erudition under which he staggers. It may be said generally, exceptions of course excepted, that the old historians were strong where their successors are weak, and the converse. Aiming chiefly at portraiture, they succeeded in it, as was only natural. Amid a crowd of errors on smaller matters, they often catch the true expression of a physiognomy, and hit off the salient points of a character with an insight and success which subsequent inquiry is often unable to modify. Bacon's portrait of Henry VII. remains substantially correct, though he wrote his book in four months, remote from the means of knowledge accessible even in his day, which did not represent a tithe of the knowledge accessible now. Even down to the practice of introducing fictitious speeches into their histories, the old writers are not without defence. Nothing more than these speeches has moved the contempt and indignation of modern critics. Macaulay says the practice was absurd, and that if an English writer were to attempt it now he would be laughed to scorn. Yet men of the calibre of Macchiavelli, Grotius, and Bacon resorted to it. It is more a question of form and less of substance than at first glance appears. It amounts to this—How are we to render our impression of a past epoch? We may give it in broad statement, in carefully reasoned argument, supported by apt quotation and appropriate footnotes. This is the modern plan, and, to speak frankly, unquestionably the best. But it is well to listen without impatience to what can be said for the old plan by the other side. Mr Spedding, referring to the speeches which Bacon introduced into his history of Henry VII., says:—"My own opinion is that the reader is less liable to be deceived by history written on this principle than upon the modern plan, though the modern be apparently the more scrupulous. The records of the past are not complete enough to enable the most diligent historian to give a connected narrative in which there shall not be many parts resting on guesses or inferences or unauthenticated rumours. He may guess for himself, or he may report other people's guesses; but guesses there must be. The advantage of the old practice is that the invention appears in the undisguised form of invention; whereas the modern practice, by scrupulously eschewing everything like avowed and deliberate invention, leaves it to be supposed that what remains is all fact, whereas in most cases of the kind the writer is but reporting his own or another man's conjecture, just as much as if he had sat down deliberately to compose a soliloquy or a speech in the first person" (Spedding's *Bacon*, vol vi. p. 76). Every one must be glad to see even plausible reasons suggested for not regarding the funeral oration of Pericles or the speech of Galgacus as "absurdities." Perhaps the truest view of this introduction of speeches into their histories by the ancients and their modern imitators is that it was their mode of offering generalizations. They adopted the concrete and dramatic form when we should use the abstract and impersonal, and perhaps, as Mr Spedding remarks, this practice was not necessarily exposed to more error than ours.

We have now to advert to the causes which led to the transformation of history from the old to the new type.

The inferior quality of history in the 17th century and the first half of the 18th is the more remarkable from the contrast presented by the brilliancy of contemporary literature in other departments. The age of Louis XIV. in France, as already remarked, and the age of Anne in England produced no histories of superior merit. Bossuet's famous discourse on universal history is no exception, being much more an eloquent sermon than a history in the true sense of the word. Written by inferior men from a low point of view, or no point of view at all, history at last sank to such a degree in the public esteem as to be spoken of in a tone of contempt. Dr Johnson openly despised it, and D'Alembert did nearly the same. And yet the time produced great antiquaries—Madox and Rymer in England, D'Achery and Mabillon in France, Maratori in Italy, Leibnitz in Germany. But history had no stamina or muscle. It was also from our point of view blind and utterly stupid: it could not see the plainest facts, and it perverted the facts it did see. Not only the inferior men whose names are barely remembered and whose works are entirely forgotten, the Daniels, the Vellys, the Creviers, the Hooks, the Eckards, but men of such magnitude as Hume and Robertson, Gibbon and Voltaire, often show such an unintelligence as to the past that this unintelligence itself becomes an interesting historical phenomenon, casting no slur on the great writers who displayed it, but deserving consideration for its own sake.

When 18th century writers are arraigned for their defective appreciation of the Middle Ages (the great stumbling-block) and remote periods generally, their critics forget the historical positions of the men they criticize. To write history in the 18th century was something very different from what it had been before, and this in several ways. First of all, the mere lengthening of the historic retrospect had enormously increased the field of historical survey. A writer of the 18th century looked back on nearly as much as we do; he had behind him the recent modern period, the long Middle Age, the barbarian epoch, those of Greece and Rome. And it was honourable to the men of the 18th century that they did not shrink from the task of writing on this immense expanse of history, imperfectly as they were prepared for it. It seems to be sometimes forgotten that most of the historical writing of the ancients, and a good part of that of the moderns up to the 18th century, had been the writing of contemporary history, or history of a quite recent past. This is true of Herodotus (when he is not merely a traveller telling travellers' stories), of Thucydides, of Polybius, of Sallust, of Tacitus, of Guicciardini, of Fra Paolo, of Davila, of Grotius, of Clarendon. Contemporaneous history may bring out some of the highest qualities of an historian—perspicacity, weightiness of judgment and language, skill in narrative, and so forth. But one quality it does not need and cannot display, insight into a remote age differing in culture, politics, and religion from those amid which the historian lives. Yet it was precisely the history of remote ages which the writers of the 18th century boldly undertook to treat. That they often failed is not surprising. It would have been a miracle if they had succeeded.

We are now so imbued with the notions of growth and development in all forms that we find no difficulty in applying them to society as well as other phenomena. But these notions were all but entirely wanting in the 18th century; indeed, they did not fully emerge till the 19th had run a good portion of its course. It was difficult for all true sons of the 18th century to conceive of men or of societies different from the men and the societies they saw around them. Or if they were forced to admit that men could exist under conditions widely differing from those in which they themselves lived, they unhesitatingly pronounced them barbarians, unpolished, hardly worthy of attention. They consequently speak of past ages habitually in a tone of supercilious contempt which is to us highly amusing. Men who differed in every other opinion agreed in this. "The Athenians of the age of Demosthenes were a people of brutes, a barbarous people," said Dr Johnson; and Voltaire was quite of his way of thinking on this point (*Dict. Philosophique*, art. "Anciens et Modernes"). With such views or rather feelings it was impossible to understand the past; they did not even wish to do so. They mostly regarded their own age as the only one worthy of respect and admiration, the only one in which "polite manners" had existed. The past to them was mainly a record of crime, ignorance, folly, and fanaticism (notice the way in which the sober Robertson speaks of the crusades); and they did not even wish to see it as it really was. It is obvious that such men could not write history as we understand it. The moral prejudices of the age shut out a true view of past times. Indeed they preferred a distorted view, if it represented better their notions of the seemly and the noble. They had always a tendency to dress up the past in the garb of the present. The French writers surpassed the English in this foible. For them the only ideal of a king is Louis XIV., and all kings must be made to resemble him more or less, though of course they were not so great. This disposition reaches its acme of absurdity in Scipion Dupleix, historiographer of France, who died in 1661. Describing the baptism of Clovis, he represents the barbarian Frank as approaching St Remi, "with lofty port and grave demeanour, richly dressed, scented, and powdered, with long wig carefully curled and perfumed according to the custom of the ancient French kings." More serious is the profound misapprehension of every great character and great period which differed from the current pattern. The unworthy interpretation of all political and religious phenomena with which the writers were unfamiliar, by sagacious references to state and priestcraft, is also apt at times to appear to us wilfully perverse, and even disingenuous. We may be sure it was nothing of the kind, and only resulted from the inadequate degree of culture then attained.

But the historians in question were hindered not only by prejudice which they could not avoid from understanding the past; they were also hindered by a want of knowledge which it was impossible for them to have. To say nothing of the larger conceptions of society which we have only recently acquired, they were unfurnished with those preparatory means of accurately observing the past which were soon to be discovered. The science of economics, as we shall presently see, was about to throw a broad and vivid light on many hitherto obscure problems of history. But the writers in question did not yet enjoy the benefit of it, and surely the fault was none of theirs. When we see a man of the genius and erudition of Montesquieu (*Grandeur et Décadence des Romains*, c. 17) gravely ascribing the decline of old Rome to the fact that all the gold and silver after the division of the empire were carried to Constantinople, we realize the value of true conceptions relative to the wealth of nations. But in Montesquieu's time the precious metals were regarded as the sole or chief sources of wealth, and he applied without hesitation to history a principle which he saw statesmen apply without hesitation to politics. Again, Gibbon, writing on the same subject, the decline and fall of Rome, considers the real cause to have been the reluctance of the soldiers to wear defensive armour. It seems hardly credible, but here are his words:—"They (the soldiers) complained of the weight of their armour, which they seldom wore; and they successively obtained permission to lay aside both their cuirasses and their helmets. The heavy weapons of their ancestors dropped from their feeble hands, and their pusillanimous indolence may be considered the immediate cause of the downfall of the empire" (chap. 27). Montesquieu and Gibbon were men of an historical genius second to none. Yet they could descend to such trivialities, and the reason was that the true sources of national wealth and military strength had not been laid open in their day. It would be easy to multiply examples of a similar kind, taken from the ablest writers, in which the most superficial explanation of wide-reaching events is hastily caught at, as if one were to explain an earthquake by a scratching of the earth's surface. In fact the old writers might be likened to surveyors as contrasted with geologists. They have little or no conception of the forces at work under the surface they see.

But a change was near—a change in feeling and a change in knowledge. That singular modulation of key in the moral life of Europe, often called, for want of a better term, the Romantic movement, which arrested and surprised the attention of the latter half of the 18th century, was felt in relation to history as well as to philosophy, politics, and religion. Whether represented by the fierce rebellion of Rousseau in France, or a milder literary reform in England and Germany, it essentially consisted in a weariness of and disenchantment with the present and the recent past, in a vague feeling after ideas and emotions outside the conventional circle in which men had been contented to live for several generations. The tastes and the tempers of men changed with a strange rapidity. The 18th century philosophy, as it is called, lately so high and apparently secure, was cast out with contumely. The recent idols—Locke, Hume, Voltaire, Diderot—were smitten down, and others needless to name were put in their place. The whole movement is now seen to have been retrograde, and finally abortive, though temporarily successful. But it had its *raison d'être* and even its uses, as all social phenomena have. Among its uses was the service it rendered to history. As it was a first principle with the Romantics to burn what their predecessors had worshipped and the converse, the past which had been recently an object of contempt was put in the place of honour. Especially the Middle Age, so unjustly despised, seemed to rise out of its grave as a lovely vision full of knights and chivalry, troubadour song, and Gothic architecture, the latter just beginning to be appreciated. Where men had only recently seen barbarism, superstition, and ignorance, they and their sons saw an enchanted land of beauty, piety, and grace. Then came Sir Walter Scott, who turned a current already flowing fast into a headlong torrent. The Middle Age was studied eagerly, sympathetically, perhaps a little too much so; zeal never is according to knowledge. But the bringing of the Middle Age into the circle of serious historic study had an influence beyond its immediate object. When men had brought themselves to study and understand 11th century popes and emperors, monasticism, feudalism, scholasticism, they became bold and capable of further adventures in historical enterprise. After the heroic ages of Christendom, the heroic ages of Greece were opened to explorers. And soon all exclusiveness disappeared. The whole past history of man was felt to be worthy of man's study,—a wide field into which many labourers entered. So much for the change in feeling.

No less a change had taken place in the condition of knowledge. Speculation had for a long time been feeling its way to a closer contact with the problems suggested by the growing wealth and industry of the modern world. Adam Smith in his memorable work resumed, co-ordinated, and enlarged the labours of his numerous predecessors, and placed the study of economics on a new and positive basis. But the suggestive stimulus of his researches spread beyond the limits of the science with which he was immediately concerned. The indirect services rendered by political economy to history have not perhaps been adequately recognized. The elucidation of the sources of wealth in the present became a means of explaining the prosperity and decay of states in the past, which soon led to valuable results, the more striking as they were unexpected. Hitherto wealth had been thought a source rather of degeneracy than of improvement. The great danger was always understood to be "luxury." Poverty was the parent of virtue. Primitive times were virtuous because they were poor. Pagan philosophers and Christian saints had agreed in condemning riches as the source of all evil, and denying the rich man a high place in their ideal republic or the city of God. Political economy cleared up the confusion of thought here implied. The wealth of states has nothing to do with the excessive opulence of a small class. Never has the mass of the people in any country or in any age suffered from an overabundance of wealth. The excessive wealth of the few generally means the poverty of the many. In short, the evil lies in the great inequality of the distribution of wealth. These common-places of economics would have been paradoxes in the early part of the 18th century, and the historians of that age show a profound ignorance of their bearing, as was only natural. So, when they have to explain the decay of a state they seek to show that it had lost its gold and silver, or that luxury had made fearful inroads, or that martial valour had somehow strangely declined. The notion that poverty in the mass of the people was very often the chief and sometimes the only cause did not occur to them. When therefore Adam Smith devoted the third book of the *Wealth of Nations* to "the different Progress of Opulence in different Nations," it seemed as if a lamp had suddenly been lit in a dark place. That book was in truth a lofty historical review of the facts of the past, guided by the principles of economic science. The question which has already come before us, and which exercised so much, as well it might, the thinkers of that age, the decline of Rome, was approached in a much more promising manner when one element of it, the decay of agriculture in Italy, was spoken of thus:—"Tillage in that part of ancient Italy which lay in the neighbourhood of Rome must have been very much discouraged by the distributions of corn which were frequently made to the people, either gratuitously or at a very low price. This corn was brought from the conquered provinces, of which several, instead of taxes, were obliged to furnish a tenth part of their produce at a stated price. The low price at which this corn was distributed to the people must necessarily have sunk the price of what could be brought to the Roman market from Latium or the ancient territory of Rome, and must have discouraged its cultivation in that country." This was catching a glimpse of a *vera causa* of the effect to be explained, and the vein of thought thus opened proved to be richer the further it was explored.

Both the moral and the intellectual tendencies at work to produce a new temper with regard to history received an incalculable impetus from the French Revolution. That cataclysm revealed the deeper forces of society which had lain silent and unsuspected under the deceitful calm of the *ancien régime* in its latter days. It was very certainly a revelation, though light came from the flames of Tophet, in Mr Carlyle's phrase. Men saw the depth of the abyss over which they had lived in quiet ignorance, and their notions on man, society, and history underwent a great change. Passions undreamed of were let loose, and the passions of the present threw light on those of the past. History was read with new eyes. "Whenever," says a man who lived through the tempest and profited as much as any one by it,—"Whenever," says Niebuhr, "an historian is reviving past times, his interest in them and sympathy with them will be the deeper the greater the events he has witnessed with a bleeding or rejoicing heart" (Preface to *Hist. of Rome*). Few generations have seen events which alternately made men's hearts bleed and rejoice more passionately than Niebuhr's own, and none have ever stimulated history so much. With the peace of 1815 historical studies acquired an activity and scope they never had before. All history, it was perceived, needed rewriting from new points of view, with more knowledge, deeper insight, keener sympathy. The French led the van of the new movement with their usual brilliancy and mastery of literary form. But it was their position as the nearest witnesses and the greatest sufferers and gainers by the Revolution which did most to open their eyes. A truly illustrious band of scholars and writers under the Restoration, the Monarchy of July, raised history into a position of honour it had never enjoyed before. Michaud, the two Thierrys, Sismondi, Guizot, De Barante, Michelet, and many more rendered services to history which must not be forgotten because on many points their labours have been superseded. It is indeed a capital proof of the merit of their labours that they furnished the means and the incentive to their supersession, a proof that their studies were vital and progressive. The Germans, with their solid erudition, were not slow in following the French. Between the two, the Middle Ages, Greek and Roman antiquity, and the history of the Christian Church were studied with a minuteness and breadth never known before. History had entered on its modern phase.

This is not the place to dwell in detail on the achievements of the modern school of historians. The whole field of history has been explored afresh with such superior insight, knowledge, and just conception of the task in hand that all historical writings anterior in date to the end of the 18th century are entirely superseded, with the single exception perhaps of Gibbon, who alone, as Mr Freeman says, has not been set aside by subsequent research. Ancient history, chiefly in consequence of the extraordinary zeal and diligence of the Germans in what they call the science of antiquity (Alterthumswissenschaft), has become a reality, vivid in interest, and fruitful in knowledge, instead of the nebulous unreality it had been before. The rejection of the fabulous elements in the histories of Greece and Rome was the first step, but a long one, which it required many years and much effort to make. The next was to obtain a firm grasp of the idea that the Greeks and Romans were living men, and not statues like the Elgin Marbles, and to look at their politics, institutions, and religions with the discriminating eye of common sense, and a real wish to see them as they were. The true nature of Athenian democracy, of the Spartan oligarchy, of the commons and patricians of Rome, of the party struggles which caused and justified the transition from the republic to the empire, has been put in a clear light, which can hardly be appreciated by those who are not aware of the darkness which it replaced. Points of view and lines of inquiry concerning the religion, government, institutions, taxation, and law of the ancient states have been opened up, of which the possibility in the old days was not suspected. The sociological knowledge of the present has illumined the past, an interesting example of which is afforded by the *rapprochement* between the English dominion in India and the Roman provincial administration.

The history of the Middle Age shows even greater results, and greater innovation, to which allusion has been already made. The great difficulty was the papacy. Between the Catholics, who regarded it as of divine institution, and the Protestants, who regarded it as a manifestation of Antichrist, and the sceptics, who despised both and regarded it as mere superstition, this great centre around which the life of the Middle Ages revolved had been unknown or misknown to a degree of absurdity. Gradually, as the 19th century arose wiser and sadder out of the chaos of the French Revolution, the immense part played by the church was at first dimly suspected, and at last with increasing clearness perceived. This must on every account be regarded as the greatest achievement of the modern school; it implied the unlearning of so many old errors, the acquiring of so many new truths, above all, the repression of so many deeply-rooted prejudices. It restored the continuity of history, in which the Middle Ages had hitherto appeared as an unexplained gap,—an unwelcome wedge of barbarism thrust between the ancient and modern civilizations.

After the Middle Ages, the period which has been most illumined by the new lamp of history is that of the early church and the whole subject of religious dogma and institutions. In spite of the fierce controversies which have raged over this region, a large residuum of undisputed fact has been rescued from ignorance and prejudice, and church history is no longer a legend, but one of the most interesting chapters in the annals of the human mind.

As regards modern history, we are oppressed and nearly overwhelmed with the mass of new materials and new discoveries which have been launched upon us. The diligent publication of state papers and documents, which all civilized states have taken in hand, has exceeded in the last half century all that had been done before in that direction. The result is that there are few periods of modern history which are not far better known to us than they were to the contemporaries who lived in them. But history in this field cannot boast of such laurels as she has won in the field of antiquity and the Middle Ages. There has been no great reversal of old points of view, no great triumph of historical perspicacity piercing through traditional error down to latent truth. Modern history has won its victories more by weight of metal than by the skill of its commanders, not that the generals have lacked skill, but they have had less occasion to display it.

The history of institutions has received much attention in recent times, and promises to be one of the most fruitful veins of inquiry yet opened, and this in reference both to primitive institutions, which are rather prehistorical than historical, and the constitutions of states which have reached adult political life. The old Aryan tenure of land and village communities, and ancient law, whether in old Rome or modern Bengal, have been the subjects of elaborate investigation, embodied in works which mark a new departure in knowledge. The institutional history of political states is at the present moment perhaps the subject which attracts the most lively attention of scholars. It is not confined to the constitutional history of England, though England, as the mother of parliaments, has a fair claim to priority of interest. But the subject is narrowed and degraded by contemplating it from the point of view of modern politics, and chiefly in reference to the popular freedom or national wellbeing produced. The earnest historical inquirer is as impartial as the pathologist who studies disease equally with health. The institutions of despotism have their *raison d'être* and normal evolution as well as those of free governments, and the scientific historian will neglect the one as little as the other. In any case the history of the institutions of Europe from the times of the Frankish empire to the end of the French monarchy offers the widest field for courageous historical research. It has absorbed and transcended all those inquiries which used to be included under the somewhat jejune title of the history of civilization. Institutions in the secular order, and religions in the spiritual order, are now seen to be the most massive and permanent factors in human life, capable indeed of evolution and change, but little susceptible to the immediate action of man's intelligence and will, and yielding only to the new modifications brought about by time and the gradual transformation of ideas and moral conceptions, the result of increased knowledge.

It is hardly necessary to add that a broad distinction must be made between history and what has been called the philosophy of history, a term now replaced by the far better one "sociology," invented by A. Comte. Sociology has the purely scientific aim of investigating the nature and constitution of societies, to discover the laws which regulate their growth and decay, to do in short for them what biology has already done for the animal and vegetable kingdoms. History, while it can never again dispense with the assistance of sociology, remains occupied with the description of the social organism (at a given period) in its *ensemble*, and the term "descriptive sociology" has been suggested as an improvement on the old one, history. We may question whether the innovation will be accepted or is needed. The human interest attaching to the story of man's past fortunes will always provoke the means of its own satisfaction, and there is little doubt that history, the name and the thing, as the highest form of prose literature, will continue to instruct and console mankind to the remotest generations. (J. C. MO.)

HIT, the ancient *Is* (see EUPHRATES, vol. vii. p. 670), a town of Asiatic Turkey, vilayet of Baghdad, is situated on the west bank of the Euphrates, 70 miles W.N.W. of Baghdad. Its streets are narrow and frequently steep, rising one above another along the side of a hill, and the houses, which are flat-roofed, and one or two stories in height, are built chiefly of clay. It contains a graceful minaret and some richly decorated tomb-towers. The prosperity of the town depends upon its fountain of bitumen, which has flowed from time immemorial, and, according to Herodotus, supplied that material for the building of Babylon. The inhabitants make use of the bitumen for lime burning, and also for covering boats. From water which bubbles up in the centre of the spring salt is manufactured. The population is about 3000.

HITCHCOCK, EDWARD (1793-1864), an American geologist, was born of poor parents at Deerfield, Massachusetts, May 24, 1793. He owed his education chiefly to his own exertions, and was preparing himself to enter Harvard College when he was compelled to interrupt his studies from a weakness in his eyesight. In 1815 he became principal of the academy of his native town; but he resigned this office in 1818 in order to study for the ministry. Having been ordained in 1821 pastor of the Congregational church of Conway, Massachusetts, he employed his hours of leisure in making a scientific survey of the western counties of the State. In 1825 he resigned his charge in order to become professor of chemistry and natural history in the newly-founded Amherst College, an institution which owed its early success, if not its continued existence, to his energetic efforts, both in rescuing it from financial difficulties, and in increasing its literary and scientific efficiency. More especially did he render to it invaluable service during the period when he was president, from 1845 to 1854. In 1830 he was appointed State geologist of Massachusetts, and in 1836 to the same office in connexion with the first district of the State of New York. On resigning the presidentship of Amherst College, he was induced to retain his professorship. In 1836 he received the degree of LL.D. from Harvard, and in 1846 that of D.D. from Middlebury College. Besides his constant labours in geology, zoology, and botany, Hitchcock took an active interest in agriculture, and in 1850 he was sent by the Massachusetts legislature to examine into the methods of the agricultural schools of Europe. In geology his most important achievement was the examination and exposition of the fossil footprints of the Connecticut valley. The collection which he accumulated in connexion with his investigations is contained in the Hitchcock Ichnological Museum of Amherst College, and a description of it was published in 1858 in his report to the Massachusetts legislature on the ichnology of New England. As a writer on geological science, Hitchcock was mainly concerned in determining the connexion between it and religion, and employing its results to explain and support what he regarded as the truths of revelation. He died at Amherst, February 27, 1864.

The following are his principal works:—*Geology of the Connecticut Valley*, 1823; *Catalogue of Plants within twenty miles of Amherst*, 1829; *Dyspepsia Forestalled and Resisted*, 1830; *Reports on the Geology of Massachusetts*, 1832, 1835, 1838, and 1841; *A Wreath for the Tomb*, 1839; *Fossil Footsteps in the United States*, 1848; *Outlines of Geology*, 1855; *Illustrations of Surface Geology*, 1856; *Ichnology of New England*, 1858; *Religious Lectures on the Peculiar Phenomena of the Four Seasons*, 1850; *History of a Zoological Temperance Convention in Central Africa*, 1850; *The Religion of Geology and its Connected Sciences*, 1851; *Religious Truths illustrated from Science*, 1857: *Reminiscences of Amherst College*, 1863; and various papers in the *Biblical Repository*, the *Bibliotheca Sacra*, the *American Journal of Science*, and other periodicals.

HITCHIN, a market-town of Hertfordshire, England, is situated on the small river Hiz, 34 miles from London, on the Great Northern Railway. It is for the most part neatly built of brick, and the streets are generally spacious. The principal buildings are the parish church in the later style of English architecture, with a fine porch, an Adoration of the Magi by Rubens, a small crypt said to have been used by Cromwell as a prison for the Royalists, and many interesting monuments; Hitchin Priory, the residence of the Radcliffe family; various chapels, schools, and banks; the infirmary, the workhouse, the town-hall, and the corn exchange. Malting and straw-plaiting are extensively carried on. There are also breweries and manufactories of agricultural implements. The population of the local board district in 1871 was 7630, and of the parish 8850.

Hitchin occurs in Domesday Book under the name of Hiz, a modification of the Saxon Hiece or Hitche, which appears more prominently in the present form of the name. During the Saxon heptarchy it formed part of the royal demesne of the king of Mercia. It was bestowed by Edward the Confessor upon Harold, and after the battle of Hastings it was retained by William the Conqueror. By William Rufus it was granted to Bernard de Baliol, and on the accession of John Baliol to the throne of Scotland it reverted to the crown of England, after which it was bestowed by Edward III. on his fifth son, Edmund de Langley.

HITTITES, a warlike and powerful nation, whose centre lay in the far north of Syria, between the Orontes and the Euphrates, but whose outposts about 1200 B.C. extended as far to the west as the Ægean sea. In the Egyptian inscriptions they are called the Khita or Kheta; in the Assyrian, the Khatti; in the Hebrew Scriptures, the Khittim. Some confusion has been caused in the treatment of the history of the Hittites by the uncritical use of the Old Testament. It is true that the Khittim or Hittites are repeatedly mentioned among the tribes which inhabited Canaan before the Israelites (Gen. xv. 20; Ex. iii. 8, 17, xiii. 5, xxiii. 23, 28, xxxiii. 2, xxxiv. 11; Num. xiii. 29; Deut. vii. 1, xx. 17; Josh. iii. 10, ix. 1, xi. 3, xii. 8, xxiv. 11; Judg. iii. 5; 1 Kings ix. 20; 2 Chr. viii. 7; Ezra ix. 1; Neh. ix. 8), but the lists of these pre-Israelitish populations cannot be taken as strictly historical documents. Not to dwell on the cases of the Perizzites (properly speaking, an appellative and not an ethnic name), and the Kenites and other Arab races, sometimes included, but evidently by an anachronism (see vol. iv. p. 763), it is obvious that narratives written, or (as all will agree) edited, so long after the events referred to cannot be taken as of equal authority with Egyptian and Assyrian inscriptions. How meagre the tradition respecting the Hittites was in the time of the great Elohistic narrator is shown by the picture of Hittite life in Gen. xxiii. As Ewald remarks, "Abraham's allies in war are Amorites; but when he desires to obtain a possession peaceably he turns to the Hittites." Yet the undoubtedly authentic inscriptions of Egypt and Assyria reveal the Hittites in far different guise, as pre-eminently a warlike, conquering race. Not less unfavourable to the accuracy of the Old Testament references to the Hittites is the evidence deducible from proper names. As we shall see presently, the Hittite names preserved in Egyptian and Assyrian records are on the whole strikingly un-Semitic. The three Hittite names given in the Old Testament (Ephron, Gen. xxiii. 8, 10; Ahimelech, 1 Sam. xxvi. 6; Uriah, 2 Sam. xi. 3, xxiii. 39) are, however, of undeniably Semitic origin. Is it unnatural to infer that these three names are no less fictitious than the Semitic names ascribed in the Old Testament to the non-Semitic Philistines? It is not surprising that at least two eminent Egyptologists (Chabas, Ebers) should absolutely deny the identity of the Khita and the Khittim. This, however, seems to be going too far. The Old Testament writers clearly meant by the latter name the same people as the Egyptian inscriptions by the former, but in their time the memory of the Khita had grown so dim that they could include it among other shadowy names of conquered Canaanitish peoples. No impartial scholar, indeed, will deny that a branch of the Khita may once have existed in Palestine. Unfortunately there is no historical evidence that it did so. In fact, the most trustworthy notices in the Old Testament itself point to the Hittites as a nation beyond the borders of the land of Israel. In 2 Kings vii. 6 we find "the kings of the Hittites" mentioned side by side with "the kings of the Egyptians;" in 1 Kings x. 29 the same phrase occurs parallel with "the kings of Aram"; and in 2 Sam. xxiv. 6 we should probably read, "and they came to Gilead, and to the land of the Hittites unto Kadesh." The position of Heth in the table of nations (Gen. x. 15) may also be regarded as a vestige of an accurate geographical tradition.

If then we continue to employ the familiar name Hittites instead of the Egyptian Khita and the Assyrian Khatti, let it be understood that by this term we do not indicate one of the Canaanitish peoples conquered by the Israelites, but an extra-Palestinian race capable of holding its own even against Egypt and Assyria. Its centre lay, as we have seen already, and as is admitted on all hands, between the Euphrates and the Orontes. This was in fact the region which—one fears to say for how many centuries—was designated in the Assyrian inscriptions *mat Khatti* or Khatti-land. Under the name of Khatti we already meet with the Hittites in the astronomical work in seventy tablets drawn up by Sargina, king of Agane, in the 16th century B.C. It appears from this venerable document that hostilities were constantly arising between Babylonia on the one hand and the Hittite country on the other (Sayce's translation of the tablets, *Transactions of Soc. of*

Biblical Archæology, iii. 245). Among the Assyrian kings it is Tiglath Pileser I. who makes the first mention of the Khatti; in his time they are already the lords paramount of the region between the Euphrates and Lebanon. Sargon, the most enterprising of the Assyrian monarchs, was impatient of such an obstacle to his victorious arms. By the conquest of Carchemish and Kummuch, Khatti-land lost its two great bulwarks on the east, and was open henceforth to the Assyrian hosts. The last reference to the Khatti is in the time of Esar-haddon, who speaks of "twenty-two kings of the land of Khatti, which is by the sea and in the midst of the sea." But it has been shown by Schrader that from the time of Sennacherib onwards the name Khatti was transferred to the western maritime lands in general, viz., Canaan and Philistia, including Edom, Moab, and Ammon (*Keilinschriften und Geschichtsforschung*, pp. 234–5).

Turning now to the hieroglyphic monuments, we find the Khita playing a still more important part in the history of Egypt,—first of all, under Thothmes III. One of his generals has left us an account of his personal experiences in the campaign against the Khita (Brugsch, *History of Egypt*, i. 354), and in the Statistical Tablet of Karnak we have a record of the tribute brought from "the great land of the [Khita]" (*ibid.*, p. 334, comp. *Records of the Past*, ii. 25). At this period, however, the Khita were but one among a number of peoples; in the wars of Seti I. and (especially) Ramses II., they occupy the first rank among the adversaries of Egypt. The account of the battle of Kadesh (the island city on the Orontes), given by the Theban poet Pentaur, presents a vivid picture of the military prowess of this rising power (comp. Brugsch's translation with that of Lushington in *Records of the Past*, ii. 65–78). Ramses was indeed victorious, but he owed his life and consequently his victory to his personal bravery, and, as Pentaur represents it, to his childlike faith in his god. On an outer wall of the temple of Karnak the treaty of peace between Egypt and Khita-land may still be read (comp. Brugsch's translation with that of Goodwin in *Records of the Past*, iv. 25–32), and the same fruitful source of primitive history has furnished inscriptions of Ramses, with the names of conquered towns of the Khita, corresponding with those already recorded by Thothmes III. Thus the long feud between Egypt and Khita was closed, and the happy result was celebrated by the marriage of the Pharaoh to a daughter of the king of his chivalrous antagonists. The name of the Khita almost disappears henceforth from Egyptian history. M. Lenormant indeed (*Ancient History of the East*, i. 268) mentions them as assailing Ramses III., but Dr Birch (*Egypt*, p. 139) and Brugsch Bey more accurately describe the war referred to as one between Ramses and the conquerors of the Khita, viz., the confederated "Carian-Colchian nations" (see Brugsch Bey, *History of Egypt*, ii. 147).

We have spoken of the Hittites as we know them from the monuments, as a people of Syria. But the extra-monumental history of the Hittites, which is only beginning to be divined from scattered indications, shows that their power was not limited to the area between the Euphrates and the Orontes. Not only had they their confederates or vassals in their near or more distant neighbourhood, but they also (as it seems) despatched conquering hosts into the far-off regions of Asia Minor. Even the Egyptian records have been thought to indicate this fact. At that great battle of Kadesh on the Orontes to which we have already referred, there were present, besides the princes of Khita, the kings of Arathu, Khilibu, Naharain, Qazanadana, Malunna, Pidasa, Leka, the Dardani or Dandani, the Masu, Kerkesh or Keshkesh, Kairkamasha (so Lushington; Brugsch, somewhat arbitrarily perhaps, Quirqimosh), Aherith, Anangas, Mushanath,—a mighty host "gathered" (as the poet Pentaur tells us) "from the margin of the sea to the land of Khita." The late M. de Rougé, a coryphæus in Egyptology, actually supposed that this list included the Dardani of Asia Minor, the Mysians, Ilion, and perhaps the Lycians; Brugsch Bey, however, who is now a greater authority, is satisfied to identify the Dardani with those of Kurdistan (comp. Herod., i. 189), the Leka with the Ligyes (comp. Herod., vii. 72), and the Masu with the people of Mount Masius. But putting M. de Rougé's opinion aside, it seems to be evident from other sources that the influence of the Khita extended even into Asia Minor. Prof. E. Curtius has already pointed out "that one of the paths by which the art and civilization of Babylonia and Assyria made its way to Greece was along the great high road which runs across Asia Minor," and Professor Tiele has been struck by the presence in the religions of Asia Minor of an unexplained element which with all reserve he conjectures may be Hittite. Professor Sayce has added an important contribution to the question by showing that the Hittite capital Carchemish (rightly identified by Mr George Smith with the modern Jerablûs) was the source from which that modified type of Assyrian art was derived, which specially characterizes the early monuments of Asia Minor. "The sculpture accompanied by inscriptions in Hittite (or Hamathite) characters which Mr Davis discovered at Ibreez in Lycaonia (*Transactions of Soc. of Bibl. Archæology*, iv. 2) proves that the Hittites had penetrated through the eastern barrier of Asia Minor formed by the Taurus range; and the two or three characters that still remain in the rock-cut inscription engraved in his *Life in Asiatic Turkey* (p. 222), and found near Bulgar Maden, make it clear that Hittite power had once extended at least as far as the central plateau of Asia Minor." Evidence has now been supplied of the extension of Hittite power to the very shores of the Ægean in the occurrence of Hittite hieroglyphics (the same which occur at Jerablûs or Carchemish) on the pseudo-Sesostris (a fellow to which has, however, been pointed out) at Ninfi, the ancient Nymphæum, on the road from Smyrna to Sardes (Letter of Professor Sayce, in *Academy*, Aug. 16, 1879). In a subsequent letter, Professor Sayce remarks that there were two roads open to the Hittites, and both, to judge by the scattered monuments already found, appear to have been travelled by their armies. The one was that taken by Crœsus on his march against Cyrus; its course was through Pessinus, Ancyra, and Pterium. The other was that traversed by Xenophon and the Ten Thousand; this road passed through the Cilician Gates by Iconium. Both roads met in Sardes.

Was this enterprising race a member of the Semitic family? Let us consider—

(1.) *The evidence supplied by the pictorial representations on the ancient monuments.*—"If it is allowable to form a judgment on the origin of this cultivated and powerful people from its outward bearing and appearance, it seems to us, under the guidance of the monuments, to be at least very doubtful whether we should reckon this chivalrous race among the Canaanites" (who, see art. CANAANITES, were probably in the main Semitic). "Beardless, armed in a different manner, fighting three men on each chariot of war [the Egyptian chariots only carry two], arranged in their order of battle according to a well considered plan previously laid down, the Khita present a striking contrast to their Canaanite allies." Such is the verdict of Brugsch and of all who have seen the wonderful wall-sculptures in the great temple of Abusimbel. No modern artist is more careful to represent distinctive racial features than this primitive sculptor. Even at such a distance from this national centre as Ninfi (see above), Professor Sayce maintains that no one who has once seen a Hittite figure can mistake the resemblance. The peaked tiara and the turned-up shoes are the peculiar marks of the Hittite, and of the Hittite alone.

(2.) *The evidence from language.*—Our knowledge of the Hittite language is confined to the proper names mentioned in the Egyptian and Assyrian inscriptions—those which occur in the Hebrew Bible being, as we have seen, of insufficient authority. Opinions differ as to the character of the names derived from hieroglyphic sources. M. de Rougé was strongly convinced of their Semitic origin, but his explanations are for the most part adventurous, and Brugsch Bey's verdict seems philologically much more sound, "that these names do not bear a Semitic, or at any rate not a pure Semitic stamp." The names of persons are the following, as represented by M. de Rougé:—Khetasar, Maursar, Kanisar, Taurteribu, Aktasib, Net'era, Tot'as, Rabasunana, Tarakaunasa, Mait'arima, Kamaiut'a, Taatur, Sapalel, Samarisa, Painsa, Akama, Tuher, Kirabsar. To these may be added the following from the list of nations of Thothmes III.:—Pirkheta, Ai, Anau, Thuka, Thel-manna, Legaba, Tunipa, Ni, Ar, Zizal, Zakal, Arzakana (Brugsch, *History of Egypt*, ii. 5). No less un-Semitic for the most part are the names of Hittite persons and places which occur on the Assyrian monument. The following is a list of the kings of Khatti-land given by Shalmaneser II. on the monolith inscription: "Sangar of Carchemish, Kundaspi of Kummuch, Arami, son of Gusi, Lalli of Lallid, Chayan, son of Gabar, Girparud of Patin, Girparud of Gamgum" (lines 82, 83), to which should be added "Sapalulmi of Patin" (lines 42, 43), which so strongly reminds one of the name of the king of Khita, Sapalili, mentioned in the treaty between Ramses II. and the Khita. The un-Semitic character of this group of names is the more remarkable, because (as Professor Sayce remarks) Assyrian, being itself a Semitic language, could not help representing foreign Semitic names in a form recognizable as Semitic. How obviously Semitic, for instance, are the names of the kings of Hamath and Damascus, handed down to us in the Assyrian inscriptions! True, one of the above names of Hittite places, Carchemish ("fortress of Chemosh"), has a Semitic air, and the same may be said of Kadesh, the scene of the victory of Ramses II. But (1) it is not quite certain that Carchemish is Semitic (the Assyrians generally reproduce it under the form Gargamis, though sometimes Kargamis), and (2) even if it is Semitic, this may arise from the towns having been occupied by Semites prior to the Hittites. As for Kadesh (in the Egyptian inscriptions, Ketesh), though under the jurisdiction of the Khita, it was reckoned as a Canaanitish or more strictly an Amoritish town (Birch, *Egypt*, p. 116), while Orontes (in Egyptian, Arunata) has not even a Semitic appearance. It is true, again, that several of the Hittite proper names are compounded with *sar—e.g.*, Khita-sar (the king who warred against Ramses II.), and that *sar* is evidently the Assyrian for "king" (also Hebrew for "prince"). But *sar* is also found in Egyptian inscriptions; it is in fact of Accadian (non-Semitic) origin, and was therefore borrowed by the Assyrians, before the Hittites and the Egyptians adopted it from them. The form of names like Kheta-sar (see list above) favours the view that the Hittite language was agglutinative, and consequently non-Semitic.

But this and all other aspects of Hittite culture will appear in a new light when the explorations have made further progress. At present we can only say that the probability is that the Hittites are not Semitic; in fact, they display an originality of genius which is not strikingly characteristic of pure Semitic races. The hypothesis which regards them as the early civilizers of Asia Minor seems confirmed by the position of Carchemish, so favourable to the radiation of civilizing influences. The importance of the Hittite capital in a commercial respect is known to all. The *maneh* or mina of Carchemish is constantly mentioned on the cuneiform tablets; probably it was of lighter weight than the silver mina in use in Phœnicia (see Mr Barclay V. Head's letter in *Academy*, Nov. 22, 1879). Of the religious life of the Hittites we are hardly in a position to speak. We know indeed that, like the Hyksos, they worshipped Sutekh (who was localized, like Baal, as the patron of particular cities on the treaty of Ramses II.), and, like the Canaanites, Astarata or Ashtoreth. The worship of Astarata will account for the name Hierapolis given afterwards, as it seems, to Carchemish, as well as to other Syrian cities (Jerablûs being a corruption of Hierapolis). But beyond this all is dark. Did the Hittites borrow in religious matters from the Assyrians? Had they legends relative to the origin of the world, and in what relation do these stand to the Hebrew narratives? Passing to philology in the narrower sense of the word, we wait longingly for a confirmation of Professor Sayce's view that the Hittites were the authors of the Hamathite hieroglyphics. No Semitic nation ever invented a syllabic system of writing; the Hittites are in all probability non-Semitic, and from their enterprising character are precisely the people likely to have invented such characters. Professor Sayce has followed up this conjecture by another of no less importance, viz., that the enigmatical Cypriote syllabary is really derived from the hieroglyphics of Hamath. If this be proved (and the propounder of it claims to have the evidence ready), and if the Hittites be really the inventors of the Hamathite hieroglyphics, this wonderful nation steps into a position hardly surpassed by that of any of the nations of the distant East.

Authorities.—Documents in Brugsch's *History of Egypt*, compared with the parallel passages in *Records of the Past*, vols. ii., iv.; "Monolith Inscription of Shalmaneser," *Records of the Past*, iii. 25–36; Schrader, *Keilinschriften und Geschichtsforschung*, pp. 225–236; Brugsch, *History of Egypt*, ii. 2–8; Chabas, *Voyage d'un Egyptien*, pp. 318–332; Vicomte de Rougé, *Mélanges d'archéologie Assyrienne et Égyptienne*, 1875, p. 264, &c. (posthumous); letters of Professor Sayce in *Academy*, Aug. 16 and Nov. 1, 1879. On the site of Carchemish, see Schrader, *Keilinschriften*, &c., pp. 221–225; Maspero, *Journal des Savans*, Oct. 1873; and Pococke's *Account of the Ruins of Jerabus (Jerablûs)*; *A Description of the East*, &c., 1743–45, ii. 165. (T. K. C.)

HITTORFF, JACQUES IGNACE (1793–1867), French architect, was born at Cologne, August 20, 1793. After serving an apprenticeship to a mason in his native town, he went in 1810 to Paris, and studied for some years at the Academy of the Fine Arts, where he was a favourite pupil of the Government architect Bélanger, who in 1814 appointed him his principal inspector. Succeeding Bélanger as Government architect in 1818, he designed many important public and private buildings in Paris and also in the south of France. After making architectural tours in Germany, England, Italy, and Sicily, he published the result of his observations in the latter country in the work *Architecture antique de la Sicile* (3 vols. 1826–30; new edition, 1866–67), and also in *Architecture moderne de la Sicile* (1826–35). One of his important discoveries was that colour had been made use of in ancient Greek architecture, a subject which he especially discussed in *Architecture polychrome chez les Grecs* (1830), and in *Restitution du temple d'Empédocle à Sélinunte* (1851); and in accordance with the doctrines enunciated in these works he was in the habit of making colour an important feature in most of his architectural designs. His principal building is the church of St Vincent de Paul in the basilica style. He also designed many of the embellishments of the Place de la Concorde, the Champs-Élysées—where he constructed the Circus of the Empress, which has been the model of many similar buildings in various parts of Europe—the Bois de Boulogne, and other places. In 1833 he was elected a member of the Academy of Fine Arts. He died at Paris, March 25, 1867.

HITZIG, FERDINAND (1807–1875), exegete and Biblical critic, was born at Hauingen, Baden, where his father was an evangelical pastor, on June 23, 1807, received his early education at the pädagogium of Lörrach and at the lyceum of Carlsruhe, and entered the university of Heidelberg as a student of theology in the autumn of 1824. There he remained for a year, attending the lectures in exegesis and church history of Paulus the famous "rationalist"; but in 1825 he removed to Halle where Gesenius first decided him to devote himself to Old Testament subjects. His next step was to Göttingen in 1828, where he had Ewald for his master, and where in 1829 he graduated, the subject of his thesis being *De Cadyti Urbe Herodotea*. Returning to Heidelberg shortly afterwards, he "qualified" as "privatdocent" in theology the same year, and in 1831 published his *Begriff der Kritik am Alten Testamente praktisch erörtert*, a treatise in which the critical principles of the grammatico-historical school were stated with great fulness, clearness, and cogency; also *Des Propheten Jonas Orakel über Moab*, an exposition of the 15th and 16th chapters of the book of Isaiah attributed by him, as by many subsequent critics, to the prophet Jonah mentioned in 2 Kings xiv. 25. His next literary performance was a commentary on Isaiah (*Uebersetzung u. Auslegung des Propheten Jesajas*), the publication of which in 1833 was soon followed by a call to an ordinary professorship of theology in the university of Zurich. There he laboured for a period of twenty-eight years, during which, besides commentaries on *The Psalms* (1835–36; 2d ed., 1863–65), *The Minor Prophets* (1838; 3d ed., 1863), *Jeremiah* (1841; 2d ed., 1866), *Ezekiel* (1847), *Daniel* (1850), *Ecclesiastes* (1847), *Canticles* (1855), and *Proverbs* (1858), he published a monograph, *Ueber Johannes Markus u. seine Schriften* (1843), in which he maintained the chronological priority of the second gospel, and sought to prove that the Apocalypse was written by the same author, and various treatises of archæological interest, of which the most important are *Die Erfindung des Alphabets* (1840), *Urgeschichte u. Mythologie der Philistäer* (1845), and *Die Grabschrift des Eschmunezar* (1855). In 1861 he was called to succeed

Umbreit in the chair of theology at Heidelberg; there he wrote his *Geschichte des Volkes Israel* (1869–70), in two parts, extending respectively to the end of the Persian domination and to the fall of Masada, 72 A.D., as well as *Zur Kritik Paulinischer Briefe* (1870), *Die Inschrift des Mescha* (1870), *Sprache u. Sprachen Assyriens* (1871), besides revising Hirzel's commentary on Job (1874). He was also a frequent contributor to the *Monatsschrift des wissenschaftlichen Vereins in Zürich*, the *Zeitschrift der Deutschen Morgenländischen Gesellschaft*, the *Theologische Studien u. Kritiken*, Zeller's *Theologische Jahrbücher*, and Hilgenfeld's *Zeitschrift für wissenschaftliche Theologie*. Hitzig died at Heidelberg on January 22, 1875. As a Hebrew philologist he holds very high rank; and as a constructive critic he is remarkable for the acuteness and sagacity shown in his combinations. His theories, however, are often carried out with a vigour and rigour quite unwarranted by the amount of evidence upon which they rest; and his deficiency as a commentator in ideality and religious sympathy sometimes almost approaches the ludicrous. His lectures on Biblical theology (*Vorlesungen über biblische Theologie u. Messianische Weissagungen*) have been recently published (1880), along with a portrait and biographical sketch by Kneucker. See also Kamphausen's article in Herzog and Plitt's *Realencyklopädie*, vol. vi.

HOACTZIN, or HOATZIN, a bird of tropical South America, thought by Buffon to be that indicated by Hernandez or Fernandez under these names, the *Opisthocomus hoazin* or *O. cristatus* of modern ornithologists—a very curious and remarkable form, which has long exercised the ingenuity of classifiers. Placed by Buffon among his "*Hoccos*" (Curassows), and then by P. L. S. Müller and Gmelin in the Linnæan genus *Phasianus*, some of its many peculiarities were recognized by Illiger in 1811 as sufficient to establish it as a distinct genus, *Opisthocomus*; but various positions were assigned to it by subsequent syste-

Hoactzin.

matic authors, whose views, not being based on any information respecting its internal structure, do not here require particular attention. L'Herminier was the first to give any account of its anatomy (*Comptes Rendus*, 1837, v. p. 433), and from his time our knowledge of it has been successively increased by Johannes Müller (*Ber. Akad. Wissensch. Berlin*, 1841, p. 177), Deville (*Rev. et Mag. de Zoologie*, 1852, p. 217), Gervais (Castelnau, *Expéd. Amérique du Sud, Zoologie, Anatomie*, p. 66), Prof. Huxley (*Proc. Zool. Society*, 1868, p. 304), Mr Perrin (*Trans. Zool. Society*, ix. p. 353), and Garrod (*Proc. Zool. Society*, 1879, p. 109). After a minute description of the skeleton of *Opisthocomus*, with the especial object of determining its affinities, Prof. Huxley declared that it "resembles the ordinary Gallinaceous birds and Pigeons more than it does any others, and that when it diverges from them it is either *sui generis* or approaches the *Musophagidæ*." He accordingly regarded it as the type and sole member of a group, named by him *Heteromorphæ*, which sprang from the great Carinate stem later than the *Tinamomorphæ*, *Turnicomorphæ*, or *Charadriomorphæ*, but before the *Peristeromorphæ*, *Pteroclomorphæ*, or *Alectoromorphæ*. This conclusion is substantially the same as that at which Garrod subsequently arrived after closely examining and dissecting specimens preserved in spirit; but the latter has gone further and endeavoured to trace more particularly the descent of this peculiar form and some others, remarking that the ancestor of *Opisthocomus* must have left the parent stem very shortly before the true *Gallinæ* first appeared, and at about the same time as the independent pedigree of the *Cuculidæ* and *Musophagidæ* commenced—these two groups being, he believed, very closely related, and *Opisthocomus* serving to fill the gap between them.

It would be impossible here to state at length the facts on which these views are grounded, and equally impossible to give more than a very few details of the anatomy of this singular form. The first thing that strikes the spectator of its skeleton is the extraordinary structure of the sternal apparatus, which is wholly unlike that of any other bird known. The keel is only developed on the posterior part of the sternum—the fore part being, as it were, cut away, while the short furcula at its symphysis meets the manubrium, with which it is firmly consolidated by means of a prolonged and straight hypocleidium, and anteriorly ossifies with the coracoids. This unique arrangement seems to be correlated with the enormously capacious crop, which rests upon the furcula and fore part of the sternum, and is also received in a cavity formed on the surface of each of the great pectoral muscles. Furthermore this crop is extremely muscular, so as more to resemble a gizzard, and consists of two portions divided by a partial constriction, after a fashion of which no other example is known among birds.

The Hoactzin appears to be about the size of a small Pheasant, but is really a much smaller bird. The beak is strong, curiously denticulated along the margin of the maxilla near the base, and is beset by diverging bristles. The eyes, placed in the middle of a patch of bare skin, are furnished with bristly lashes, resembling those of Hornbills and some few other birds. The head bears a long pendent crest of loose yellowish feathers. The body is olive-coloured, varied with white above, and beneath is of a dull bay. The wings are short and rounded. The tail is long, and tipped with yellow. The legs are long, the feet stout, the tarsi reticulated, and the toes scutellated; the claws long and slightly curved. According to all who have observed the habits of this bird, it lives in bands on the lower trees and bushes bordering the streams and lagoons, feeding on leaves and various wild fruits, especially, says Mr Bates (*Naturalist on the River Amazons*, i. p. 120), on those of a species of *Psidium*, and it is also credited with eating those of an arum (*Caladium arborescens*), which grows plentifully in its haunts. "Its voice is a harsh, grating hiss," continues the same traveller, and "it makes the noise when alarmed, all the individuals sibilating as they fly heavily away from tree to tree, when disturbed by passing canoes." It exhales a very strong odour—wherefore it is known in British Guiana as the "Stink-bird"—compared by Mr Bates to "musk combined with wet hides," and by Deville to that of a cow-house. The species is said to be polygamous; the nest is built on trees, of sticks placed above one another, and softer materials atop. Therein the hen lays her eggs to the number of three or four, of a dull yellowish-white, somewhat profusely marked with reddish blotches and spots, so as to resemble those of some of the *Rallidæ* (*Proc. Zool. Society*, 1867, pl. xv. fig. 7. p. 164). In the valley of the Amazon it is called the "*Cigano*" or Gipsy, and in no part of the country where it occurs does it seem to be regarded with much favour. Only one species of the genus is known to have existed, for Mr Wallace's statement (*Geogr. Distrib. Animals*, i. p. 164) that remains of a second have been found in Brazilian caves seems to have originated in a mistake. (A. N.)

HOADLY, BENJAMIN (1676–1761), the originator of the Bangorian controversy, was the second son of the Rev. Samuel Hoadly, and was born at Westerham, Kent, November 14, 1676. After receiving his early education under the direction of his father, he entered Catherine Hall, Cambridge, where he graduated M.A. and was for two years tutor, after which he held for ten years the lectureship of St Mildred in the Poultry, and along with it for the last eight years the rectory of St Peter-le-Poer, London. His first appearance as a controversialist was against Mr Calamy in reference to conformity, and immediately after this he engaged in a more important dispute with Bishop Atterbury against the Anglican doctrine of nonresistance. His principal treatises on this subject were the *Measures of Submission to the Civil Magistrate* and *The Origin and Institution of Civil Government discussed*; and his part in the discussion was so much appreciated by the Commons that in 1709 they presented an address to the queen praying her to "bestow some dignity in the church on Mr Hoadly for his eminent services both to church and state." The queen returned a favourable answer, but the dignity was not conferred. In 1710 he was presented by a private patron to the rectory of Streatham in Surrey. In 1715 he was appointed chaplain to the king, and the same year he obtained the bishopric of Bangor. In 1716 he published a *Preservative against the Principles and Practices of Nonjurors in Church and State*, and in the following year preached before the king his famous sermon on the *Kingdom of Christ*, which was immediately published by royal command. These works were attacks on the divine authority of kings and of the clergy, but as the sermon dealt more specifically and distinctly with the power of the church, its publication caused an ecclesiastical ferment which in certain aspects has no parallel in religious history. It was at once resolved to proceed against him in convocation, but this was prevented by the king proroguing the assembly, a step which had consequences of vital bearing on the history of the church, since from that period the great Anglican council ceased to transact business of a more than formal nature. The restrained sentiments of the council in regard to Hoadly found expression in a war of pamphlets known as the Bangorian controversy, which, partly from a want of clearness in the statements of Hoadly, due perhaps both to his intellectual defects and to a cautious regard to ulterior consequences, partly from the disingenuousness of his opponents and the confusion resulting from exasperated feelings, developed into an intricate and bewildering maze of side discussions in which the main issues of the dispute were concealed almost beyond the possibility of discovery. But however vague and uncertain might be the meaning of Hoadly in regard to several of the important bearings of the questions around which he aroused discussion, he was explicit in denying the power of the church over the conscience, and its right to determine the condition of men in relation to the favour of God. To such an extent was the mind of the religious world exercised on the matters in dispute that in July 1717 as many as seventy-four pamphlets made their appearance; and at one period the crisis became so serious that the business of London was for some days virtually at a standstill. Hoadly was translated in 1721 to the see of Hereford, in 1723 to Salisbury, and in 1734 to Winchester. He died at his palace at Chelsea, April 17, 1761. Though his writings possess no charm of style, and are not only devoid of originality, but characterized by great prolixity and dulness, they in their own day did important service to the cause of civil and religious liberty, and accidentally he was the occasion of a change in the practical authority of the church which had an influence of prime importance on its after history. He was an intimate friend of Dr Samuel Clarke, of whom he wrote a life.

The works of Hoadly were collected and published by his son in 3 vols., 1773. To the first volume was prefixed the article "Hoadly," from the supplement to the *Biographia Britannica*.

HOARE, SIR RICHARD COBB (1758–1838), Bart., English antiquary, eldest son of Sir Richard Hoare, the first baronet, an eminent banker, was born 9th December 1758. Having been accustomed in his youth to apply himself to business, the diligent habits which he then acquired induced him afterwards to relieve the tedium of his life by the study of topography and antiquities. In 1783 he married the eldest daughter of Lord Lyttelton, and on her death in 1785 he made a tour on the Continent, visiting France, Italy, and Switzerland. He succeeded to the baronetcy on the death of his father in 1787, and in the following year he left England on a second Continental tour. The record of his travels was originally published by him in four volumes, and these were afterwards condensed into two, which appeared in 1810 under the title *A Classical Tour through Italy and Sicily.* Travelling on the Continent having been rendered insecure on account of the war with France, he next resolved to make a tour in Wales, taking Giraldus Cambrensis (de Barri) as his guide, and in 1808 he published a translation of Giraldus, with notes, illustrations, and a life of the author, in two splendid quarto volumes. In 1807 he visited Ireland; and he also published an account of this excursion. His most important contribution to antiquarian science was, however, his history of his native county, Wiltshire. In 1821 he completed in two volumes folio the *History of Ancient Wiltshire*, after which he commenced the *History of Modern Wiltshire*, and confining his attention to South Wiltshire was able with the help of several coadjutors almost to finish the work before his death. The first part—the history of the hundred of Mere—appeared in 1822, and the last part in 1843. Hoare died at Stourhead, May 19, 1838. For a notice of him and a list of his works, many of which were printed privately, see the *Gentleman's Magazine* for July 1838.

HOBART TOWN, sometimes wrongly HOBARTOWN or HOBARTON, the capital of Tasmania (named by its founder, Colonel Collins, on the 19th February 1804, in honour of Lord Hobart, then secretary of state for the colonies), is situated in the south of the island in 42° 53′ 22″ S. lat. and 147° 21′ 20″ E. long. It occupies a succession of hills along a sheltered bight on the western bank of the Derwent river, known as Sullivan's Cove, about 17 miles from the ocean, and not far from the base of Mount Wellington, an eminence whose summit, 4166 feet above the level of the sea, is covered with snow during many months of the year. The city proper, forming nearly a square, and laid out in wide streets intersecting at right angles, has an area of 1270 acres, and contains about 5000 houses, with a population estimated on the 1st of January 1879 at 23,000. Of the public squares the most extensive is the Queen's Domain, and the most central the Franklin Square, with the bronze statue of the eminent Arctic explorer, who governed Tasmania from 5th January 1837 to 21st August 1843. Most of the public buildings (the houses of parliament, the town-hall, the supreme court, and the museum) are conveniently adjacent to each other in Magdalen Street. The town-hall, erected about 1872 at a cost of £12,000, contains a large reading-room and a suite of rooms for the free public library, which has upwards of 8000 volumes. The museum comprises a scientific library and apartments for the Royal Society of Tasmania. Besides the Anglican cathedral of St David's, founded in 1873, and the Roman Catholic cathedral of St Mary's, the churches comprise a Congregational memorial church, a Wesleyan "Centenary" chapel, and others belonging to Baptists, Independents, and Quakers. There is also a synagogue, but the Jewish community consists of only a few families. The charitable institutions of the town are maintained at the expense of the state. Among the remaining buildings may be mentioned five banks, a theatre, the freemasons' hall and the oddfellows' hall. In the neighbourhood of the city is the official residence of the governor of Tasmania, an ornate castellated mansion; the grounds of this adjoin the botanic gardens, which occupy an area of 21 acres.

Hobart Town has been under municipal government since 1853, and was incorporated as a city in 1857. There are nine aldermen elected by the ratepayers, and one of them is appointed mayor. The annual value of rateable property exceeds £100,000. An abundant supply of pure water is brought from the springs of Mount Wellington, and stored in a reservoir about a mile from the city, capable of holding 50,000,000 gallons. Among the industrial establishments are six breweries, a candle factory, a foundry, ten hat and cap factories, seven steam flour-mills, a pottery, twelve saw-mills, and a tin-smelting work. The commerce of the town is steadily increasing. The securely sheltered harbour is capable of accommodating ships of the largest tonnage, and is provided with three patent slips of considerable size; not only is the port the headquarters of the Tasmanian Steam Navigation Company, which trades with Melbourne, Sydney, and New Zealand, but a line of colonial vessels communicates regularly with London. During the year 1877 the total burthen of shipping inwards was 79,480 tons, of the shipping outwards 82,827 tons. The declared value of the imports at the Custom House was £664,439 (£255,344 from the United Kingdom), and that of the exports £720,136 (£301,477 to the United Kingdom), £715,304 worth being produce of the colony. The customs collected during the year 1878 amounted to £118,306, being an increase of about £4000 on the previous year. According to the returns for 1877 the principal exports were tin ore (value £61,765), tin (£20,886), bark (2086 tons, £13,410), fruit (138,585 bushels, £44,001), jam (3,742,341 lb, £100,069), hops (696,048 lb, £36,457), sperm-oil (450 tons, £33,410), rabbit skins (58,781 dozen, £5072), timber, shingles, railings, &c. (£351,851), and wool (£299,514). The principal imports are sugar, tea, oil, tobacco, live stock, machinery, spirits and wine, boots and shoes, wearing apparel, ironmongery and cutlery, glass and china-ware, books and stationery, saddlery, manure, drugs, &c. The first newspaper was published in Hobart Town in 1810. There are now (1880) two dailies, one weekly, and four monthlies. During the summer season the city is a favourite resort of Australian tourists attracted by the comparative coolness of the climate. The mean temperature for 35 years was 55·41° Fahr.; and in the same period the barometer at a temperature of 32° has registered an average of 29·82 inches.

HOBBEMA, MEYNDERT (*c.* 1638–1709), the greatest landscape painter of the Dutch school after Ruysdael, lived at Amsterdam in the second half of the 17th century. His merit has been but recently recognized, whence the obscurity in which his life remains. Nothing is more disappointing than to find that in Hobbema's case chronology and signed pictures substantially contradict each other. According to the latter his practice lasted from 1650 to 1689; according to the former his birth occurred in 1638, his death as late as 1709. That no attempt has yet been made to reconcile these contradictions is strange. It is perfectly clear that if the masterpiece of the late Bredel collection, called A Wooded Stream, honestly bears the date of 1650, or The Cottages under Trees of the Ford collection the date of 1652, the painter of these canvases cannot be Hobbema, whose birth took place in 1638, unless indeed we admit that Hobbema painted some of his finest works at the age of twelve or fourteen. No doubt, as regards signatures, there is much in Hobbema's creations to excite suspicion. For a considerable period it was profitable to pass Hobbemas as Ruysdaels, and the name of the lesser master was probably erased from several of his productions. When Hobbema's talent was recognized, the contrary process was followed, and in this way the name, and perhaps fictitious dates, reappeared by fraud. It is difficult to account for the discrepancies of pictures and chronology by any other cause. Yet this leaves unexplained why dates as well as names should have been forged. An experienced eye will note the differences which occur in Hobbema's signatures in such well known examples as adorn the galleries of London and Rotterdam, or the Grosvenor and Van der Hoop collections. The dates can only be tested by chemical means. Meanwhile, we must be content to know that, if the question of dates could be brought into accordance with records and chronology, the facts of Hobbema's life would be as follows. Meyndert Hobbema was married at the age of thirty to Eeltije Vinck of Gorcum, in the Oudekerk or old church at Amsterdam, on the 2d of November 1668. Witnesses to the marriage were the bride's brother Cornelius Vinck and Jacob Ruysdael. We might suppose from this that Hobbema and Ruysdael, the two great masters of landscape, were united at this time by ties of friendship, and accept the belief that the former was the pupil of the latter. Yet even this is denied to us, since records tell us that there were two Jacob Ruysdaels, cousins and contemporaries, at Amsterdam in the middle of the 17th century—one a frame-maker, the son of Solomon, the other a painter, the son of Isaac Ruysdael. Of Hobbema's marriage there came between 1668 and 1673 four children. In 1704 Eeltije died, and was buried in the pauper section of the Leyden cemetery at Amsterdam. Hobbema himself survived till December 1709, receiving burial on the 14th of that month in the pauper section of the Westerkerk cemetery at Amsterdam. Husband and wife had lived during their lifetime in the Rozengracht, at no great distance from Rembrandt, who also dwelt there in his later and impoverished days. Rembrandt, Hals, Jacob Ruysdael, and Hobbema were in one respect alike. They all died in misery, insufficiently rewarded perhaps for their toil, imprudent perhaps in the use of the means derived from their labours. Posterity has recognized that Hobbema and Ruysdael together represent the final development of landscape art in Holland. Their style is so related that we cannot suppose the first to have been unconnected with the second. Still their works differ in certain ways, and their character is generally so marked that we shall find little difficulty in distinguishing them, nor indeed shall we hesitate in separating those of Hobbema from the feebler productions of his imitators and predecessors—Isaac Ruysdael, Rontbouts, De Vries, Dekker, Looten, Verboom, Du Bois, Van Kessel, Van der Hagen, even Philip de Koningk. In the exercise of his craft Hobbema was patient beyond all conception. It is doubtful whether any one ever so completely mastered as he did the still life of woods and hedges, or mills and pools. Nor can we believe that he obtained this mastery otherwise than by constantly dwelling in the same neighbourhood, say in Guelders or on the Dutch Westphalian border, where day after day he might study the branching and foliage of trees and underwood embowering cottages and mills, under every variety of light, in every shade of transparency, in all changes produced by the seasons. Though his landscapes are severely and moderately toned, generally in an olive key, and often attuned to a puritanical grey or russet, they surprise us, not only by the variety of their leafage, but by the finish of their detail as well as the boldness of their touch. With astonishing subtlety light is shown penetrating cloud, and illuminating, sometimes transiently, sometimes steadily, different portions of the ground, shining through leaves upon other leaves, and multiplying in an endless way the transparency of the picture. If the chance be given him he mirrors all these things in the still pool near a cottage, the reaches of a sluggish river, or the swirl of the stream that feeds a busy mill. The same spot will furnish him with several pictures. One mill gives him repeated opportunities of charming our eye; and this wonderful artist, who is only second to Ruysdael because he had not Ruysdael's versatility and did not extend his study equally to downs and rocky eminences, or torrents and estuaries—this is the man who lived penuriously, died poor, and left no trace in the artistic annals of his country! It has been said that Hobbema did not paint his own figures, but transferred that duty to Adrian van de Velde, Lingelbach, Barendt Gael, and Abraham Storck. As to this much is conjecture.

The best of Hobbema's dated pictures are those of the years 1663 to 1667. Of the former, several in the galleries of Brussels and St Petersburg, and one in the Holford collection, are celebrated. Another was shown as the property of Lord Hatherton at Manchester. Of 1665 fine specimens are in the Grosvenor gallery and the collection of Sir R. Wallace. Of seven pieces in the National Gallery, including the Avenue at Middelharnis, which some assign to 1689, two are dated 1667. A sample of the last of these years is also in the Fitzwilliam museum at Cambridge. The value of Hobbema's pictures may be gathered from this that the Watermill bought from the Schneider collection in 1876 for the Antwerp museum cost 100,000 francs (£4000), whilst a smaller landscape in the Hodshen sale at Amsterdam was knocked down to Sir R. Wallace for 49,500 florins, or £4300. The Brussels gallery also bought a Hobbema in 1874 for 60,000 francs. Amongst the masterpieces in private hands in England may be noticed two landscapes in Buckingham palace, one belonging to Lord Overstone, two to the Earl of Ellesmere, and one to Mr Walter of Bearwood. On the Continent we register a Wood in the Berlin gallery, a Forest belonging to the duchess of Sagan in Paris, and a Glade in the Louvre. There are other fine Hobbemas in the Arenberg gallery at Brussels and the Belvedere at Vienna. (J. A. C.)

HOBBES, Thomas (1588–1679), was born at Westport, adjoining (now forming part of) Malmesbury, in North Wilts, on Good Friday, the 5th of April 1588,—brought prematurely into the world through his mother's fright at the rumours of the coming Spanish Armada. His father was vicar of Charlton and Westport, an illiterate and choleric man, who is said to have got into trouble later on by quarrelling with a rival at the church door, and been forced to decamp, leaving his three children (of whom Thomas was second) to the charitable care of an elder brother, a flourishing glover in Malmesbury. Hobbes was put to school at Westport church at the age of four, passed to the Malmesbury school at eight, and was taught again in Westport later, at a private school kept by a young man named Robert Latimer, fresh from Oxford and "a good Grecian." He had begun Latin and Greek early, and under Latimer made such progress as to be able to translate the *Medea* of Euripides into Latin iambic verse before he was fourteen. About the age of fifteen he was sent to Oxford by his uncle and entered at Magdalen Hall, which had just been put on an independent footing, after being first a grammar school in connexion with the great foundation of Magdalen College and then governed as a hall by one of the college fellows. While Hobbes was there as a student the first principal of Magdalen Hall, Dr John Hussee, gave way to a second, Dr John Wilkinson, who is noted as having ruled strongly in the interest of the Calvinistic party in the university; and this fact, with other circumstances in the Oxford life of the time, makes it not improbable that the destined foe of the Puritan Revolution was thus early led to mark the aggressive Puritan spirit. For the rest, Oxford did no more to train Hobbes's mind for his future philosophical work than the decayed scholastic regimen of the universities in that age was able to do for any other of the active spirits that then began in different countries to open the modern era of thought and inquiry. We have from himself a lively record of his experience and pursuits as a student (*Vit. carm. exp.*, p. lxxxv.),[1] which, though penned in extreme old age, may be taken as sufficiently trustworthy. In this he tells how he was set to learn "Barbara, Celarent," but, when he had slowly taken in the doctrine of figures and moods, he put it aside and would prove things only in his own way; how he then heard about bodies as consisting of matter and form, as throwing off species of themselves for perception, and as moved by sympathies and antipathies, with much else of a like sort, all beyond his comprehension; and how he therefore turned to things more congenial, took up his old books again, fed his mind on maps and charts of earth and sky, traced the sun in his path, followed Drake and Cavendish girdling the main, and gazed with delight upon pictured haunts of men and wonders of unknown lands. Very characteristic in this account is the interest in men and things, and the disposition to cut through questions in the schools after a trenchant fashion of his own. We may also believe that he was little attracted by the scholastic learning, and only should err if we took his words as evidence of a precocious insight into its weakness. The truth probably is that, finding himself left at Oxford very much to his own devices, he took no particular interest in studies which there was no risk in neglecting, and thought as little of rejecting as of accepting the traditional doctrines. He adds that he took his degree at the proper time; but in fact, upon any computation and from whatever cause, he remained at Magdalen Hall five, instead of the required four, years, not being admitted as bachelor till February 5, 1608.

In the same year, shortly after leaving the university, Hobbes was recommended by Wilkinson as tutor to the son of William Cavendish, baron of Hardwick, and thus began a connexion with a great and powerful family that ended only with his life. Twice it was loosened—once, for a short time, after twenty years, and again, for a longer period, during the Civil War—but it never was broken, and during more than fifty years, to the credit alike of him and his patrons, it was of the closest character. William Cavendish, second son of the famous "Bess of Hardwick" by the second of her four marriages, had just by the favour of King James obtained his barony, before being advanced, a few years later, to the earldom of Devonshire. His son, the heir to a name thus rising as well as to a great fortune, was hardly younger than Hobbes, and was indeed already married, a few months before, at the instance of the king, who made up the match, to the only daughter of the Scottish Lord Bruce of Kinloss, though by reason of the bride's age, which was only twelve years, the pair had no establishment for some time to come. In the circumstances Hobbes was companion rather than tutor (before becoming secretary) to young Cavendish; and, growing soon greatly attached to each other, they were sent abroad together on the grand tour in 1610. How long they were gone upon this journey, which lay through France, Germany, and Italy, is not known: but it was long enough to give

[1] There are three accounts of Hobbes's life, first published together in 1681, two years after his death, by R. B. (Richard Blackburne, a friend of Hobbes's admirer, John Aubrey), and reprinted, with complimentary verses by Cowley and others, at the beginning of Sir W. Molesworth's collection of the *Latin Works*:—(1) *T. H. Malmesb. Vita* (pp. xiii.-xxi.), written by Hobbes himself, or (as also reported) by T. Rymer, at his dictation; (2) *Vitæ Hobbianæ Auctarium* (pp. xxii.-lxxx.), turned into Latin from Aubrey's English; (3) *T. H. Malmesb. Vita carmine expressa* (pp. lxxxi.-xcix.), written by Hobbes at the age of eighty-four (first published by itself in 1680). The *Life of Mr T. H. of Malmesburie*, printed among the *Lives of Eminent Men*, in 1813, from Aubrey's papers in the Bodleian, &c. (vol. ii. pt. ii. pp. 593-637), contains some interesting particulars not found in the *Auctarium*.

Hobbes the opportunity of acquiring a moderate knowledge of French and Italian; and he did not return without having received a distinct mental impulse that had a lasting effect on his life. The real intellectual activity of that time (still more than five and twenty years before the definite inauguration of modern philosophy by Descartes's *Discourse on Method* in 1637) was in the newly enlarged if not newly opened domain of physical science; and Hobbes was little prepared by his juvenile training to understand the achievements of Galileo and Kepler, if he heard anything of them. But he had had a little modicum of scholastic philosophy retailed to him at Oxford; and now, wherever he went, he could hear nothing but words of scorn poured upon all such learning. How it had come to pass that the scholastic way of thinking, once so dominant, was thus discredited at the hands alike of revolutionary thinkers such as Bruno, of scientific workers like Galileo, and of men of the world like Montaigne, he could not know. Accordingly, it seems that at first he was more dismayed to find that the only knowledge to which he could pretend was laughed at by people whom he did not understand, than pleased to be furnished with such an excuse for his own youthful indifference to its value. It was not long, however, before he yielded to the stream. He was not yet able to strike out a new line of thought, and so (like Descartes) rise above the misconceptions mingled with the general aversion from scholasticism, amounting to a neglect of all philosophy. He had but sufficient force of mind to wish to be seen, like others, at work upon something else. The line he should take could hardly be doubtful; he had nothing to fall back upon except his Latin and Greek. He was no longer so familiar with them, but it was still open to him to become a scholar; nor in the age of Scaliger and Casaubon was there any lack of ambition in making classical study the occupation of a life. The resolution was made when he returned home, if not earlier, and made in a determined spirit; but when after many years' labour he had made himself a scholar, his true work was still to lie all before him.

Hobbes's period of scholarly acquirement lasted till 1628, and had as its immediate outcome a translation of Thucydides. In Derbyshire or in London, with his young master, he had abundant leisure and easy access to books, and he went carefully through the classical poets and historians, reading critically with the help of commentators, and at the same time bent on acquiring (as if for future use) a good Latin style, clear and easy to read, because fitting words to thoughts. Among all the ancient writers Thucydides attracted him most, and he seems to have set himself early to the work of translation, wishing others to share in the pleasure and instruction he derived from his favourite's pages. But when he had finished his work he kept it lying by him for years, being no longer so sure of finding appreciative readers; and when he did send it forth at last, in 1628, he was fain to be content with "the few and better sort."[1] That he was finally determined to publication by the political troubles of the year 1628 may be regarded as certain, not only from his own express declaration at a later time (*Vit. carm. exp.*), but also from unmistakable hints in the account of the life and work of his author prefixed to the translation on its appearance. 1628 was the year of the Petition of Right, extorted by the popular leaders from a reluctant king in the third parliament he had tried within three years of his accession; and, in view of Hobbes's later activity, it is very significant that just then he should come forward, at the mature age of forty, with his version of the impressive story of the Athenian democracy as the first production of his pen. Nothing else is known of his doings before 1628, except that through his connexion with young Cavendish, who from about the year 1619 became an important social and political figure, he had relations with literary men of note like Ben Jonson, and also with the two philosophical thinkers who before himself rendered the English name illustrious in the 17th century—Bacon and Lord Herbert of Cherbury. If he never had any sympathy with Herbert's intuitionalist principles in philosophy, he was no less eager, as he afterwards showed, than Herbert to rationalize in matters of religious doctrine, so that he may with the same reason be called the second of the English deists as Herbert has been called the first. With Bacon there is evidence of his having been so intimate (Aubrey's *Lives*, pp. 222, 602) that it is not surprising that some writers have been betrayed into describing him as the disciple and follower of the great Instaurator. The facts as recorded, however,—that he used sometimes to walk with Bacon at Gorhambury, and would jot down with exceptional intelligence the eager thinker's sudden "notions," also that he was employed to make the Latin version of some of the *Essays*,—prove nothing of the sort, when weighed against his own disregard of all Bacon's most characteristic principles, and the other evidence that the impulse to independent philosophical thinking came to him not from Bacon, and not till some time after Bacon's death in 1626.[2]

So far as we have any positive evidence, it was not before the year 1629 that Hobbes first entered on the path of philosophical inquiry; and meanwhile a great change had been wrought in his outer life. His friend and master, after only about two years' tenure of the earldom, fell a sudden victim to the plague in June 1628; and the affairs of the Devonshire family having become greatly disordered by lavish expenditure, the widowed countess was left with the task of righting them in the boyhood of the third earl. Hobbes went on for a time living in the household; but his services were no longer in demand as before, and, remaining inconsolable under his personal bereavement, he sought distraction, in 1629, in another engagement which took him abroad as tutor to the son of Sir Gervase Clifton, of an old Notts family. This, his second, sojourn abroad appears to have been spent chiefly in Paris, and the one important fact recorded of it is that he then first began to look into Euclid. Sojourn and engagement came to an end together in 1631, when he was recalled to train the young earl of Devonshire, now thirteen years old, as he never had had an opportunity of training the boy's father. In the course of the next

[1] The translation, under the title *Eight Books of the Peloponnesian War, written by Thucydides the son of Olorus, interpreted with faith and diligence immediately out of the Greek by Thomas Hobbes, secretary to the late Earl of Devonshire*, appeared in 1628 (given also as 1629), after the death of the earl, to whom touching reference is made in the dedication. It reappeared in 1634, with the date of the dedication altered, as if then newly written. Though Hobbes claims to have performed his work "with much more diligence than elegance," his version is remarkable as a piece of English writing, but is by no means accurate. It fills vols. viii. and ix. in Molesworth's collection (11 vols., including index vol.) of Hobbes's *English Works* (London, Bohn, 1839–45). The volumes of this collection will here be cited as *E. W.* Molesworth's collection of the Latin *Opera Philosophica* (5 vols., 1839–45) will be cited as *L. W.* The five hundred and odd Latin hexameters under the title *De Mirabilibus Pecci* (*L. W.*, v. 323–40), giving an account of a short excursion from Chatsworth to view the seven wonders of the Derbyshire Peak, were written before 1628 (in 1626 or 1627), though not published till 1636. A later edition, in 1678, included an English version by another hand.

[2] Hobbes, in minor works dealing with physical questions (*L. W.*, iv. p. 316; *E. W.*, vii. p. 112), makes two incidental references to Bacon's writings, but never mentions Bacon as he mentions Galileo, Kepler, Harvey, and others (*De Corpore*, ep. ded.), among the lights of the century. The word "Induction," which occurs in only three or four passages throughout all his works (and these again minor ones), is never used by him with the faintest reminiscence of the import assigned to it by Bacon; and, as will be seen, he had nothing but scorn for *experimental* work in physics.

seven years Hobbes took his young pupil over rhetoric,[1] logic, astronomy, and the principles of law, with other subjects. Most probably their life for the first three years was in Derbyshire, till they went abroad in the middle of 1634. They remained away till the spring of 1637, and Hobbes went over much the same ground as in his first journey, but now in a very different frame of mind. His head was now full of the thought of motion in nature, and whenever he could meet with the philosophical speculators or scientific workers who were then with a new-born ardour seeking for a clue to the secret of the physical world, none so forward to consort with them as he. He was still in time to pay his respects to the aged Galileo, for whom he conceived and ever retained the warmest admiration; and on the way homewards he spent no less than eight months in daily converse with the members of a busy scientific circle in Paris, held together by the genial influence of the Père Mersenne. From that time (the winter of 1636–7) he too, as he tells us, was numbered among philosophers.

It is not impossible to trace a little more exactly the steps by which Hobbes reached this consummation when he was just touching his fiftieth year. There can be no doubt, it seems, that his introduction to Euclid took place in 1629, and according to Aubrey, who tells the story with a quaint dramatic vigour (*Lives*, p. 604), the introduction was quite accidental. Euclid's manner of proof was as a revelation to him, and it became the model for his own way of thinking upon all subjects ever after; nor was he content till he too could be seen at work solving questions of geometry with as much confidence as if he had been, like Descartes, an accomplished mathematician from his boyhood. It is less easy to determine when he awoke to an interest in the physical doctrine of motion. The story told by himself (*Vit.*, p. xx.) is that, being struck one day in a company of learned men by the question, What is sense? which some one asked and nobody could answer, he fell to thinking often on the subject, till it suddenly occurred to him that if bodies and their internal parts were at rest, or were always in the same state of motion, there could be no distinction of anything, and consequently no sense; the cause of all things must, therefore, he presumed, be sought in diversity of movements, and starting from this principle he was driven to geometry for insight into the ground and modes of motion. Unfortunately no date or place is given; but if it may be supposed that he must already have known something of geometry to understand its bearing on the study of motion, the scene or at least the conclusion to which it led should be referred to some time after his casual introduction to Euclid. It is even suggested in one or two of the biographical narratives that the new mental advance was not made till the time of the third journey. Nothing is said, however, which should exclude another account, that on the third journey he began to study the doctrine of motion more seriously, being interested in it before; and as he claims more than once (*L. W.*, v. p. 303; *E. W.*, vii. p. 468) to have explained light and sound by a mechanical hypothesis as far back as 1630, the company-scene (which is more likely to have occurred abroad than in England) and the sudden inspiration may perhaps more safely be assigned to the time of the second journey. But it was not till the third journey that the new interest became an overpowering passion, and the "philosopher" was on his way home before he had advanced so far as to conceive the scheme of a system of thought to the elaboration of which his life should henceforth be devoted.

Hobbes was able to carry out his plan in some twenty years or more from the time of its conception, but the execution was so broken in upon by the dire political events that happened from the year 1637, and became so complicated with other labours, that its stages can hardly be followed without some previous understanding of the relations of the parts of the scheme, as there is reason to believe they were sketched out from the beginning. And there is the more need for some preliminary statement because at least one of the parts—the doctrine of Man—is far more effectively wrought out in other works than in the treatise *De Homine*, which professes to contain the formal exposition of it. Hobbes's notion was that the whole body of philosophical truth should be disposed in three sections, dealing progressively with Body, Man, and State or Society. An anxious political observer before he became a philosopher, he was supremely interested in the problem of conduct; but the philosopher could not be satisfied till the foundations of settled social life were based deep in the constitution of human nature; and his new philosophical insight revealed to him the need and the possibility of interpreting the facts of human nature by what had begun to be known of physical nature generally. He would therefore first work out, in a separate treatise *De Corpore*, a systematic doctrine of Body, showing how physical phenomena were universally explicable in terms of motion, as motion or mechanical action was now (through Galileo and others) understood,—the theory of motion being applied in the light of mathematical science, after quantity, the subject-matter of mathematics, had been duly considered in its place among the fundamental conceptions of philosophy, and a clear indication had been given, at first starting, of the logical ground and method of all philosophical inquiry. He would then single out Man from the realm of nature, and, in a treatise *De Homine*, show what specific bodily motions were involved in the production of the peculiar phenomena of sensation and knowledge, as also of the affections and passions thence resulting, whereby man came into relation with man. Finally he would consider, in a crowning treatise *De Cive*, how men, being naturally rivals or foes, were moved to enter into the better relation of Society, and demonstrate how this grand and beneficent product of human wit must be regulated if men were not to fall back into brutishness and misery. Such, in briefest summary, was the scheme conceived, at a time of new intellectual expansion, with reference to a threatening movement of social upheaval. We are now to see how it fared in the execution.

Hobbes came home, in 1637, to a country seething with discontent. The reign of "Thorough" was collapsing, and the forces pent up since 1629 were soon to rend the fabric of the English state to pieces. In February Hampden's case began to be tried; in July broke out the Edinburgh riot over Laud's prayer-book; next year was formed the Solemn League and Covenant; the year after the rebel Scots had the king at their mercy in the open field; and finally, in the spring of 1640, with a new prospect of war, Charles had no resource left but once more, after eleven years of personal rule, to call a parliament. Such a rush of events was but too likely to overpower Hobbes's resolution to work up to social problems from abstract questions of body and space and motion, and there is clear evidence that he was soon distracted from the orderly execution of his philosophic plan. The Short Parliament, as he tells us himself at a later time (*E. W.*, iv. p. 414), was not dissolved, in three weeks from the time of its meeting, before he had ready "a little treatise in English," in which he sought to prove that the points of the royal prerogative which the members were determined to dispute before granting supplies, "were inseparably annexed to the sovereignty which they did not then deny to be in the king." Now it can be proved that at this time he had written not only his *Human Nature* but also his *De Corpore Politico*, the two treatises, though published separately ten years later, having been composed as parts of one work;[2] and there cannot be the least question that together they make "the little treatise" just mentioned. We are therefore to understand, first, that he wrote the earliest draft of his political theory some years before the outbreak of the Civil War, and, secondly, that this earliest draft was not written till, in accordance with his philosophical conception, he had established the grounds of polity in human nature. The first point is to be noted, because it has often been supposed that Hobbes's political doctrine took its peculiar complexion from his revulsion against the state of anarchy before his eyes, as he wrote during the progress of the Civil War. The second point must be maintained against his own implied, if not express, statement some years later, when publishing his *De Cive* (*L. W.*, ii. p. 151), that he wrote this third part of his system before he had

[1] The free English abstract of Aristotle's *Rhetoric*, published in 1681, after Hobbes's death, as *The Whole Art of Rhetoric* (*E. W.*, vi. pp. 423-510), corresponds with a Latin version dictated to his young pupil. Among Hobbes's papers preserved at Hardwick, where he died, there remains the boy's dictation-book, interspersed with headings, examples, &c., in Hobbes's hand.

[2] Among the Hardwick papers there is preserved a MS. copy of the work, under the title *Elementes of Law Naturall and Politique*, with the dedication to the earl of Newcastle, written in Hobbes's own hand, and dated May 9, 1640. This dedication was prefixed to the first thirteen chapters of the work when printed by themselves, under the title *Human Nature*, in 1650.

been able to set down any finished representation of the fundamental doctrines which it presupposed. If his philosophical plans were disordered and the doctrine of Body was still in the air, he had, in the beginning of 1640, written out his doctrine of Man at least, with almost as much elaboration as it ever received from him.

When, in six months more, the Long Parliament succeeded to the Short, and set to work at once by sending Laud and Strafford to the Tower, Hobbes, who had become, or thought he had become, a marked man by the circulation of his treatise (of which, "though not printed, many gentlemen had copies"), instantly took fright and hasted away to Paris. He was now for the fourth and last time abroad, and did not see England again for eleven years. Apparently he remained the greater part of the time in or about Paris, though he can be traced to Rouen in 1646. In Paris he was welcomed back into the old scientific coterie about Mersenne, and forthwith had the task assigned him of criticizing the *Meditations* of Descartes, which had been sent from Holland, before publication, to Mersenne with the author's request for criticism from the most different points of view. Hobbes was soon ready with the remarks that were printed as "Third" among the six (later seven) sets of "Objections" appended, with "Replies" from Descartes, to the *Meditations*, when published shortly afterwards in 1641 (reprinted in *L. W.*, v. pp. 249–74). About the same time also Mersenne sent to Descartes, as if they came from a friend in England, another set of objections which Hobbes had to offer on various points in the scientific treatises, especially the *Dioptrics*, appended by Descartes to his *Discourse on Method* in 1637; to which Descartes replied without suspecting the common authorship of the two sets. The result in both cases was to keep the two thinkers apart rather than bring them together. Hobbes was more eager to bring forward his own philosophical and physical ideas, over which he had now been brooding for ten years, than careful to enter into the full meaning of another's thought; and Descartes was by nature too jealous, and had become too confident in his hard-won conclusions, to be able to bear with this kind of criticism. He was very curt in his replies to Hobbes's philosophical objections, and after a little impatiently broke off all correspondence on the physical questions, writing privately to Mersenne (who had continued to act as intermediary) that he had grave doubts of the Englishman's good faith in drawing him into controversy (*L. W.*, v. pp. 277–307).

Meanwhile Hobbes, however eager he might be to keep himself abreast of the general philosophical movement of the time, had his thoughts too full of the political theory which the rush of events in the last years had ripened within him, to be able to settle, even in Paris, to the orderly composition of his systematic works. Though connected in his own mind with his view of human nature and of nature generally, the political theory, as he always declared, could stand by itself. Also, while he may have hoped at this time to be able to add much (though he never did add much) to the first popular sketch of his doctrine of Man contained in the unpublished "little treatise," he might extend, but could hardly otherwise modify, the sketch he had there given of his carefully articulated theory of Body Politic. Possibly, indeed, before that sketch was written early in 1640, he may, under pressure of the political excitement, have advanced no small way in the actual composition of the treatise *De Cive*, the third section of his projected system. In any case, it was upon this section, before the others, that he set to work as soon as he was fixed in Paris; and before the end of 1641 the book, as we know from the date of the dedication (November 1), was finished. He determined, however, though it was forthwith printed in the course of the year 1642, not to commit himself to formal publication, but was content to circulate a limited number of copies privately;[1] and when he found his work received with great applause by his friends (it was praised even by Descartes), he seems to have taken this recognition of his philosophical achievement as but a reason the more for deferring publication till the earlier works of the system were completed. Accordingly, for the next three or four years, he remained steadily at work, and nothing appeared from him in public except a short treatise on optics (*Tractatus Opticus, L. W.*, v. pp. 217–248) included in the collection of scientific tracts published by Mersenne under the title *Cogitata Physico-Mathematica* in 1644, and a highly compressed statement of his psychological application of the doctrine of motion (*L. W.*, v. pp. 309–318), incorporated with Mersenne's *Ballistica*, published in the same year. Thus or otherwise he had become sufficiently known by 1645 to be chosen, with Descartes, Roberval, and others, a referee in a once famous controversy between Pell, an English mathematician in Amsterdam, and the Dane Longomontanus, over that problem of the quadrature of the circle which was seen later on to have such a fatal charm for himself. But though about this time he had got ready all or most of the materials for his fundamental work on Body, not even now was he able to make way with its composition. New distractions came to tear him away from the orderly execution of the fundamental part of his scheme, and when he returned to it after a number of years, he returned a different man.

The Civil War had broken out in the middle of 1642, and, after a period of varying fortunes on either side, the royalist cause began to decline from the time of the defeat of the marquis of Newcastle at Marston Moor, in the middle of 1644. Then commenced an exodus of the king's friends. Newcastle himself, a cousin of Hobbes's dead master and the patron to whom he dedicated the "little treatise" of 1640, found his way to Paris, and was followed, especially after the decisive defeat at Naseby in June 1645, by an ever increasing stream of fugitives, many of whom were known to Hobbes from former days. The sight of these exiles, from whom he learned all the details of the fierce work that had been going on in England while he was quietly busy with his studies in Paris, made the political interest once more predominant in Hobbes, and before long the revived feeling issued in the formation of a new and important design. It first showed itself in the publication of the *De Cive*, of which the fame, but only the fame, had extended beyond the inner circle of friends and critics who had copies of the original impression. Hobbes now entrusted it, early in 1646, to his admirer, the Frenchman Sorbière, by whom it was seen through the Elzevir press at Amsterdam in 1647,—having previously inserted a number of notes in reply to objections, and also a striking preface, in the course of which he explained its relation to the other parts of the system not yet forthcoming, and the (political) occasion of its having been composed and being now published before them.[2] So hopeless, meanwhile, was he growing of being able to return home that, later on in the year, he was on the point of leaving Paris to take

[1] The book, of which the copies are rare (one in Dr Williams's library in London), was printed in quarto size (Paris, 1642), with a pictorial title-page (not afterwards reproduced) of scenes and figures illustrating its three divisions, "Libertas," "Imperium," "Religio." The title *Elementorum Philosophiæ Sectio Tertia, De Cive*, expresses its relation to the unwritten sections, which also comes out in one or two back-references in the text.

[2] *L. W.*, ii. pp. 133-134. In this first public edition (12mo), the title was changed to *Elementa Philosophica de Cive*, the references in the text to the previous sections being omitted. The date of the dedication to the young earl of Devonshire was altered from 1641 to 1646.

up his abode in the south with a French friend,[1] when he was induced to remain as mathematical instructor to the young prince of Wales, who had come over from Jersey about the month of July. Thus thrown more than ever into the company of the exiled royalists, it was then, if not earlier, that he conceived his new design of bringing all his powers of thought and expression to bear upon the production of an English book that should set forth his whole theory of civil government in relation to the stupendous political crisis resulting from the war. The *De Cive*, presently to be published, was written in Latin for the learned, and gave the political theory without its foundation in human nature. The unpublished treatise of 1640 contained all or nearly all that he had to tell concerning human nature, but was written before the terrible events of the last years had disclosed how men might still be urged by their anti-social passions back into the abyss of anarchy. There was need of an exposition at once comprehensive, incisive, and popular. The State, it now seemed to Hobbes, might be regarded as a great artificial man or monster (*Leviathan*), composed of men, with a life that might be traced from its generation through human reason under pressure of human needs to its dissolution through civil strife proceeding from human passions. This, we may suppose, was the presiding conception from the first, but the design may have been variously modified in the three or four years of its execution. Before the end, in 1650-1, it is plain that he wrote in direct reference to the greatly changed aspect of affairs in England. The king being no more, and the royalist cause appearing to be hopelessly lost, he did not scruple, in closing the work with a general "Review and Conclusion," to raise the question of the subject's right to change allegiance when a former sovereign's power to protect was irrecoverably gone. Also he took advantage of the lax rule of the Commonwealth to indulge much more freely than he might have otherwise dared in rationalistic criticism of religious doctrines; while, amid the turmoil of sects, he could the more forcibly urge that the preservation of social order, when again firmly restored, must depend on the assumption by the civil power of the right to wield all sanctions, supernatural as well as natural, against the pretensions of any clergy, Catholic, Anglican, or Presbyterian, to the exercise of an *imperium in imperio*. We know the *Leviathan* only as it finally emerged from Hobbes's pen. During the years of its composition he remained in or near Paris, at first in attendance on his royal pupil, with whom he became a great favourite. The engagement must in any case have come to an end in the year 1648, when the prince removed to Holland, but it was probably broken off earlier by an illness that overtook Hobbes in 1647 and disabled him for six months. On recovering from this illness, which nearly proved fatal, he resumed his literary task, and carried it steadily forward to completion by the year 1650, having also within the same time translated into English, with characteristic force of expression, his Latin treatise. Otherwise the only thing known (from one or two letters) of his life in those years is that from the year 1648 he had begun to think of returning home; he was then sixty, and might well be weary of exile. When 1650 came, as if to prepare the way for the reception of his *magnum opus*, he allowed the publication of his earliest treatise, divided into two separate small volumes (*Human Nature, or the Fundamental Elements of Policy*, *E. W.*, iv. pp. 1-76, and *De Corpore Politico, or the Elements of Law, Moral and Politic*, pp. 77-228).[2] In 1651[3] he published his translation of the *De Cive* under the title of *Philosophical Rudiments concerning Government and Society* (*E. W.*, ii.). Meanwhile the printing of the greater work was proceeding, and finally it appeared about the middle of the same year, 1651, under the title of *Leviathan, or the Matter, Form, and Power of a Commonwealth, Ecclesiastical and Civil* (*E. W.*, iii.), with a quaint frontispiece in which, from behind hills overlooking a fair landscape of town and country, there towered the body (above the waist) of a crowned giant, made up of tiny figures of human beings and bearing sword and crozier in the two hands. It appeared, and soon its author was more lauded and decried than any other thinker of his time; but the first effect of its publication was to sever his connexion with the exiled royalist party, and to throw him for protection on the revolutionary Government. No sooner did copies of the book reach Paris than he found himself shunned by his former associates, and though he was himself so little conscious of disloyalty that he was forward to present a manuscript copy "engrossed in vellum in a marvellous fair hand"[4] to the young king of the Scots (who, after the defeat at Worcester, escaped to Paris about the end of October), he was denied the royal presence when he sought it shortly afterwards. Straightway, then, he saw himself exposed to a double peril. The exiles had among them desperadoes who could slay; and, besides exciting the enmity of the Anglican clergy about the king, who bitterly resented the secularist spirit of his book, he had compromised himself with the French authorities by his elaborate attack on the papal system. In the circumstances, no resource was left him but secret flight. Travelling with what speed he could in the depths of a severe winter and under the effects of a recent (second) illness, he managed to reach London, where, sending in his submission to the council of state, he was allowed without trouble to subside into private life.

Though Hobbes came back, after his eleven years' absence, without having as yet publicly proved his title to rank with the natural philosophers of the age, he was sufficiently conscious of what he had been able to achieve in *Leviathan*; and it was in no humble mood that he now, at the age of sixty-four, turned to complete the fundamental treatise of his philosophical system. Neither were those whom his masterpiece soon roused to enthusiasm, or those whom it moved to indignation, likely to be indifferent to anything he should now write, whether it lay near to or far from the region of practice. Taking up his abode in London on his return, and continuing to reside there for the sake of intellectual society, even after renewing his old ties with the earl of Devonshire, who lived in the country till the Restoration,[5] he worked so steadily upon the

[1] Described as "nobilis Languedocianus" in *Vit.*; doubtless the same with the "Dominus Verdusius, nobilis Aquitanus," to whom was dedicated the *Exam. et Emend. Math. Hod.* (*L. W.*, iv.) in 1660. Du Verdus was one of Hobbes's profoundest admirers and most frequent correspondents in later years; there are many of his letters among Hobbes's papers at Hardwick.

[2] The *Human Nature* corresponds with cc. i-xiii of the first part of the original treatise. The remaining six chapters of the part stand now as Part I. of the *De Corpore Politico*. Part II. of the *D. C. P.* corresponds with the original second part of the whole work.

[3] At the beginning of this year he wrote and published in Paris a letter on the nature and conditions of poetry, chiefly epic, in answer to an appeal to his judgment made in the preface to Sir W. Davenant's heroic poem, *Gondibert* (*E. W.*, iv. pp. 441-58). The letter is dated Jan. 10, 1650 (165½).

[4] This presentation copy, so described by Clarendon (*Survey of the Leviathan*, 1676, p. 8), is doubtless the beautifully written and finely bound MS. now to be found in the British Museum (Egerton MSS. 1910).

[5] During all the time he was abroad he had continued to receive from his patron a yearly pension of £80, and they remained in steady correspondence. The earl, having sided with the king in 1642, was declared unfit to sit in the House of Peers, and though, by submission to Parliament, he recovered his estates when they were sequestered later on, he did not sit again till 1660. Among Hobbes's friends at this time are specially mentioned Selden and Harvey, who each left him a legacy of £10 on dying, Selden in 1654 and Harvey in 1657. Harvey (not Bacon) is the only Englishman he mentions in the dedicatory epistle prefixed to the *De Corpore*, among the founders, before himself, of the new natural philosophy.

materials he had long had by him as to be printing the *De Corpore* in the year 1654. Circumstances (of which more presently), however, kept the book back till the following year, and meanwhile the readers of *Leviathan* had a different excitement. In 1654 a small treatise, *Of Liberty and Necessity* (*E. W.*, iv. pp. 229–278), issued from the press, claiming to be an answer to a discourse on the same subject by Bishop Bramhall of Londonderry, addressed by Hobbes to the marquis of Newcastle.[1] It was really such, and had grown out of an oral discussion between Hobbes and Bramhall in the marquis's presence at Paris in 1646,—Bramhall, a strong Arminian, having afterwards written down his views and sent them to Newcastle to be answered in this form by Hobbes, and Hobbes having duly replied, but not for publication, because he thought the subject a delicate one. Unpublished, accordingly, the piece remained; but it happened that Hobbes, in the interval between writing his own reply and receiving from the bishop in 1647 a rejoinder which he left unanswered, allowed a French acquaintance to have a private translation of his reply made by a young Englishman, who secretly took also a copy of the original for himself; and now it was this unnamed purloiner who, in 1654, when Hobbes had become famous and feared, gave it to the world of his own motion, with an extravagantly laudatory epistle to the reader in its front. Upon Hobbes himself the publication came as a surprise, but, after his plain speaking in *Leviathan*, there was nothing in the piece that he need scruple to have made known, and he seems to have readily enough condoned the offender's act. On the other hand, Bramhall, supposing Hobbes privy to the publication, might well resent the manner of it, especially as no mention was made of his rejoinder. Accordingly, in 1655, he printed everything that had passed between them (under the title of *A Defence of the True Liberty of Human Actions from Antecedent or Extrinsic Necessity*), with loud complaint against the treatment he had received, and the promise added that, in default of others, he himself would stand forward to expose the deadly principles of *Leviathan*. About this time Hobbes had begun to be hard pressed by other foes, and, being never more sure of himself than upon the question of the will, he appears to have welcomed the opportunity thus given him of showing his strength. By 1656 he was ready with his *Questions concerning Liberty, Necessity, and Chance* (*E. W.*, v.), in which he replied with astonishing force to the bishop's rejoinder point by point, besides explaining the occasion and circumstances of the whole debate, and reproducing (as Bramhall had done) all the pieces from the beginning. As perhaps the first clear exposition and defence of the *psychological* doctrine of determinism, Hobbes's own two pieces must ever retain a classical importance in the history of the free-will controversy; while Bramhall's are still worth study as specimens of scholastic fence. The bishop, it should be added, returned to the charge in 1658 with ponderous *Castigations of Hobbes's Animadversions*, and also made good his previous threat in a bulky appendix entitled *The Catching of Leviathan the Great Whale*. Hobbes never took any notice of the *Castigations*, but ten years later replied to the charges of atheism, &c., made in the non-political part of the appendix, of which he says he then heard for the first time (*E. W.*, iv. pp. 279–384. This *Answer* was first published after Hobbes's death. Bramhall had died, as archbishop of Armagh, in 1663).[2]

We may now follow out the more troublesome conflict, or rather series of conflicts, in which Hobbes became entangled from the time of publishing his *De Corpore* in 1655, and which checkered all his remaining years. In *Leviathan* he had vehemently assailed the system of the universities, as originally founded for the support of the papal against the civil authority, and as still working social mischief by adherence to the old learning. The attack was duly noted at Oxford, where under the Commonwealth a new spirit of scientific activity had begun to stir; and in 1654 Seth Ward, the Savilian professor of astronomy, replying in his *Vindiciæ Academiarum* to some other assaults (then very common) on the academic system, retorted upon Hobbes that, so far from the universities being now what he had known them in his youth, he would find his geometrical pieces, when they appeared, better understood there than he should like. This was said in reference to the boasts in which Hobbes seems to have been freely indulging of having squared the circle and accomplished other such feats; and, when a year later the *De Corpore* (*L. W.*, i.) finally appeared, it was seen how the thrust had gone home. In the chapter (xx.) of that work where Hobbes dealt with the famous problem whose solution he fondly thought he had found, there were left some self-complacent expressions vented against Vindex (Ward) at a time when the solutions still seemed to him good; but the solutions themselves, as printed, were allowed to be all in different ways halting, as he naively confessed he had discovered only when he had been driven by the insults of malevolent men to examine them more closely with the help of his friends. A strange conclusion this, and reached by a path not less strange, as was now to be disclosed by a relentless hand. Ward's colleague, the more famous John Wallis, Savilian professor of geometry, had been privy to the challenge thrown out in 1654, and it was arranged that they should critically dispose of the *De Corpore* between them. Ward was to occupy himself with the philosophical and physical sections, which he did in leisurely fashion, bringing out his criticism in the course of next year (*In Th. Hobbii Philosophiam Exercitatio Epistolica*). Wallis was to confine himself to the mathematical chapters, and set to work at once with characteristic energy. Obtaining an unbound copy of the *De Corpore*, he saw by the mutilated appearance of the sheets that Hobbes had repeatedly altered his demonstrations before he issued them at last in their actual form, grotesque as it was, rather than delay the book longer. Obtaining also a copy of the work as it had been printed before Hobbes had any doubt of the validity of his solutions, Wallis was able to track his whole course from the time of Ward's provocation—his passage from exultation to doubt, from doubt to confessed impotence, yet still without abandoning the old assumption of confident strength; and all his turnings and windings were now laid bare in one of the most trenchant pieces of controversial writing ever penned. Wallis's *Elenchus Geometriæ Hobbianæ*, published in 1655 about three months after the *De Corpore*, contained also an elaborate criticism of Hobbes's whole attempt to relay the foundations of mathematical science in its place within the general body of reasoned knowledge—a criticism which, if it failed to allow for the merit of the conception, exposed only too effectually the utter inadequacy of the result. Taking up mathematics when not only his mind was already formed but his thoughts were crystallizing into a philosophical system, Hobbes had, in fact, never put himself to school and sought to work up gradually to the best knowledge of the time, but had been more anxious from the first to become himself an innovator with whatever insufficient means. The consequence was that, when not spending himself in vain attempts to solve the impossible problems that have always waylaid the fancy of self-sufficient beginners, he took an interest only in the elements of geometry, and never had any notion of the full scope of mathematical science, undergoing as it then was (and not least at the hands of Wallis) the extraordinary development which made it before the end of the century the potent instrument of physical discovery which it became in the hands of Newton. He was even unable, in dealing with the elementary conceptions of geometry, to work out with any consistency the few original thoughts he had, and thus became the easy sport of Wallis. At his advanced age, however, and with the sense he had of his powers, he was not likely to be brought to a better mind by so insulting an opponent. He did indeed, before allowing an English translation of the *De Corpore* (*E. W.*, i.) to appear in 1656, take care to remove some of the worst mistakes exposed by Wallis, and, while leaving out all the references to Vindex, now profess to make, in altered form, a series of mere "attempts" at quadrature; but he was far from yielding the ground to the enemy. With the translation,[3] in the spring of 1656, he had ready *Six Lessons to the*

[1] The treatise bore the date, "Rouen, Aug. 20, 1652," but it should have been 1646, as afterwards explained by Hobbes himself (*E. W.*, v. p. 25).

[2] A little tract by Bishop Laney of Ely, directed against the concluding summary in Hobbes's original statement to Newcastle, was published in 1676, and called forth a printed reply from Hobbes, again addressed to Newcastle (who had meanwhile become duke). This letter is not reprinted by Molesworth.

[3] This translation, *Concerning Body*, though not made by Hobbes, was revised by him; but it is far from accurate, and not seldom, at critical places (*e.g.*, c. vi. § 2), quite misleading. Philosophical citations from the *De Corpore* should always be made in the original Latin. Molesworth reprints the Latin, not from the first edition of 1655, but from the modified edition of 1668—modified, in the mathe-

Professors of Mathematics, one of Geometry, the other of Astronomy, in the University of Oxford (*E. W.*, vii. pp. 181–356), in which, after reasserting his view of the principles of geometry in opposition to Euclid's, he proceeded to repel Wallis's objections with no lack of dialectical skill, and with an unreserve equal to Wallis's own. He did not scruple, in the ardour of conflict, even to maintain positions that he had resigned in the translation, and he was not afraid to assume the offensive by a counter criticism of three of Wallis's works then published. When he had thus disposed of the "Paralogisms" of his more formidable antagonist in the first five lessons, he ended with a lesson on "Manners" to the two professors together, and set himself gravely at the close to show that he too could be abusive. In this particular part of his task, it must be allowed, he succeeded very well; his criticism of Wallis's works, especially the great treatise *Arithmetica Infinitorum* (1655), only showed how little able he was to enter into the meaning of the modern analysis. Wallis, on his side, was not less ready to keep up the game in English than he had been to begin it in Latin. Swift as before to strike, in three months' time he had deftly turned his own word against the would-be master by administering *Due Correction for Mr Hobbes, or School Discipline for not saying his Lessons right*, in a piece that differed from the *Elenchus* only in being more biting and unrestrained. Having an easy task in defending himself against Hobbes's trivial criticism, he seized the opportunity given him by the English translation of the *De Corpore* to track Hobbes again step by step over the whole course, and now to confront him with his incredible inconsistencies multiplied by every new utterance. But it was no longer a fight over mathematical questions only. Wallis having been betrayed originally by his fatal cleverness into the pettiest carping at words, Hobbes had retorted in kind, and then it became a high duty in the other to defend his Latin with great parade of learning and give fresh provocation. One of Wallis's rough sallies in this kind suggested to Hobbes the title of the next rejoinder with which, in 1657, he sought to close the unseemly wrangle. Arguing in the *Lessons* that a mathematical point must have quantity, though this were not reckoned, he had explained the Greek word στίγμη, used for a point, to mean a visible mark made with a hot iron; whereupon he was charged by Wallis with gross ignorance for confounding στιγμή and στίγμα. Hence the title of his new piece:—Στιγμαί Ἀγεωμετρίας, Ἀγροικίας, Ἀντιπολιτείας, Ἀμαθείας, *or Marks of the Absurd Geometry, Rural Language, Scottish Church Politics, and Barbarisms of John Wallis, Professor of Geometry and Doctor of Divinity* (*E. W.*, vii. pp. 357–400). He now attacked more in detail but not more happily than before Wallis's great work, while hardly attempting any further defence of his own positions; also he repelled with some force and dignity the insults that had been heaped upon him, and fought the verbal points, but could not leave the field without making political insinuations against his adversary, quite irrelevant in themselves and only noteworthy as evidence of his own resignation to Cromwell's rule. The thrusts were easily and nimbly parried by Wallis in a reply (*Hobbiani Puncti Dispunctio*, 1657) occupied mainly with the verbal questions. Irritating as it was, it did not avail to shake Hobbes's determination to remain silent; and thus at last there was peace for a time.

Before the strife flamed up again, Hobbes had published, in 1658, the outstanding section of his philosophical system, and thus completed, after a fashion, the scheme he had planned more than twenty years before. So far as the treatise *De Homine* (*L. W.*, ii. pp. 1–132) was concerned, the completion was more in name than in fact. It consisted for the most part of an elaborate theory of vision which, though very creditable to Hobbes's scientific insight, was out of place, or at least out of proportion, in a philosophical consideration of human nature generally. The remainder of the treatise, dealing cursorily with some of the topics more fully treated in the *Human Nature* and the *Leviathan*, has all the appearance of having been tagged in haste to the optical chapters (composed years before)[1] as a makeshift for the proper transition required in the system from questions of Body Natural to questions of Body Politic. Hobbes had in fact spent himself in his earlier constructive efforts, and at the age of seventy, having nothing to add to his doctrine of Man as it was already in one form or another before the world, was content with anything that might stand for the fulfilment of his philosophical purpose. But he had still in him more than twenty years of vigorous vitality, and, not conscious to himself of any shortcoming, looked forward, now his hands were free, to doing battle for his doctrines. Rather than remain quiet, on finding no notice taken of his latest production, he would himself force on a new conflict with the enemy. Wallis having meanwhile published other works and especially a comprehensive treatise on the general principles of calculus (*Mathesis Universalis*, 1657), he might take this occasion of exposing afresh the new-fangled methods of mathematical analysis and reasserting his own earlier positions. Accordingly, by the spring of 1660, he had managed to put his criticism and assertions into five dialogues under the title *Examinatio et Emendatio Mathematicæ Hodiernæ qualis explicatur in Libris Johannis Wallisii*, with a sixth dialogue so called, consisting almost entirely of seventy or more propositions on the circle and cycloid.[2] Wallis, however, would not take the bait. Hobbes then tried another tack. Next year, having solved, as he thought, another ancient *crux*, the duplication of the cube, he had his solution brought out anonymously at Paris in French, so as to put Wallis and other critics off the scent and extort a judgment that might be withheld from a work of his. The artifice was successful, and no sooner had Wallis publicly refuted the solution than Hobbes claimed the credit of it, and went more wonderfully than ever astray in its defence. He presently republished it (in modified form), with his remarks, at the end of a new Latin dialogue which he had meanwhile written in defence of another part of his philosophical doctrine. This was the *Dialogus Physicus, sive De Natura Aeris* (*L. W.*, iv. pp. 233–296), fulminated in 1661 against Boyle and other friends of Wallis who, as he fancied, under the influence of that malevolent spirit, were now in London, after the Restoration, forming themselves into a society (incorporated as the Royal Society in 1662) for experimental research, to the exclusion of himself personally, and in direct contravention of the method of physical inquiry enjoined in the *De Corpore*.[3] All the laborious manipulation recorded in Boyle's *New Experiments touching the Spring of the Air* (1660), which Hobbes chose, without the least warrant, to take as the manifesto of the new "academicians," seemed to him only to confirm the conclusions he had reasoned out years before from speculative principles, and he warned them that if they were not content to begin where he had left off their work would come to nought. To as much of this diatribe as concerned himself Boyle quickly replied with force and dignity, but it was from Hobbes's old enemy that retribution came, in the scathing satire *Hobbius Heauton-timorumenos* (1662). Wallis, who had deftly steered his course amid all the political changes of the previous years, managing ever to be on the side of the ruling power, was now apparently stung to fury by a wanton allusion in Hobbes's latest dialogue to a passage of his former life (his deciphering for the Parliament the king's papers taken at Naseby), whereof he had once boasted but after the Restoration could not speak or hear too little. The revenge he took was crushing. Professing to be roused by the attack on his friend Boyle, when he had scorned to lift a finger in defence of himself against the earlier dialogues, he tore them all to shreds with an art of which no general description can give an idea. He got, however, upon more dangerous ground when, passing wholly by the political insinuation against himself, he roundly charged Hobbes with having written *Leviathan* in support of Oliver's title, and deserted his royal master in distress. Hobbes seems to have been fairly bewildered by the rush and whirl of sarcasm with which Wallis drove him anew from every mathematical position he had ever taken up, and did not venture forth into the field of scientific controversy again for some years, when he had once followed up the physical dialogue of 1661 by seven shorter ones, with the inevitable appendix, entitled *Problemata Physica, una cum Magnitudine Circuli* (*L. W.*, iv. pp. 297–384), in 1662.[4] But all the more eagerly did he take advantage of Wallis's loose calumny to strike where he felt himself safe. His answer to the personal charges took the form of a letter about him-

matical chapters, in general (not exact) keeping with the English edition of 1656. The Vindex episode, referred to in the *Six Lessons*, becomes intelligible only by going beyond Molesworth to the original Latin edition of 1655.

[1] They were composed originally, in a somewhat different and rather more extended form, as the second part of an English treatise on Optics, completed by the year 1646. Of this treatise, preserved in Harleian MSS. 3360, Molesworth otherwise prints the dedication to the marquis of Newcastle, and the concluding paragraphs (*E. W.*, vii. pp. 467–471).

[2] *L. W.*, iv. pp. 1–232. The propositions on the circle, forty-six in number (shattered by Wallis in 1662), were omitted by Hobbes when he republished the *Dialogues* in 1668, in the collected edition of his Latin works from which Molesworth reprints. In the part omitted, at p. 154 of the original edition, Hobbes refers to his first introduction to Euclid, in a way that confirms the story in Aubrey quoted in an earlier paragraph.

[3] Remaining at Oxford, Wallis, in fact, took no active part in the constitution of the new society, but he had been, from 1645, one of the originators of an earlier association in London, thus continued or revived. This earlier society had been continued also at Oxford after the year 1649, when Wallis and others of its members received appointments there.

[4] The *Problemata Physica* was at the same time put into English (with some changes and omission of part of the mathematical appendix), and presented to the king, to whom the work was dedicated in a remarkable letter apologizing for *Leviathan*. In its English form, as *Seven Philosophical Problems and Two Propositions of Geometry* (*E. W.*, vii. pp. 1–68), the work was first published in 1682, after Hobbes's death.

self in the third person addressed to Wallis in 1662, under the title of *Considerations upon the Reputation, Loyalty, Manners, and Religion of Thomas Hobbes* (*E. W.*, iv. pp. 409–440). In this piece, which is of great biographical value, he told his own and Wallis's "little stories during the time of the late rebellion" with such effect that Wallis, like a wise man, attempted no further reply. Thus ended the second bout.

After a time Hobbes took heart again and began a third period of controversial activity, which did not end, on his side, till his ninetieth year. Little need be added to the simple catalogue of the untiring old man's labours in this last stage of his life. The first piece, published in 1666, *De Principiis et Ratiocinatione Geometrarum* (*L. W.*, iv. pp. 385–484), was designed, as the sub-title declared, to lower the pride of geometrical professors by showing that there was no less uncertainty and error in their works than in those of physical or ethical writers. Wallis replied shortly in the *Philosophical Transactions* (August, 1666). Three years later he brought his three great achievements together in compendious form, *Quadratura Circuli, Cubatio Sphæræ, Duplicatio Cubi*, and as soon as they were once more refuted by Wallis, reprinted them with an answer to the objections, in compliment to the grand-duke of Tuscany, who paid him attentions on a visit to England in 1669 (*L. W.*, iv. pp. 485–522). Wallis, who had promised to leave him alone henceforward, refuted him again before the year was out. In 1671 he worked up his propositions over again in *Rosetum Geometricum* (*L. W.*, v. pp. 1–50), as a fragrant offering to the geometrical reader, appending a criticism (*Censura brevis*, pp. 50–88) on the first part of Wallis's treatise *De Motu*, published in 1669; also he sent *Three Papers* to the Royal Society on selected points treated very briefly, and when Wallis, still not weary of confuting, shortly replied, published them separately with triumphant *Considerations on Dr Wallis's Answer to them* (*E. W.*, vii. pp. 429–448). Next year, 1672, having now, as he believed, established himself with the Royal Society, he proceeded to complete the discomfiture of Wallis by a public address to the Society on all the points at issue between them from the beginning, *Lux Mathematica excussa collisionibus Johannis Wallisii et Thomæ Hobbesii* (*L. W.*, v. pp. 89–150), the light, as the author R. R. (Roseti Repertor) added, being here "increased by many very brilliant rays." Wallis replied in the *Transactions*, and then finally held his hand. Hobbes's energy was not yet exhausted. In 1674, at the age of eighty-six, he published his *Principia et Problemata aliquot Geometrica, ante desperata nunc breviter explicata et demonstrata* (*L. W.*, v. pp. 150–214), containing in the chapters dealing with questions of principle not a few striking observations, which ought not to be overlooked in the study of his philosophy. His last piece of all, *Decameron Physiologicum* (*E. W.*, vii. pp. 69–180), in 1678, was a new set of dialogues on physical questions, most of which he had treated in a similar fashion before; but now, in dealing with gravitation, he was able to fire a parting shot at Wallis; and one more demonstration of the equality of a straight line to the arc of a circle, thrown in at the end, appropriately closed the strangest warfare in which perverse thinker ever engaged.[1]

We must now turn back to trace the fortunes of Hobbes and his other doings in the last twenty years of his life. All these controversial writings on mathematics and physics represent but one half of his activity after the age of seventy; though, as regards the other half, it is not possible, for a reason that will be seen, to say as definitely in what order the works belonging to the period were produced. From the time of the Restoration he acquired a new prominence in the public eye. No year had passed since the appearance of *Leviathan* without some indignant protest against the influence which its trenchant doctrine was calculated to produce upon minds longing above everything for civil repose; but it was not until the old political order was set up again that "Hobbism" became a fashionable creed, which it was the duty of every lover of true morality and religion to denounce. Friends and foes alike were impressed by the king's behaviour to the aged philosopher. Two or three days after Charles's arrival in London, Hobbes, who had come up to town from spending the previous winter in Derbyshire, drew in the street the notice of his former pupil, and was at once received into favour. The young king, if he had ever himself resented the apparent disloyalty of the "Conclusion" of *Leviathan*, had not retained the feeling long, and could well enough appreciate the principles of the great book when the application of them happened, as now, to be turned in his own favour. He had, besides, from of old a relish for Hobbes's lively wit, and did not like the old man the less because his presence at court scandalized the bishops or the prim virtue of Chancellor Hyde. He even went the length of bestowing on Hobbes (but not always paying) a yearly pension of £100, and had his portrait hung up in the royal closet. These marks of favour, naturally, did not lessen Hobbes's self-esteem, and perhaps they explain, in his later writings, a certain slavishness of feeling toward the regal authority, which is wholly absent from his rational demonstration of absolutism in the earlier works. At all events Hobbes remained very well satisfied with the rule of a king who had the sense to appreciate the author of *Leviathan*, and to protect him, when after a time protection in a very real sense became necessary. His eagerness to defend himself against Wallis's imputation of disloyalty, and his apologetic dedication of the *Problemata Physica* to the king, are evidence of the hostility with which he was being pressed as early as 1662; but it was not till 1666 that he felt himself seriously in danger. In that year the Great Fire of London, following in ominous succession on the Great Plague of the year before, roused the superstitious fears and intolerant passions of the people, and the House of Commons embodied the general feeling in a bill against atheism and profaneness. On the 17th October it was ordered that the committee to which the bill was referred "should be empowered to receive information touching such books as tend to atheism, blasphemy, and profaneness, or against the essence and attributes of God, and in particular the book published in the name of one White,[2] and the book of Mr Hobbes called the *Leviathan*, and to report the matter with their opinion to the House." What steps were taken before the 31st of January following, when the bill was read a third time and passed, does not appear; but Hobbes, then verging upon eighty, was greatly terrified at the prospect of being treated as a heretic, and proceeded to burn such of his papers as he thought might compromise him. At the same time he set himself, with a very characteristic determination, to inquire into the actual state of the law of heresy. The results of his investigation were first announced in three short Dialogues added (in place of the old "Review and Conclusion," for which the day had passed) as an Appendix to his Latin translation of *Leviathan* (*L. W.*, iii.), included with the general collection of his works published at Amsterdam in 1668. In this appendix, as also in the posthumous tract, published in 1680, *An Historical Narration concerning Heresy and the Punishment thereof* (*E. W.*, iv. pp. 385–408), he aimed at showing that, since the High Court of Commission had been put down, there remained in England no court of heresy at all to which he was amenable, and that even when it stood nothing was to be declared heresy but what was at variance with the Nicene Creed, as he maintained the doctrine of *Leviathan* was not.

The only consequence that came of the parliamentary scare was that Hobbes could never afterwards get permission to print anything on subjects relating to human conduct. The collected edition of his Latin works (in two quarto volumes) appeared at Amsterdam in 1668, because he could not obtain the censor's licence for its publication at London, Oxford, or Cambridge. Other writings which he had finished, or on which he must have been engaged about this time, were not made public till after his death —the king apparently having made it the price of his protection that no fresh provocation should be offered to the

[1] Wallis's pieces were excluded from the collected edition of his works (1693–97), and have become extremely rare.

[2] The *De Medio Animarum Statu* of Thomas White, a heterodox Catholic priest, who contested the natural immortality of the soul. White (who died 1676) and Hobbes were friends.

popular sentiment. The most important of the works composed towards 1670, and thus kept back, is the extremely spirited dialogue to which he gave the title *Behemoth: the History of the Causes of the Civil Wars of England and of the Counsels and Artifices by which they were carried on from the year* 1640 *to the year* 1660.[1] To the same period probably belongs the unfinished *Dialogue between a Philosopher and a Student of the Common Laws of England* (*E. W.*, vi. pp. 1–160), a trenchant criticism of the constitutional theory of English government as upheld by Coke. Aubrey takes credit for having tried to induce Hobbes to write upon the subject in 1664 by presenting him with a copy of Bacon's *Elements of the Laws of England*, and though the attempt was then unsuccessful, Hobbes later on took to studying the statute-book, with *Coke upon Littleton*. One other posthumous production (besides the tract on Heresy before mentioned) may also be referred to this, if not, as Aubrey suggests, an earlier time—the two thousand and odd elegiac verses into which he amused himself by throwing his view of ecclesiastical encroachment on the civil power; the quaint verses, disposed in his now favourite dialogue-form, were first published, nine years after his death, under the title *Historia Ecclesiastica* (*L. W.*, v. pp. 341–408), with a preface by Thomas Rymer.

For some time Hobbes was not even allowed to utter a word of protest, whatever might be the occasion that his enemies took to triumph over him. In 1669 he had silently to bear the spectacle of an unworthy follower—Daniel Scargil by name, a fellow of Corpus Christi at Cambridge—made to act an edifying part in a public recantation of his principles, after having brought them into discredit by offensively supporting them in the public schools. A few years later, in 1674, he had another experience of academic disfavour when Dr John Fell, the dean of Christ Church, who bore the charges of the Latin translation of Anthony Wood's *History and Antiquities of the University of Oxford* (1670), struck out all the complimentary epithets in the account of his life, and substituted very different ones; but this time the king did suffer him to defend himself by publishing a dignified letter (*Vit. Auct.*, pp. xlviii.-l.), to which Fell replied by adding to the translation when it appeared a note full of the grossest insults. And, amid all his troubles, Hobbes was not without his consolations. No Englishman of that day stood in the same repute abroad, and foreigners, noble or learned, who came to England, never forgot to pay their respects to the old man, whose vigour and freshness of intellect no progress of the years seemed able to quench.

His pastimes in the latest years were as singular as his labours. The autobiography in Latin verse, with its playful humour, occasional pathos, and sublime self-complacency, was thrown off at the age of eighty-four. At eighty-five, in the year 1673, he sent forth a translation of four books of the *Odyssey* (ix.–xii.) in rugged but not seldom happily turned English rhymes; and, when he found this *Voyage of Ulysses* eagerly received, he had ready by 1675 a complete translation of both *Iliad* and *Odyssey* (*E. W.*, x.), prefaced by a lively dissertation "Concerning the virtues of an heroic poem," showing his unabated interest in questions of literary style. In that year (1675) he ceased coming to London, and thenceforth passed his time at his patron's seats in Derbyshire, always occupied to the last with some intellectual work in the early morning and in the afternoon hours, which it had long been his habit to devote to thinking and to writing. With such tenacity did he cling to his pursuits (always systematically keeping up exercise for the sake of health) that even as late as August 1679 he was promising his publisher "somewhat to print in English." The end came very soon afterwards. A suppression of urine in October, in spite of which he insisted upon being conveyed with the family from Chatsworth to Hardwick Hall towards the end of November, was followed by a paralytic stroke, under which he sank on the 4th of December, in his ninety-second year. He lies buried in the neighbouring parish church of Hault Hucknall.

In the foregoing sketch the aim has been to give a definite idea of the circumstances in which Hobbes, after slowly developing in the first forty years of his life, displayed a mental activity of such extraordinary variety in his last fifty years. The task of expounding and criticizing either his better-known or his less-known doctrines will not be attempted in this place; but a few remarks may be added as to his position in the general movement of English philosophy. As already suggested, it cannot be allowed that he falls into any regular succession from Bacon; neither can it be said that he handed on the torch to Locke. He was the one English thinker of the first rank in the long period of two generations separating Locke from Bacon, but, save in the chronological sense, there is no true relation of succession among the three. It would be difficult even to prove any ground of affinity among them beyond a disposition to take sense as a prime factor in the account of subjective experience: their common interest in physical science was shared equally by rationalist thinkers of the Cartesian school, and was indeed begotten of the time. Backwards, Hobbes's relations are rather with Galileo and the other inquirers who, from the beginning of the 17th century, occupied themselves with the physical world in the manner that has come later to be distinguished by the name of science in opposition to philosophy. But it happened that, even more than in external nature, Hobbes was interested in the phenomena of social life, presenting themselves so impressively in an age of political revolution. So it came to pass that, while he was unable, by reason of imperfect training and too tardy development, with all his pains, to make any contribution to physical science or to mathematics as instrumental in physical research, he attempted a task which no other adherent of the new "mechanical philosophy" conceived—nothing less than such a universal construction of human knowledge as would bring Society and Man (at once the matter and maker of Society) within the same principles of scientific explanation as were found applicable to the world of Nature. The construction was, of course, utterly premature, even supposing it were inherently possible; but it is Hobbes's distinction, in his century, to have conceived it, and he is thereby lifted from among the scientific workers with whom he associated to the rank of those philosophical thinkers who have sought to order the whole domain of human knowledge. Such as it was, the effects of his philosophical endeavour may be traced on a variety of lines. Upon every subject that came within the sweep of his system, except mathematics and physics, his thoughts have been productive of thought. When the first storm of opposition from smaller men, roused as much by his paradoxical expressions as by his doctrines, had begun to die down, thinkers of real weight, beginning with Cumberland and Cudworth, were moved by his analysis of the moral nature of man to probe anew the question of the natural springs and the rational grounds of human action; and thus it may be said that Hobbes gave the first impulse to the whole of that movement of ethical speculation that, in modern times, has been carried on with such remarkable continuity in England. In politics, the revulsion from his particular conclusions did not prevent the more clear-sighted of his opponents from recognizing the force of his supreme demonstration of the practical irresponsibility of

[1] *E. W.*, vi. pp. 161–418. Though *Behemoth* was kept back at the king's express desire it saw the light, without Hobbes's leave, in 1679, before his death.

the sovereign power, wherever seated, in the state; and, when in a later age the foundations of a positive theory of legislation were laid in England, it was extreme liberals of the school of Bentham—James Mill, Grote, Molesworth—that brought again into general notice the writings of the great publicist of the 17th century, who, however he might, by the force of temperament, himself prefer the rule of one, based his whole political system upon a rational regard to the common weal. Finally, the psychology of Hobbes, though too undeveloped to guide the thoughts or even perhaps arrest the attention of Locke, when essaying the scientific analysis of knowledge, came in course of time (chiefly through James Mill) to be connected with the theory of associationism developed from within the school of Locke, in different ways, by Hartley and Hume; nor is it surprising that the later associationists, finding their principle more distinctly formulated in the earlier thinker, should sometimes have been betrayed into affiliating themselves to Hobbes rather than to Locke.

Sufficient information is given in the *Vitæ Hobbianæ Auctarium* (*L. W.*, i. pp. lxv. *ff.*) concerning the frequent early editions of Hobbes's separate works, and also concerning the works of those who wrote against him, to the end of the 17th century. In the 18th century, after Clarke's *Boyle Lectures* of 1704-5, the opposition was less express. In 1750 *The Moral and Political Works* were collected, with life, &c., by Dr Campbell, in a folio edition, including in order, *Human Nature, De Corpore Politico, Leviathan, Answer to Bramhall's Catching of the Leviathan, Narration concerning Heresy, Of Liberty and Necessity, Behemoth, Dialogue of the Common Laws*, the Introduction to the *Thucydides, Letter to Davenant and two others*, the Preface to the *Homer, De Mirabilibus Pecci* (with English translation), *Considerations on the Reputation, &c., of T. H.* In 1812 the *Human Nature* and the *Liberty and Necessity* (with supplementary extracts from the *Questions* of 1656) were reprinted in a small edition of 250 copies, with a meritorious memoir (based on Campbell) and dedication to Horne Tooke, by Philip Mallet. Molesworth's edition (1839-45), dedicated to Grote, has been referred to in a former note. Of translations may be mentioned *Les Élémens philosophiques du Citoyen* (1649) and *Le Corps politique* (1652), both by Sorbière, conjoined with *Le Traité de la Nature humaine*, by D'Holbach, in 1787, under the general title *Les Œuvres philosophiques et politiques de Thomas Hobbes*; a translation of the first section, "Computatio sive Logica," of the *De Corpore*, included by Destutt de Tracy with his *Élémens d'Idéologie* (1804); a translation of *Leviathan* into Dutch in 1678, and another (anonymous) into German—*Des Engländers Thomas Hobbes Leviathan oder der kirchliche und bürgerliche Staat* (Halle, 1794, 2 vols.); a translation of the *De Cive* by J. H. v. Kirchmann—*T. Hobbes: Abhandlung über den Bürger, &c.* (Leipsic, 1873). No comprehensive monograph on Hobbes's whole philosophical performance has yet been produced. Molesworth had begun to make preparations for writing one when his energies were diverted into practical politics. (G. C. R.)

HOBOKEN, a city and port of entry of the United States, in Hudson county, New Jersey, is situated on the Hudson river, contiguous to Jersey city, which stretches immediately to the south. It lies opposite New York city, ¾ of a mile distant, and occupies a picturesque site at the foot of a steep hill, with a considerable river frontage. The principal public buildings are the Stevens institute of technology, the bequest of the late Commodore Stevens, whose mansion in the Gothic style of architecture is a noteworthy feature of the place; St Mary's Catholic hospital; and the Franklin lyceum association library. The manufactories include iron-foundries and a lead pencil work; and the trade in coal is important. Castle Point and the adjoining "Elysian Fields" afford delightful views of the river, and, before the recent building operations, used to be a favourite resort of the New-Yorkers. The city, which was originally settled by the Dutch, who named it after a village on the Scheldt, was incorporated in 1855. Population in 1870, 20,000; in 1880, 30,999.

HOCHE, Lazare (1768-1797), a French general of the time of the Revolution, was born of poor parents at Montreuil near Versailles, June 25, 1768. At the age of sixteen he enlisted as a private soldier with the intention of proceeding to the East Indies, but was sent instead to a depôt of the Gardes Françaises. Having risen to the rank of sergeant, he, at the outbreak of the Revolution, made an important stand with a mere handful of troops against a large body of insurgents; and it was he also who, at a later period, defended the entrance to the chamber of the queen when her apartments were invaded by a revolutionary mob. He distinguished himself at the siege of Thionville in 1792, and at the battle of Neerwinden, 18th March 1793. Shortly afterwards he received the brevet of general of brigade, and was appointed to the command of Dunkirk, for his brilliant defence of which against the duke of York he received the chief command of the army of the Moselle. The purpose which he originally proposed to himself in this campaign was to cut the communication between the Austrians and Prussians, and, though foiled in this attempt by the superior forces of the duke of Brunswick, he succeeded by a masterly manœuvre in effecting a junction of a portion of his troops with the army of the Rhine, and thus causing the Austrians to evacuate Alsace. Shortly afterwards he was assigned the chief command by the representatives of the people with the two armies, but, this promotion awakening the morbid suspicion of Robespierre, he was recalled and thrown into prison, and it was only the timely fall of Robespierre that saved him from the guillotine. On being released by the convention, he was so successful in pacifying La Vendée and Brittany that he was appointed to the command of the three united armies, numbering in all 100,000 men, in order to apply similar measures for the disarmament of the other departments. After accomplishing this task with an admirable combination of firmness and moderation, he was appointed to the command of an army organized for the conquest of Ireland. The expedition set sail from Brest, 16th December 1796, but was dispersed by a storm, scarcely one half of the vessels escaping shipwreck or capture. In the following year Hoche was sent to the eastern frontier to act against Austria, and by a series of masterly manœuvres he succeeded in surrounding the army of General Kray, and but for a declaration of peace would have taken him and all his troops prisoners of war. Not long after his return he was appointed to the command of the united army in Germany, but eight days afterwards he died suddenly at Wetzlar, 18th September 1797. The belief was widely spread that he had been poisoned, but the suspicion seems to have been without foundation. Though Hoche at his death had not attained the age of thirty, he had already displayed powers, both as politician and as strategist, which, had he lived, would have rendered him a formidable rival of Napoleon, and might have effectually frustrated the latter's unscrupulous ambition.

See *Notes historiques sur la vie morale politique et militaire du général Hoche*, Strasburg, 1798; Rousselin, *Vie de Lazare Hoche, général des armées de la république Française*, Paris, 1798; Dubroca, *Éloge funèbre du général Hoche*, Paris, 1800; *Vie et pensées du général Hoche*, Bern; Champrobert, *Notice historique sur Lazare Hoche, le pacificateur de la Vendée*, Paris, 1840; Dourille, *Histoire de Lazare Hoche*, Paris, 1844; Desprez, *Lazare Hoche d'après sa correspondance*, Paris, 1858.

HODGE, Charles (1797-1878), theologian, was born in Philadelphia, December 28, 1797. He was educated at the college of New Jersey in Princeton, where he graduated in 1815, and afterwards at the theological seminary of the Presbyterian Church in the same place, where he continued a student until 1819; in 1820 he became assistant teacher; and in 1822 he was chosen by the general assembly to be professor of Oriental and Biblical literature there. He spent two years on the Continent, from 1826 to 1828, studying under De Sacy in Paris, under Gesenius and Tholuck in Halle, and under Hengstenberg, Neander, and Humboldt in Berlin. In 1840 he was transferred to the chair of didactic and exegetical theology, to which subjects that of polemic theology was added in 1852, and this office he held to the day of his death. In 1825 he established a quarterly publication entitled the *Biblical Repertory*, designed to furnish translations and reprints of the best contemporaneous foreign essays on theological and religious subjects. On his return from Europe in 1828 he changed it into a vehicle for publishing original theological essays and reviews, and added the words *Princeton Review* to its title. He secured for it the position of theological organ of the old school division of the Presbyterian Church, and continued its principal editor and contributor until 1868. He contributed over 130 articles on subjects ranging through every department of theology and ecclesiology, and all the great practical, ecclesiastical, moral, and national questions of the day. From 1835 to 1868 he wrote yearly an article reviewing the action of each general assembly, which series has exerted a powerful influence over the current opinion and history of the church to which he belonged. The most important of these have been republished in Great Britain and in America, in volumes, under the titles of *Hodge's Essays*, *Princeton Theological Essays*, and *Hodge's Church Polity*. He was made doctor of divinity by Rutgers College, N.J., in 1834, moderator of the general assembly (O.S.) in 1846, member of the committee to revise the *Book of Discipline* of the Presbyterian Church in 1858, and LL.D. by Washington College, Pa., in 1864. April 24, 1872, the fiftieth anniversary of his election to his professorship, was observed in Princeton as his jubilee by between 400 and 500 representatives of his 3000 pupils, when he received congratulatory addresses and letters from all the Presbyterian theological faculties of Scotland and Ireland, and from a majority of those belonging to the various Evangelical churches of America. He continued to instruct his classes uninterruptedly up to the time of his death in Princeton, June 19, 1878. The main characteristics of Hodge were strength and persistence of conviction and of purpose, logical clearness and symmetry of thought and style, energy and effective vigour in the defence of his convictions and in assaults upon what he considered error, sunny cheerfulness of disposition, and humility, tenderness, and gentleness of heart and manner.

Besides his articles in the *Princeton Review*, he published a *Commentary on the Epistle to the Romans*, Phila., 1835, abridged 1836, rewritten and enlarged 1866; *Constitutional History of the Presbyterian Church in the United States*, 2 vols., 1840-41; *The Way of Life*, 1842; Commentaries on *Ephesians*, 1856, 1 *Corinthians*, 1857, 2 *Corinthians*, 1860; *Systematic Theology*, probably the best of all modern expositions of Calvinistic dogmatic, 3 vols., 2200 pp., 1871–73; *What is Darwinism?* 1874; and there have been published since his death *Hodge's Church Polity*, 1878, and *Conference Papers*, 1879.

HODGKINSON, EATON (1789–1861), a distinguished engineer, was the son of a farmer, and was born at Anderton near Northwich, Cheshire, 26th February 1789. He received his first stimulus to the study of mathematics at the grammar school of Northwich, and this interest was further quickened by the instructions of Dr Dalton at Manchester, whither he had removed in 1811, and where, instead of following his original purpose to study for the church, he was assisting his widowed mother to establish a business. For several years he carried on mechanical researches and experiments, but his first discovery of importance was that of a new form of iron girder, by which a gain of two-fifths in strength was obtained over that formerly in use. After this he carried on investigations of a similar character in conjunction with Sir William Fairbairn, who greatly profited by his suggestions and assistance in some of his more important inventions. In 1840 Hodgkinson communicated a paper to the Royal Society on *Experimental Researches on the Strength of Pillars of Cast-iron and other Materials* in recognition of which he in 1841 received the royal medal, and was also elected a fellow. His formulæ for solid and hollow pillars soon obtained general adoption in all engineering class-books. Subsequently he was employed by Stephenson to verify the experiments of Fairbairn on wrought-iron tubes, with a view to the construction of the Britannia Bridge; and for his co-operation in this work he received a silver medal at the Paris Exhibition of 1855. In 1847 he was appointed professor of the mechanical principles of engineering in University College, London. In 1848 he was chosen president of the Manchester Philosophical Society, of which he had been a member since 1826, and to which, both previously and subsequently, he contributed many of the more important results of his discoveries. For several years he took an active part in the discussions of the Institution of Civil Engineers, of which he was elected an honorary member in 1851. He died at Eaglesfield House, near Manchester, 18th June 1861. The name of Hodgkinson will always be associated with those of Fairbairn and Stephenson, and without his assistance it may safely be affirmed that the most brilliant achievements of both would have been impossible.

HÓDMEZÖ-VÁSÁRHELY, a corporate town in the county of Csongrád, Hungary, is situated on the lake Hód, and on the Alföld Railway, about 90 miles S.E. of Budapest, 46° 27′ N. lat., 20° 22′ E. long. The town is large and rapidly improving, and has many public buildings. Of these the most noteworthy are the town-hall, the Roman Catholic, Greek, and Protestant (one Lutheran and two Calvinist) churches, the Jews' synagogue, the Protestant gymnasium, and the royal law courts. Hódmezö-Vásárhely possesses also many elegant private residences, two hospitals, two banks, and several literary institutions, and has a flourishing trade. The soil of the surrounding country is exceedingly fertile, the chief products being wheat, mangcorn, barley, oats, millet, maize, and various descriptions of fruit, especially melons. Extensive vineyards, yielding large quantities of both white and red grapes, skirt the town, which has also a fine public garden. The horned cattle and horses of Hódmezö-Vásárhely are considered the best in the Alföld; sheep and pigs are also extensively reared. The commune is protected from inundations of the Theiss by an enormous dike, but the town, nevertheless, sometimes suffers considerable damage during the spring floods. In 1870 the population was 49,153, chiefly Magyars.

HODOGRAPH is the name given to a geometrical construction which greatly facilitates the study of kinematical questions. It was invented by Sir William Rowan Hamilton about 1845, and the first account of it, written by him, is to be found in the *Proc. R. I. A.* for 1846.

The hodograph may be thus defined:—If a point be in motion in any orbit and with any velocity, and if, at each instant, a line be drawn from a fixed point parallel and equal to the velocity of the moving point at that instant, the extremities of these lines will lie on a curve called the hodograph. Let PP_1P_2 be the path of the moving point, and let OT, OT_1, OT_2, be drawn from the fixed point O parallel and equal to the velocities at P, P_1, P_2 respectively, then the locus of T is the hodograph of the orbit described by P (fig. 1).

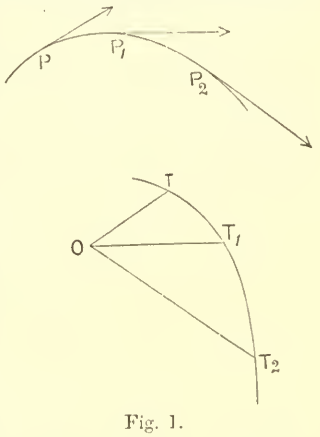


Fig. 1.

From this definition we have the following important fundamental property which belongs to all hodographs, viz., that at any point the tangent to the hodograph is parallel to the direction, and the velocity in the hodograph equal to the magnitude of the resultant acceleration at the corresponding point of the orbit. This will be evident if we consider that, since radii vectores of the hodograph represent velocities in the orbit, the elementary arc between two consecutive radii vectores of the hodograph represents the velocity which must be compounded with the velocity of the moving point at the beginning of any short interval of time to get the velocity at the end of that interval, that is to say, represents the change of velocity for that interval. Hence the elementary arc divided by the element of time is the rate of change of velocity of the moving-point, or in other words, the velocity in the hodograph is the acceleration in the orbit.

Analytically thus (Thomson and Tait, *Nat. Phil.*):—Let x, y, z be the coordinates of P in the orbit, ξ, η, ζ those of the corresponding point T in the hodograph, then

$$\xi=\frac{dx}{dt}\,,\quad \eta=\frac{dy}{dt}\,,\quad \zeta=\frac{dz}{dt}\,;$$

therefore

$$\frac{d\xi}{\frac{d^2x}{dt^2}}=\frac{d\eta}{\frac{d^2y}{dt^2}}=\frac{d\zeta}{\frac{d^2z}{dt^2}}\quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Also, if s be the arc of the hodograph,

$$\frac{ds}{dt}=v=\sqrt{\left(\frac{d\xi}{dt}\right)^2+\left(\frac{d\eta}{dt}\right)^2+\left(\frac{d\zeta}{dt}\right)^2}\,,$$

$$=\sqrt{\left(\frac{d^2x}{dt^2}\right)^2+\left(\frac{d^2y}{dt^2}\right)^2+\left(\frac{d^2z}{dt^2}\right)^2}\quad . \quad . \quad (2).$$

Equation (1) shows that the tangent to the hodograph is parallel to the line of resultant acceleration, and (2) that the velocity in the hodograph is equal to the acceleration.

Every orbit must clearly have a hodograph, and, conversely, every hodograph a corresponding orbit; and, theoretically speaking, it is possible to deduce the one from the other, having given the other circumstances of the motion. We give a few examples:—

1. For uniform motion in a straight line the hodograph is easily seen to be a point.

2. For uniform or variable acceleration in a straight line the hodograph is the line described by a point moving with uniform or variable velocity.

3. For uniform circular motion the hodograph is also a circle. In this case it may be useful to show how the conception of the hodograph leads easily to the ordinary expression for the so-called centrifugal force.

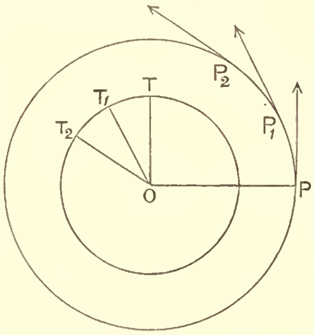


Fig. 2.

Let P (fig. 2) describe the circumference PP_1P_2 with uniform velocity v, and from the centre O draw OT, OT_1, OT_2, &c., equal to each other and parallel to the tangents at P, P_1, P_2 respectively, then TT_1T_2 is the hodograph circle. Also let a equal the acceleration of P, which also equals the velocity of T; then, since T describes the hodograph uniformly in the same time that P describes the orbit, we have

$$\frac{v}{a}=\frac{OP}{OT}=\frac{r}{v}\quad \therefore\ a=\frac{v^2}{r}\,.$$

It is evident that the tangent at T is parallel to PO the direction of acceleration at P.

4. For simple harmonic motion the hodograph is also simple harmonic motion, and similarly for elliptic harmonic motion. For the former we have

$$s=a\cos(nt+\epsilon)\,;$$

$$\therefore\ v=\dot{s}=-na\sin(nt+\epsilon)=na\cos(nt+\epsilon+\tfrac{1}{2}\pi)\,;$$

which indicates simple harmonic motion with changed amplitude and phase.

5. For parabolic motion the hodograph is a straight line.

Let OF (fig. 3) be the velocity of projection. Resolve it vertically and horizontally; the horizontal component OH is constant, so that the hodograph must be the vertical line FHT. The velocity at any point P of the parabola is evidently represented by the line OT drawn parallel to the tangent at P.

Analytically thus:—If x, y be the coordinates of the moving point and ξ and η those of the hodograph, we have

$$\ddot{x}=0\,,\ \ddot{y}=-f\ (f \text{ being the vertical acceleration})\,;$$

$$\therefore\ \dot{\xi}=0\,,\ \dot{\eta}=-f\,;$$

$$\therefore\ \xi=c\,,\quad \eta=c'-ft,$$

which indicates a vertical straight line described with uniform velocity f.

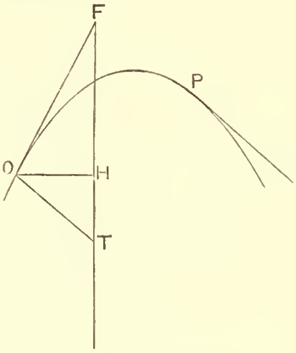


Fig. 3.

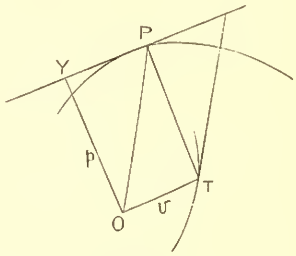


Fig. 4.

6. For central forces the hodograph will vary with the law of acceleration towards the centre. Hamilton showed that, for the Newtonian law of the inverse square of the distance, the hodograph is always a circle, and for that reason he designated that law the *law of the circular hodograph.*

Assuming the centre of force as origin for the hodograph, we see that, from definition, the tangent and radius vector at any point P of the orbit are respectively parallel to the radius vector and tangent at the corresponding point T of the hodograph (fig. 4). These four lines thus enclose a parallelogram PT, whose shape is constantly changing, although its area is constant, being equal to the constant rectangle YT contained by the velocity and the perpendicular on the tangent. As usual, let $TY=vp=h$. Also the angle between two consecutive tangents to the hodograph is equal to the angle between the corresponding radii vectores of the orbit, and hence, if θ be the angle between OP and some initial line, and s the arc of the hodograph, the ordinary formula for curvature gives

$$\frac{1}{\rho}=\frac{d\theta}{ds}=\frac{\dot{\theta}}{\dot{s}}\,;$$

but

$$h=r^2\dot{\theta}\,,$$

and $\dot{s}$ = velocity in hodograph = acceleration in orbit = P (say);

$$\therefore\ \frac{1}{\rho}=\frac{hr^{-2}}{P}\,;$$

$$\therefore\ \rho=\frac{Pr^2}{h}\quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)\,;$$

a most useful expression for the radius of curvature of the hodograph to any central orbit.

If the acceleration vary inversely as the square of the distance, $P=\frac{M}{r^2}$, where M is the mass at the centre acting upon unit mass in the orbit. Substituting in (3), we get

$$\rho=\frac{M}{h}=\text{constant}.$$

Hence, for this law of force, and evidently for it only, the hodograph is a circle.

Assuming that the hodograph is a circle, we can show that the orbit for this law of force must be a conic section. Let CTB (fig. 5) be the hodograph circle, O the origin, and H the centre; and let the ratio $\frac{OH}{HT}=\epsilon$. Draw OP parallel to the tangent at T and, therefore, perpendicular to TG. Take OP such that the parallelogram contained by OP and OT = a constant = h. Draw OA perpendicular to CB; and let POA = θ; then,

$$OP\,.\,TG=h\,;$$

$$\therefore\ OP\,.\,(TH+HG)=h\,;\ \text{but}\ TH=\rho=\frac{M}{h},\ \text{and}$$

$$HG=HO\cos\theta=\epsilon\rho\cos\theta=\frac{\epsilon M}{h}\cos\theta\,;$$

$$\therefore\ OP\left(\frac{M}{h}+\epsilon\frac{M}{h}\cos\theta\right)=h\,;$$

$$\therefore\ OP=r=\frac{h^2}{M}\cdot\frac{1}{1+\epsilon\cos\theta}\,.$$

Hence the locus of P is a conic section whose semi-parameter is $\frac{h^2}{M}$. If $\epsilon < 1$, O is within the circle and the orbit is an ellipse; if $\epsilon = 1$, O is on the circumference and the orbit is a parabola; and if $\epsilon > 1$, O is without the circle and the orbit is an hyperbola.

Two values of the potential, V, can readily be found from the above:—

$$V = \frac{M}{r}\text{ ; but } r = \frac{h}{TG}\text{ ;}$$

$$\therefore\ V = \frac{M}{h}\ .\ TG = TH\ .\ TG\ .$$

Also, since OGH is a right angle, V = TH . TG = the square of the tangent from T to the circle described on HO as diameter.

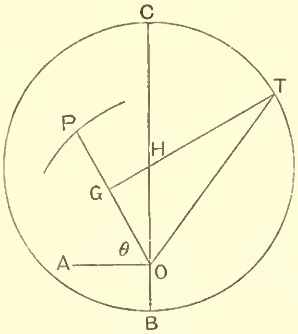


Fig. 5.

A beautiful result connected with the hodograph, and one which has attracted the attention of several of the ablest mathematicians, was communicated by Sir William Hamilton to the Royal Irish Academy in March 1847. It is called the theorem of hodographic isochronism, and is thus stated:—If two circular hodographs, having a common chord, which passes through, or tends towards, a common centre of force, be cut perpendicularly by a third circle, the times of hodographically describing the intercepted arcs will be equal. A purely quaternion proof is given of this theorem by Hamilton in his *Elements*, and, following the hints given by that method, he has also indicated the following geometrical proof.

Let TMT′M′, WMW′M′ (fig. 6), be the two hodographic circles with centres H and L and common chord MM′. Let P, P′, on the common chord produced, be the centres of two circles WTW′T′ and BAB′A′, near each other, which cut the hodographs orthogonally. Let O be the centre of force, OZ perpendicular to the tangent at T, and TR, T′R′ perpendicular to SX. Also let AT mean the arc AT, and similarly for the other small arcs. Draw PY perpendicular to PT.

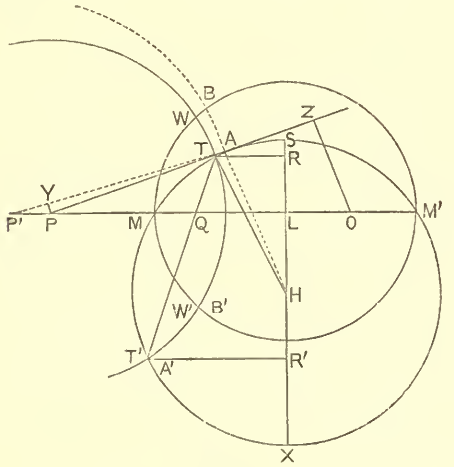


Fig. 6.

From similar triangles THA and TPY we have

$$\frac{AT}{TH} = \frac{PY}{PT}\ ;$$

also from similar triangles THR and PP′Y

$$\frac{TH}{TR} = \frac{PP'}{PY}\ \therefore\ \frac{AT}{TR} = \frac{PP'}{PT}\ ;$$

$$\therefore\ AT = \frac{PP'\ .\ TR}{PT}\ .$$

Similarly, $$A'T' = \frac{PP'\ .\ T'R'}{PT}\ .$$

If t and t' be the times of hodographically describing the arcs AT and A′T′ respectively,

$$t = \frac{AT}{Mr^{-2}} = \frac{M\ .\ AT}{M^2r^{-2}} = \frac{M\ .\ AT}{V^2}\ \text{(if V be the potential at T).}$$

But V = HT . OZ = OP . TR from similar triangles OPZ and THR;

$$\therefore\ t = \frac{M\ .\ AT}{OP^2\ .\ TR^2} = \frac{M\ .\ PP'\ .\ TR}{OP^2\ .\ TR^2\ .\ PT} = \frac{M\ .\ PP'}{OP^2\ .\ PT\ .\ TR}\ .$$

Similarly,

$$t' = \frac{M\ .\ PP'\ .\ T'R'}{OP^2\ .\ T'R'^2\ .\ PT} = \frac{M\ .\ PP'}{OP^2\ .\ PT\ .\ T'R'}\ .$$

$$\therefore\ t + t' = \frac{M\ .\ PP'}{OP^2\ .\ PT}\left\{\frac{1}{TR} + \frac{1}{T'R'}\right\} = \frac{2M\ .\ PP'}{OP^2\ .\ PT}\left\{\frac{TR + T'R'}{2TR\ .\ T'R'}\right\}.$$

Now $\frac{2TR\ .\ T'R'}{TR + T'R'}$ = the harmonic mean between TR and T′R′ = QL ;

$$\therefore\ t + t' = \frac{2M\ .\ PP'}{OP^2\ .\ PT\ .\ QL}\ .$$

From this expression we see that the time of describing the two small arcs TA and T′A′ is independent of the radius of the hodograph and the distance of its centre from L. Hence it is equal to the time of describing the two arcs BW and B′W′. By continuing the process of drawing orthogonals we arrive at the conclusion that the time of describing the whole arc ATT′A′ is equal to the time of describing the arc BWW′B′. A very simple analytical proof is given in Tait and Steele's *Dynamics of a Particle*. Others not so simple by Cayley and Droop are to be found in the *Quarterly Journal of Mathematics*. We can only mention that the theorem of Lambert can be deduced from the above theorem of hodographic isochronism without using any property of conic sections.

Sir William Hamilton has observed that we have a good instance of a hodograph in the curve of aberration of a star, which is merely the hodograph of the earth's annual motion. The fact that this curve is a circle in a plane parallel to the earth's orbit, abstracted, however, from the general idea of the hodograph, was known long before the date of the hodograph. It will be found clearly stated and proved in Woodhouse's *Astronomy*, of date 1821, and from allusions there it appears to have been known even earlier. As an application of the hodograph, Thomson and Tait point out that the heat and light received by a planet from the sun in any time are proportional to the corresponding arc of the hodograph.

See *Proc. Roy. Irish Acad.*, 1846; Hamilton's *Elements of Quaternions*; Tait, *Proc. R. S. E.*, 1867-8; Tait's *Quaternions*; Thomson and Tait, *Nat. Phil.* (J. BL.)

HODY, Humphrey (1659-1706), an English divine, was born at Odcombe in Somersetshire in 1659. In 1676 he entered Wadham College, Oxford, of which, having proceeded M.A. in 1682, he became fellow in 1684. Previously he had published in 1680 *Dissertatio contra Historiam Aristeæ de LXX. Interpretibus*, in which he showed that the so-called letter of Aristeas, containing an account of the production of the Septuagint, was the late forgery of a Hellenist Jew originally circulated to lend authority to that version. The dissertation was generally regarded as conclusive, although Vossius published an angry and scurrilous reply to it in the appendix to his edition of Pomponius Mela. In 1689 Hody wrote the "Prolegomena" to the chronicle of John Malala, published at Oxford in 1691. The following year he became chaplain to Stillingfleet, bishop of Worcester, and, on account of his supporting the ruling party in a controversy with Dodwell regarding the nonconforming bishops, he was appointed chaplain to Archbishop Tillotson, an office which he continued to hold under Tenison. In 1698 he was appointed regius professor of Greek in the university of Oxford, and in 1704 he was promoted to the archdeaconry of Oxford. In 1701 he published *History of English Councils and Convocations*, and in 1704 in four volumes *De Bibliorum textis originalibus*, in which he included his original work on the Septuagint, and published a reply to the attack of Vossius. He died 20th January 1706. A work, *De Græcis Illustribus*, which he left in manuscript, was published in 1742 by Dr Jebb, who prefixed to it a Latin dissertation.

HOF, originally Regnitzhof, a town of Bavaria, circle of Upper Franconia, is beautifully situated on the Saale, on the north-eastern spurs of the Fichtelgebirge, and at the junction of several railways, 30 miles N.N.E. of Baireuth. It is the seat of district, town, country, and commercial courts, a chamber of commerce, and a head tax office. It is surrounded by walls, and has one Catholic and three Protestant churches, a town-house of 1563 in the Gothic style, a gymnasium with an extensive library, a trade and commercial school, a female school of the higher grade, a people's school, an orphanage, a richly endowed hospital founded in 1262, and an infirmary. Its industries are chiefly connected with wool and cotton, and include woollen, cotton, and jute spinning, jute weaving, and the manufacture of cotton and half-woollen fabrics. It has also dye-works, flour-mills, saw-mills, breweries, iron-works, and manufactures for machinery, iron and tin wares, chemicals, and sugar. In the neighbourhood there are large marble quarries and extensive iron mines. The population in 1875 was 18,122.

Hof was built about 1080, on the site of an old robber castle. Originally it belonged to the empire, but afterwards it was held by the dukes of Meran, and then by the counts of Orlamünde, until it was sold in 1373 to the counts of Nuremberg. The cloth manufacture introduced into it in the 15th century, and the manufacture of veils, begun in the 16th century, greatly promoted its prosperity, but it suffered severely in the Albertine and Hussite wars, as well as in the Thirty Years' War; and in 1823 the greater part of it was destroyed by fire. In 1792 it came into the possession of Prussia; in 1806 it fell to France; and in 1810 it was incorporated with Bavaria. See Widmann, *Chronik der Stadt Hof*, 1844; Ernst, *Geschichte und Beschreibung des Bezirks und der Stadt Hof*, 1866.

HOFER, Andreas (1767–1810), a Tyrolese patriot, was born October 2, 1767, at St Leonhard, in the Passeyr valley. There his father kept a tavern called the Sandhof, which Hofer inherited, and on that account he was popularly known as the "Sandwirth." In addition to this he carried on a trade in wine and horses with the north of Italy, acquiring a high reputation for intelligence and honesty. On the outbreak of the war in 1796, he commanded a company of riflemen against the French at Lake Garda, and after the peace of Lunéville he took an active part in organizing the Tyrolese militia. After the treaty of Presburg (1805), by which Tyrol was transferred from Austria to Bavaria, Hofer was chosen a member of the secret Tyrolese deputation which went to Vienna to confer with the emperor on the condition of their country; and when, on the advice of Austria, the whole of Tyrol in April 1809 rose in arms, Hofer was chosen to the command of a large division of the insurgents, and inflicted an overwhelming defeat on the Bavarians at Sterzing. Reinforcements sent by Napoleon defeated the Austrians at Woergl and the Tyrolese at Feuersinger, but Hofer coming to the rescue of his country repulsed the Bavarians with great loss at Innsbruck. Notwithstanding also that Austria after Napoleon's victory at Wagram agreed to evacuate Tyrol, Hofer resolved to maintain the struggle, and on the 13th August, at Berg Isel, routed with great slaughter a combined French and Bavarian force, and completely freed his country from foreign dominion. For some time the internal affairs of Tyrol were administered by an independent Government of which Hofer was the head, but after the peace of Vienna the Bavarians again endeavoured to assert their supremacy, and after a heroic resistance Hofer was compelled to flee for safety to the mountains. A price was set upon his head, and on account of the treachery of one of his most trusted followers, he was captured, January 27, 1810, in a châlet in the Passeyr valley. He was sent to Mantua for trial, and on the 20th February, by the orders of Napoleon, was executed twenty-four hours after his condemnation. In 1823 his remains were removed from the place of sepulture at Mantua to Innsbruck, where they were interred in the Franciscan church, and in 1834 a marble statue was erected over his tomb. In 1819 the patent of nobility decreed for him by Austria in 1809 was conferred upon his family by the title of Von Passeyr.

See *Leben und Thaten des ehemaligen Tyroler Insurgenten-Chefs Andr. Hofer*, Berlin, 1810; *Andr. Hofer und die Tyroler Insurrection im Jahre* 1809, Munich, 1811; Hormayr, *Geschichte Andr. Hofer's Sandwirths auf Passeyr*, Leipsic, 1845; B. Weber, *Das Thal Passeyr und seine Bewohner mit besonderer Rücksicht auf Andreas Hofer und das Jahr* 1809, Innsbruck, 1851; Rapp, *Tirol im Jahr* 1809, Innsbruck, 1852; Heigel, *Andreas Hofer*, Munich, 1874. His history has supplied the materials for tragedies to B. Auerbach and Immermann.

HOFFMANN, August Heinrich (1798–1874), known as Hoffmann von Fallersleben, German poet, philologist, and historian of literature, was born at Fallersleben, in Lüneburg, April 2, 1798. He was educated at Helmstädt and Brunswick, and afterwards at the universities of Göttingen and Bonn. His original intention was to study theology, but he soon devoted himself entirely to literature. In 1823 he was appointed librarian to the university of Breslau, a post which he held till 1838. He was made extraordinary professor of the German language and literature at the university in 1830, and full professor in 1835; but he was deprived of his chair in 1842 in consequence of his *Unpolitische Lieder*, which gave much offence to the ruling classes of Prussia. He then travelled for some time in Germany, Switzerland, and Italy, and lived for two or three years in Mecklenburg, of which he became a naturalized citizen. The revolution of 1848 brought him back to Prussia, where he was restored to his rights, and received as a pension the "Wartegeld," that is, the salary attached to a promised office which is not yet vacant. He married in 1849, and during the next ten years lived first in Bingerbrück, afterwards in Neuwied, and then in Weimar, where he was one of the editors of the *Weimarische Jahrbuch*. In 1860 he became librarian to the duke of Ratibor, and he retained this appointment till his death on the 20th of January 1874. Fallersleben was one of the best popular poets of modern Germany. In politics he ardently sympathized with the progressive tendencies of his time, and he was among the earliest and most effective of the political poets who prepared the way for the outbreak of 1848. As a poet, however, he acquired distinction chiefly by the ease, simplicity, and grace with which he gave expression to the passions and aspirations of ordinary life. Although he had not been scientifically trained in music, he composed melodies for many of his songs, and a considerable number of them are sung by all classes in every part of Germany.

The best known of his poetical writings is his *Gedichte* (8th edition, Berlin, 1874); but there is great merit also in his *Alemannische Lieder* (5th edition, Mannheim, 1843), *Soldatenlieder* (Mainz, 1851), *Soldatenleben* (Berlin, 1852), *Rheinleben* (Neuwied, 1865), and in his *Fünfzig Kinderlieder*, *Fünfzig Neue Kinderlieder*, and *Alte und Neue Kinderlieder*. His *Unpolitische Lieder*, *Deutsche Lieder aus der Schweiz*, and *Streiflichter* are not without poetical value, but they are mainly interesting in relation to the practical movements of the age in which they were written. As a student of ancient Teutonic literature Fallersleben ranks among the most persevering and cultivated of German scholars, some of the chief results of his labours being embodied in his *Horæ Belgicæ*, *Fundgruben für Geschichte deutscher Sprache und Literatur*, *Altdeutsche Blätter*, *Spenden zur deutschen Literaturgeschichte*, and *Findlinge*. Among his editions of particular works may be named *Reineke Vos*, *Monumenta Elnonensia*, and *Theophilus*. *Die Deutsche Philologie im Grundriss* (1836) was at the time of its publication a valuable contribution to philological research, and historians of German literature still attach importance to his *Geschichte des deutschen Kirchenliedes bis auf Luther* (1832; 3d ed., 1861), *Unsere volksthümlichen Lieder* (3d ed., 1869), and *Die deutschen Gesellschaftslieder des 16 und 17 Jahrh.* (2d ed., 1860). In 1868–70 Fallersleben published in 6 vols. an autobiography, *Mein Leben: Aufzeichnungen und Erinnerungen*. See also *Briefe von Hoffmann von Fallersleben und Moritz Haupt an Ferdinand Wolf* (Vienna, 1874); Wagner, *Hoffmann von Fallersleben*, 1818–68 (Vienna, 1869); and Gottschall, *Porträts und Studien* (vol. v., Leipsic, 1876).

HOFFMANN, Ernst Theodor Wilhelm (1776–1822), German romance writer (for whose name Wilhelm his own substitute, in homage to Mozart, was Amadeus), was born at Königsberg, January 24, 1776. His parents, who lived unhappily together, separating a year or two after his birth, he was brought up in his grandmother's house, under the care of a bachelor uncle. His relations seem to have been fairly puzzled at the waywardness, cunning, and precocity of the boy, who neglected his school lessons and hated routine, but applied himself with passionate zest to the study of music and painting, extemporized marvellously on the harpsichord, and with his pencil caricatured friend and foe alike with terrible facility. Incited by his friend Hippel, Hoffmann on leaving school turned to the hereditary profession of the law; but, as no immediate post offered itself, he gave lessons in music and painting, and wrote two novels, for which he could not find a publisher. A discreditable love episode with one of his pupils drove him at this time from Königsberg, and he went to act as assistant to another lawyer uncle at Gross-Glogau in Silesia. In 1798 he became referendary in the supreme court at Berlin, and in 1800 passed his final examination and was appointed assessor to the court of Posen. Here he seems to have led a dissipated life, and to have contracted the habit of excessive drinking which marred his whole career. He subsequently made enemies in Posen by sending a series of scandalous caricatures for distribution at a masquerade ball, and his appointment was on this account changed to a councillorship at Plozk, where, having married ere this time, he spent two years in retirement, studying in his leisure hours the theory of music, translating Italian poetry, and sketching plans for future literary work; but in 1804, again in favour at headquarters, he was transferred as councillor to Warsaw. There he found a true friend in Hitzig, his colleague, and made the acquaintance of Werner, at whose request he set music to some parts of the *Kreuz an der Ostsee*. He soon became the centre of musical society in Warsaw, helped to institute a concert-house or "Ressource," found leisure not only to paint its saloons but to compose music for its orchestra, and was actually conducting this orchestra before enthusiastic audiences when Warsaw was taken by the French in 1806. For some time he lingered in Warsaw; but in the spring of 1807, having recovered from a fever to find himself almost penniless, he returned to Berlin to seek some means of livelihood. His only child died in Posen while he was in Berlin; and, though he succeeded in obtaining the post of music-director to the Bamberg theatre, the theatre soon after became bankrupt, and Hoffmann was once more destitute. He now found occasional employment as a composer of operatic music, and, as a last resource, attempted authorship. The editor of the *Allgemeine Musikalische Zeitung* enlisted his services, and in that paper appeared a series, afterwards published, with a preface by Jean Paul Richter, as *Fantasiestücke in Callots Manier* (1814; 4th ed., 1864). He composed at this time, among other things, a *Miserere* by order of the grand-duke of Würzburg, and, for the proprietors of the Bamberg theatre, music to Kotzebue's opera *Das Gespenst*; and he also gave lessons in music and drawing, decorated saloons, and painted portraits to order. The misery of his condition was enhanced by his wife's illness and his own light-hearted recklessness. The money which he inherited at the death of his uncle did not suffice to pay his debts; and he had been reduced to selling his last coat for food when his friends obtained for him the post of music-director to another theatrical company, performing alternately at Dresden and Leipsic. Hoffmann was writing romances in a garret in Dresden, or, bedridden by gout, was drawing caricatures of the "verwünschte Franzosen" while Napoleon and the allied armies were struggling round its walls. In 1814 appeared his *Vision auf der Schlachtfelde von Dresden*; and in the same year, on the fall of Napoleon, he returned to Berlin, and was reinstated in the legal profession. Two years later he was appointed councillor in the supreme court, and from that time enjoyed a good income, a dignified position, and the society of his best friends. He was already, in virtue of his *Fantasiestücke*, regarded as one of the most notable romance writers of his day, but most of his works were yet to come. These followed each other in quick succession. *Die Elixire des Teufels* appeared in 1816; *Nachtstücke* in 1817; *Seltsame Leiden eines Theaterdirektors* in 1818; *Die Serapionsbrüder*, a collection of tales, in 1819–24; *Klein Zaches, genannt Zinnober*, in 1819; *Prinzessin Brambilla* in 1821; *Meister Floh* in 1822; and *Lebensansichten des Katers Murr* in 1821–22. He also composed the opera *Undine*, the libretto of which was prepared by Fouqué himself. It was performed with success in Berlin; but the music was lost in the subsequent destruction of the opera-house by fire. Hoffmann's prospects in Berlin were ruined by the old habit of intemperance, which had grown upon him during the years of his poverty. We are told that his legal duties were scrupulously performed, and that the remainder of his day was spent in literary work, but that, when this was over, he avoided refined society, and his nights became a series of wild pothouse revels. His health soon gave way; and, after intense suffering from spinal paralysis, he died at Berlin, July 24, 1822. *Der Feind*, his last work, remained unfinished.

Versatility is the chief characteristic of Hoffmann's genius, and it is also its greatest weakness. He is admitted to have been an excellent jurist. His paintings were clever, though fantastic. He was a popular composer and a brilliant romance-writer. But this very versatility prevented his rising to eminence in any one vocation; and, even as a romance-writer, in which capacity he will be longest remembered, he was deficient in some of the highest attributes. His imagination was unbounded, his wit light and acrid, his dialogue stirring. His descriptive passages, in their minute vividness, have been compared to those of Sir Walter Scott, and his romances abound in the superstitious and mythical, that dæmonic element which is so peculiarly German, and which in Hoffmann amounted almost to a frenzy. But, with all this, a perusal of his writings leaves a disagreeable impression on the mind, a feeling of dissatisfaction and unrest. They are the production of a misdeveloped nature, of a man full of feverish impulses, oddities, and weakness, not devoid of tenderness, but whose temper was unforgiving and malicious, whose prevailing mood was the sarcastic, and whose only religious creed was a blind, headlong fatalism. There is also a strong element in his writings which Carlyle in his biography of Hoffmann has called "playerlike," a glitter which is of tinsel, a something "false, brawling, and tawdry." His writings, like his character, are a curious mixture of what is really beautiful and rare with much that is petty and sordid. Their cleverness is irresistible; but the dignity of true greatness is not there.

Die Elixire der Teufels, his longest completed work, contains in a narrative form some of his own wildest and most revolting delusions; and the derisive *Kater Murr*, of which the third volume is wanting, is not less characteristic. Some of his smaller pieces have justly been thought the most pleasing and perfect of his works. Among these are *Der goldene Topf*, *Das Fräulein von Scudery*, *Doge und Dogaresse*, and *Meister Martin und seine Gesellen*. The delicacy and finish of the last, slight though it is, have stamped it as Hoffmann's masterpiece.

A life of Hoffmann has been written by Hitzig, his colleague first in Warsaw and afterwards in Berlin, under the title of *Hoffmann's Leben und Nachlass*. A selection of his writings was published in Berlin, 1827-28, and five more volumes (including Hitzig's life) were added by his widow in 1839. A selection of his writings by Kurz appeared in 1870, and an edition of his collected works, in 12 vols., in 1871-73. Most of his romances are to be obtained separately in the *Universal-Bibliothek*, a cheap edition of standard authors published at Leipsic. *Die Elixire des Teufels* has been translated into English (Edin., 1824), and Carlyle has given us a biography of Hoffmann, together with a translation of one of the *Fantasiestücke*, "Der Goldene Topf," in his *German Romance*. (F. M.)

HOFFMANN, Friedrich (1660-1742), the most famous physician in a family that had been connected with medicine for 200 years before him, was born at Halle, February 19, 1660. He received his school education at the gymnasium of his native town, where he acquired that taste for and skill in mathematics to which he attributed much of his after success. At the age of eighteen he went to study medicine at Jena, whence in 1680 he passed to Erfurt, in order to attend Kasper Cramer's lectures on chemistry. Next year, returning to Jena, he received his doctor's diploma, and, after publishing a thesis, was permitted to teach. Constant study then began to tell on his health, and in 1682, leaving his already numerous pupils, he proceeded to Minden in Westphalia to recruit himself, at the request of a relative who held a high position in that town. After practising his profession at Minden for two years, Hoffmann made a journey to Holland and England, where he formed the acquaintance of many illustrious chemists and physicians. Towards the end of 1684 he returned to Minden, and during the next three years he received many flattering appointments. In 1688 he removed to the more promising sphere of Halberstadt, with the title of physician to the principality of Halberstadt; and on the founding of Halle university in 1693, his reputation, which had been steadily increasing, procured for him the primarius chair of medicine, while at the same time he was charged with the responsible duty of framing the statutes for the new medical faculty. He filled also the chair of natural philosophy. With the exception of four years (1708-12), which he passed at Berlin in the capacity of royal physician, without however giving up his professorship, Hoffmann spent the rest of his life at Halle in instruction, practice, and study, interrupted now and again by visits to different courts of Germany, where his services procured him honours and rewards. His fame became European. He was enrolled a member of many learned societies in different foreign countries, while in his own he became privy councillor. He died at Halle, on November 12, 1742.

Hoffmann's writings, the result both of compilation and original research, have still a considerable suggestive value. His theories, though sometimes vague and even idle, contributed in some degree to introduce a revolution in medical science; while his doctrine of atony and spasm in the living solid as the sole cause of internal disorders turned the attention of physicians more directly to the primary moving powers of the system. He pursued with ardour the study of practical chemistry, and pharmacy owes to him several preparations which are still in general use. It was through Hoffmann also that many of the mineral springs of Germany first came into repute as health resorts.

Of his numerous writings a catalogue is to be found in Haller's *Bibliotheca Medicinæ Practicæ*. The chief is *Medicina Rationalis Systematica*, undertaken at the age of sixty, and published in 1730. It was translated into French in 1739, under the title of *Médecine Raisonnée d'Hoffmann*. A complete edition of Hoffmann's works, with a life of the author, was published at Geneva in 1740, to which supplements were added in 1753 and 1760. Editions appeared also at Venice in 1745, and at Naples in 1753 and 1793.

HOFFMANN, Johann Joseph (1805-1878), an eminent Chinese and Japanese scholar, was born at Würzburg on the 16th of February 1805. After studying in the philosophical department of the Würzburg university, the young man took to the stage in 1825; and it was only by an accidental meeting with the German traveller, Dr Siebold, in July 1830, that his interest was diverted to Oriental philology. From Siebold himself he acquired the rudiments of Japanese; and in order to take advantage of the instructions of Ko-ching-chang, a Chinese teacher whom Siebold had brought home with him, he made himself acquainted with Malay, the only language except Chinese which the Chinaman could understand. Such rapid advance did Hoffmann make that in a few years he was able to supply the translations for Siebold's *Nippon*; and the high character of his work soon attracted the attention of older scholars. Stanislas Julien invited him to Paris; and he would probably have accepted the invitation, as a disagreement had broken out between him and Siebold, had not M. Baud, the Dutch colonial minister, appointed him Japanese translator with a salary of 1800 florins or £150. The Dutch authorities were slow in giving him further recognition; and he was too modest a man successfully to urge his claims. It was not till after he had received the offer of the professorship of Chinese in King's College, London, that the authorities made him professor at Leyden, and the king allowed him a yearly pension. In 1875 he was decorated with the order of the Netherlands Lion, and in 1877 he was elected corresponding member of the Berlin Academy. But these honours came almost too late; for a disease of the lungs from which he had long suffered terminated fatally on the 19th of January 1878.

Hoffmann's chief work is his Japanese Dictionary. Though begun in 1839 it is still unfinished, for the difficulties against which he had to contend were immense. Unable at first to procure the necessary type, he set himself to the cutting of punches; and even when the proper founts were obtained he had to act as his own compositor as far as Chinese and Japanese were concerned. His Japanese grammar is a standard work; it was published in Dutch and English in 1867, and in English and German in 1876. Of his miscellaneous productions it is enough to mention "Japan's Bezüge mit der Koraischen Halbinsel und mit Schina" in *Nippon*, vii.; *Yo-San-fi-Rok, L'art d'élever les vers à soie au Japan, par Ouckaki Mourikouni*, Paris, 1848; "Die Heilkunde in Japan" in *Mittheil. d. deutsch. Gesellsch. für Natur- und Völkerk. Ost-Asiens*, 1873-1874; and *Japanische Studien*, 1877, dealing with Japanese poetry. The Dictionary is being continued by L. Serrurier.

For further details see Kern in *Koninklijke Akademie van Wetenschappen*; W. Vissering in *Het Vaderland*, 23d Jan. 1878; and *Leiden Studenten-almanak*, 1879.

HOFMANN, Johann Christian Konrad von (1810-1877), Lutheran theologian, was born December 21, 1810, at Nuremberg, whence, after passing through the usual gymnasium course, he in 1827 proceeded to the university of Erlangen as a student of theology and history. In 1829 he became the pupil of Schleiermacher, Hengstenberg, Neander, and Ranke, at Berlin; in 1832 he passed his examination as a candidate in theology at Erlangen; and in the following year he received an appointment to teach Hebrew and history in the gymnasium there. In 1835 and 1838 respectively he "habilitated" in the philosophical and in the theological faculty at Erlangen, where in 1841 he was appointed professor extraordinarius in theology. In 1842 he accepted a call to an ordinary theological chair at Rostock, but in 1845 he returned once more to Erlangen, where he had been nominated as successor of Harless. Apart from his professorial and literary activities, his life was a singularly uneventful one; he was, however, an enthusiastic adherent of the political party of progress, and as such sat as member for Erlangen and Fürth in the Bavarian second chamber from 1863 to 1868. His death occurred on December 20, 1877.

He wrote *Die siebzig Jahre des Jeremias u. die siebzig Jahrwochen des Daniel*, 1836; *Geschichte des Aufruhrs in den Cevennen*, 1837; *Lehrbuch der Weltgeschichte*, 1839, which became a text-book in the Protestant gymnasia of Bavaria; *Weissagung u. Erfüllung im alten u. neuen Testamente*, 1841–44, 2d ed., 1857–60; *Der Schriftbeweis*, 1852–56, 2d ed., 1857–60; *Die Heilige Schrift Neuen Testaments zusammenhängend untersucht*, 1862–75; and *Theologische Ethik*, 1878. He also edited, in conjunction with Höfling and Thomasius, the *Zeitschrift für Protestantismus u. Kirche* from 1846 onwards. His most important works are the four last named. In *Weissagung u. Erfüllung* he not only carries out the idea, originated by Herder, that the entire Old Testament as an organic whole is one great connected prophecy, pointing towards Christ, but elaborates the thought that the New Testament also is organically prophetic of the last things. In the *Schriftbeweis*, on the fundamental axiom that the history of redemption as recorded in Scripture is the history of a development he at great length sets forth the methods according to which dogmatic theology must seek for and use the Scripture proofs on which it is or ought to be based. His work upon the New Testament discusses the credibility of the several books, and seeks to ascertain the place occupied by each in the organic whole. The *Theologische Ethik* unfolds the scheme of Christian duty as arising out of the new relations of the believer to God through Christ. In theology as in ecclesiastical polity Hoffmann was a Lutheran of a very extreme type, although the strongly marked individuality of some of his opinions laid him open to repeated accusations of heterodoxy.

HOGARTH, WILLIAM (1697–1764). Apart from the story of his works, the life of the greatest English pictorial satirist, when divested of doubtful tradition, is singularly devoid of incident. It is mainly to be found in the autobiographical *Memoranda* published by John Ireland in 1798, and the successive *Anecdotes* of the antiquary, John Nichols. Hogarth was born in London on the 10th day of November 1697, and baptized on the 28th in the church of St Bartholomew the Great. His father was a schoolmaster and literary hack, who had come to the metropolis to seek that fortune which had been denied to him in his native Westmoreland. His son seems to have been early distinguished rather by a talent for drawing and an active perceptive faculty than by any close attention to the learning which he was soon shrewd enough to see had not made his parent prosper. "Shows of all sorts gave me uncommon pleasure when an infant," he says, "and mimicry, common to all children, was remarkable in me. . . . My exercises when at school were more remarkable for the ornaments which adorned them than for the exercise itself." This being the case, it is no wonder that, by his own desire, he was apprenticed to a silver-plate engraver, Mr Ellis Gamble, at the sign of the "Golden Angel" in Cranbourne Street or Alley, Leicester Fields. For this master he engraved a shop-card which is still extant. When his apprenticeship began is not recorded; but it must have been concluded before the beginning of 1720, for in April of that year he appears to have set up as engraver on his own account. His desires, however, were not limited to silver-plate engraving. "Engraving on copper was, at twenty years of age, my utmost ambition." For this he lacked the needful skill as a draughtsman; and his account of the means which he took to supply this want, without too much interfering with his pleasure, is thoroughly characteristic, though it can scarcely be recommended as an example. "Laying it down," he says, "first as an axiom, that he who could by any means acquire and retain in his memory perfect ideas of the subjects he meant to draw would have as clear a knowledge of the figure as a man who can write freely hath of the twenty-four letters of the alphabet and their infinite combinations (each of these being composed of lines), and would consequently be an accurate designer, . . . I therefore endeavoured to habituate myself to the exercise of a sort of technical memory, and by repeating in my own mind the parts of which objects were composed I could by degrees combine and put them down with my pencil." This account, it is possible, has something of the complacency of the old age in which it was written; but there is little doubt that his marvellous power of seizing expression owed less to patient academical study than to his unexampled eye-memory and tenacity of minor detail. But he was not entirely without technical training, as, by his own showing, he occasionally "took the life" to correct his memories, and is known to have studied at Sir James Thornhill's then recently opened art school.

"His first employment" (*i.e.*, after he set up for himself) "seems," says Nichols, "to have been the engraving of arms and shop bills." After this he was employed in designing "plates for booksellers." Of these early and mostly insignificant works we may pass over The Lottery, an Emblematic Print on the South Sea, and some book illustrations, to pause at Masquerades and Operas, 1724, the first plate he published on his own account. This is a clever little satire on contemporary follies, such as the masquerades of the Swiss adventurer Heidegger, the popular Italian opera singers, Rich's pantomimes at Lincoln's Inn Fields, and last, but by no means least, the exaggerated popularity of Lord Burlington's *protégé*, the architect painter William Kent, who is here represented on the summit of Burlington Gate, with Raphael and Michelangelo for supporters. This worthy Hogarth had doubtless not learned to despise less in the school of his rival Sir James Thornhill. Indeed almost the next of Hogarth's important prints was aimed at Kent alone, being that memorable burlesque of the unfortunate altarpiece designed by the latter for St Clement's Danes, and which, in deference to the ridicule of the parishioners, Bishop Gibson took down in 1725. Hogarth's squib, which appeared subsequently, exhibits it as a very masterpiece of confusion and bad drawing. In 1726 he prepared twelve large engravings for Butler's *Hudibras*. These he himself valued highly, and they are the best of his book illustrations. But he was far too individual to be the patient interpreter of other men's thoughts, and it is not in this direction that his successes are to be sought.

To 1727–28 belongs one of those rare occurrences which have survived as contributions to his biography. He was engaged by a certain Morris, a tapestry worker, to prepare a design for the Element of Earth. Morris, however, having heard that he was "an engraver and no painter," declined the work when completed, and Hogarth accordingly sued him for the money in the Westminster Court, where, on the 28th of May 1728, the case was decided in his (Hogarth's) favour. It may have been the aspersion thus early cast on his skill as a painter (coupled perhaps with the unsatisfactory state of print-selling, owing to the uncontrolled circulation of piratical copies) that induced him about this time to turn his attention to the production of "small conversation pieces" (*i.e.*, groups in oil of full-length portraits from 12 to 15 inches high), many of which are still preserved in different collections. "This," he says, "having novelty, succeeded for a few years." Among his other efforts in oil between 1728 and 1732 were The Wanstead Assembly, The House of Commons examining Bambridge, an infamous warden of the Fleet, and numerous pictures of the chief actors in Gay's popular *Beggar's Opera*.

On the 23d of March 1729 he was married at old Paddington church to Jane Thornhill, the only daughter of Kent's rival above-mentioned. The match was a clandestine one, although Lady Thornhill appears to have favoured it. We next hear of him in "lodgings at South Lambeth," where he rendered some assistance to the then well-known Jonathan Tyers, who opened Vauxhall in 1732 with an entertainment styled a *ridotto al fresco*. For these gardens Hogarth painted a poor picture of Henry VIII. and Anna Bullen, and for them he also made some designs of the Four Times of the Day, which he afterwards elaborated into a finished series. The only engravings between 1726 and 1732 which need be referred to are the Large Masquerade Ticket (1727), another satire on masquerades, and the print of Burlington Gate, 1731, evoked by Pope's *Epistle to Lord Burlington*, and defending Lord Chandos, who is therein satirized. This print gave great offence, and was, it is said, suppressed. To 1732 belongs that genial journey from London to Sheerness, of which the original record still survives at the British Museum in an oblong MS. volume, entitled *An Account of what seem'd most Remarkable in the Five Days' Peregrination of the Five Following Persons, Vizt., Messieurs Tothall. Scott, Hogarth, Thornhill and Forrest. Begun on Saturday May 27th* 1732 *and Finish'd On the 31st of the Same Month. Abi tu et fac similiter.—Inscription on Dulwich Colledge Porch.* The journal, which is written by Forrest, the father of Garrick's friend Theodosius Forrest, gives a good idea of what a "frisk"—as Johnson called it—was in those days, while the illustrations were by Hogarth and Samuel Scott the landscape painter. John Thornhill, Sir James's son, made the map. This version (in prose) was subsequently run into rhyme by one of Hogarth's friends, the Rev. Mr Gostling of Canterbury, and after the artist's death both versions were published. In the absence of other biographical detail, they are of considerable interest to the student of Hogarth.

In 1733 Hogarth moved into the "Golden Head" in Leicester Fields, which, with occasional absences at Chiswick, he continued to occupy until his death. By this date he must have completed the earliest of those great series of moral paintings which first gave him his position as a great and original genius. This was A Harlot's Progress, the paintings for which, if we may trust the date in the last of the pictures, were finished in 1731. The engravings, by the artist himself, were published in 1734. We have no record of the particular train of thought which prompted these story-pictures; but it may perhaps be fairly assumed that the necessity for creating some link of interest between the personages of the little "conversation pieces" above referred to led to the further idea of connecting several groups or scenes so as to form a sequent narrative. "I wished," says Hogarth, "to compose pictures on canvas, similar to representations on the stage." "I have endeavoured," he says again, "to treat my subject as a dramatic writer; my picture is my stage, and men and women my players, who by means of certain actions and gestures are to exhibit *a dumb show.*" There was never a more eloquent dumb show than this of the Harlot's Progress. In six scenes the miserable career of a woman of the town is traced out remorselessly from its first facile beginning to its shameful and degraded end. Nothing of the detail is softened or abated; the whole is acted out *coram populo*, with the hard, uncompassionate morality of the age the painter lived in, while the introduction here and there of one or two well-known characters like Colonel Charteris and Justice Gonson give a vivid reality to the satire. It had an immediate success. To say nothing of the fact that the talent of the paintings completely reconciled Sir James Thornhill to the son-in-law he had hitherto refused to acknowledge, more than twelve hundred names of subscribers to the engravings were entered in the artist's book. On the appearance of plate iii. the lords of the treasury trooped to Leicester Fields for Sir John Gonson's portrait which it contained. Theophilus Cibber made the story into a pantomime, and some one else into a ballad opera; and it gave rise to numerous pamphlets and poems. It was painted on fan-mounts and transferred to cups and saucers. Lastly, it was freely pirated. There could be no surer testimony to its popularity.

The favourable reception given to A Harlot's Progress prompted A Rake's Progress, which speedily followed, although it had not a like success. It was in eight plates in lieu of six. The story is unequal; but there is nothing finer than the figure of the desperate rake in the Covent Garden gaming-house, or the admirable scenes in the Fleet prison and Bedlam, where at last his headlong career comes to its tragic termination. The plates abound with allusive suggestion and covert humour; but it is impossible to attempt any detailed description of them here.

A Rake's Progress was dated June 25, 1735, and the engravings bear the words "according to Act of Parliament." This was an Act (8 Geo. II. cap. 13) which Hogarth had been instrumental in obtaining from the legislature, being stirred thereto by the shameless piracies of rival printsellers. Although loosely drawn, it served its purpose; and the painter commemorated his success by a long inscription on the plate entitled Crowns, Mitres, &c., afterwards used as a subscription ticket to the Election series. These subscription tickets to his engravings, let us add, are among the brightest and most vivacious of the artist's productions. That to the Harlot's Progress was entitled Boys peeping at Nature, while the Rake's Progress was heralded by the delighful etching known as A Pleased Audience at a Play, or The Laughing Audience.

We must pass more briefly over the prints which followed the two Progresses, noting first A Midnight Modern Conversation, an admirable drinking scene which comes between them in 1734, and the bright little plate of Southwark Fair, which, though dated 1733, was published with A Rake's Progress in 1735. Between these and Marriage *à la Mode*, upon the pictures of which the painter must have been not long after at work, come the small prints of the Consultation of Physicians, Scholars at a Lecture, and Sleeping Congregation, 1736; the Four Times of the Day, 1738, a series of pictures of everyday 18th century life, the earlier designs for which have been already referred to; the Strolling Actresses dressing in a Barn, 1738, which Walpole held to be, "for wit and imagination, without any other end, the best of all the painter's works;" and finally the admirable plates of the Distrest Poet, painfully composing a poem on "Riches" in a garret, and the Enraged Musician fulminating from his parlour window upon a discordant orchestra of knife-grinders, milk-girls, ballad-singers, and the rest upon the pavement outside. These are dated respectively 1736 and 1741. To this period also (*i.e.*, the period preceding the production of the plates of Marriage *à la Mode*) belong two of those history pictures to which, in emulation of the Haymans and Thornhills, the artist was continually attracted. The Pool of Bethesda and the Good Samaritan, "with figures seven feet high," were painted *circa* 1736, and presented by the artist to St Bartholomew's Hospital, where they remain. They were not masterpieces; and it is pleasanter to think of his connexion with Captain Coram's recently established Foundling Hospital (1739), which he aided with his money, his graver, and his brush, and for which he painted that admirable portrait of the good old philanthropist which is still, and deservedly, one of its chief ornaments.

In A Harlot's Progress Hogarth had not strayed much beyond the lower walks of society, and although, in A Rake's Progress, his hero was taken from the middle classes, he can scarcely be said to have quitted those fields of observation which are common to every spectator. It is therefore more remarkable, looking to his education and antecedents, that his masterpiece, Marriage *à la Mode*, should successfully depict, as the advertisement has it, "a variety of modern occurrences in high life." Yet, as an accurate delineation of the surroundings of upper class 18th century society, his Marriage *à la Mode* has never, we believe, been seriously assailed. The countess's bedroom, the earl's apartment with its lavish coronets and old masters, the grand saloon with its marble pillars and grotesque ornaments, are fully as true to nature as the frowsy chamber in the "Turk's

Head Bagnio," the quack-doctor's museum in St Martin's Lane, or the mean opulence of the merchant's house in the city. And what story could be more vividly, more perspicuously, more powerfully told than this godless alliance of *sacs et parchemins*—this miserable tragedy of an ill-assorted marriage? There is no defect of invention, no superfluity of detail, no purposeless stroke. It has the merit of a work by a great master of fiction, with the additional advantages which result from the pictorial fashion of the narrative; and it is matter for congratulation that it is still to be seen by all the world in the National Gallery, where it can tell its own tale better than pages of commentary.

The engravings of Marriage *à la Mode* were dated April 1745. Although the painter by this time found a ready market for his engravings, he does not appear to have been equally successful in selling his pictures. The people bought his prints; but the more opulent and not numerous connoisseurs who purchased pictures were wholly in the hands of the importers and manufacturers of "old masters." In February 1745 the original oil paintings of the two Progresses, the Four Times of the Day, and the Strolling Actresses were still unsold. On the last day of that month Hogarth disposed of them by an ill-devised kind of auction, the details of which may be read in Nichols's *Anecdotes*, for the paltry sum of £427, 7s. No better fate attended Marriage *à la Mode*, which five years later became the property of Mr Lane of Hillingdon for 120 guineas, being then in Carlo Maratti frames which had cost the artist four guineas a piece. Something of this was no doubt due to Hogarth's impracticable arrangements, but the fact shows conclusively how completely blind his contemporaries were to his merits as a painter, and how hopelessly in bondage to the all-powerful picture-dealers. Of these latter the painter himself gave a graphic picture in a letter addressed by him under the pseudonym of "Britophil" to the *St James's Evening Post*, in 1737.

But, if Hogarth was not successful with his dramas on canvas, he occasionally shared with his contemporaries in the popularity of portrait painting. For a picture, executed in 1746, of Garrick as Richard III. he was paid £200, "which was more," says he, "than any English artist ever received for a single portrait." In the same year a sketch of Simon Fraser, Lord Lovat, afterwards beheaded on Tower Hill, had an exceptional success. Our limits do not, however, enable us to refer to his remaining works in detail, and we must content ourselves with a brief enumeration of the most important. These are The Stage Coach or Country Inn Yard, 1747; the series of twelve plates entitled Industry and Idleness, 1747, depicting the career of two London apprentices; the Gate of Calais, 1749, which had its origin in a rather unfortunate visit paid to France by the painter after the peace of Aix-la-Chapelle; the March to Finchley, 1750; Beer Street, Gin Lane, and the Four Stages of Cruelty, 1751; the admirable representations of election humours in the days of Sir Robert Walpole, entitled Four Prints of an Election, 1755–8; and the plate of Credulity, Superstition, and Fanaticism, a Medley, 1762, adapted from an earlier unpublished design called Enthusiasm Delineated. Besides these must be chronicled three more essays in the "great style of history painting," viz., Paul before Felix, Moses brought to Pharaoh's Daughter, and the Altarpiece for St Mary Redcliff at Bristol. The first two were engraved in 1751–2, the last in 1794. A subscription ticket to the earlier pictures, entitled Paul before Felix Burlesqued, had a popularity far greater than that of the prints themselves.

In 1745 Hogarth painted that admirable portrait of himself with his pug-dog Trump, which is now in the National Gallery. In a corner of this he had drawn on a palette a serpentine line with the words "The Line of Beauty and Grace." Much inquiry ensued as to "the meaning of this hieroglyphic;" and in an unpropitious hour the painter resolved to explain his meaning in writing. The result was the well-known *Analysis of Beauty*, 1753, a treatise "to fix the fluctuating ideas of Taste," otherwise a desultory essay having for pretext the precept attributed to Michelangelo that a figure should be always "Pyramidall, Serpent-like, and multiplied by one two and three." The fate of the book was what might have been expected. By the painter's adherents it was praised as a final deliverance upon æsthetics; by his enemies and professional rivals, its obscurities, and the minor errors which, notwithstanding the benevolent efforts of literary friends, the work had not escaped, were made the subject of endless ridicule and caricature. It added little to its author's fame, and it is perhaps to be regretted that he ever undertook it. Moreover, there were further humiliations in store for him. In 1759 the success of a little picture called The Lady's Last Stake, painted for Lord Charlemont, procured him a commission from Sir Richard Grosvenor to paint another picture "upon the same terms." Unhappily on this occasion he deserted his own field of *genre* and social satire, to select the story from Boccaccio (or rather Dryden) of Sigismonda weeping over the heart of her murdered lover Guiscardo, being the subject of a picture by Furini in Sir Luke Schaub's collection which had recently been sold for £400. The picture, over which he spent much time and patience, was not regarded as a success; and Sir Richard rather meanly shuffled out of his bargain upon the plea that "the constantly having it before one's eyes would be too often occasioning melancholy thoughts to arise in one's mind." Sigismonda, therefore, much to the artist's mortification, and the delight of the malicious, remained upon his hands. As, by her husband's desire, his widow valued it at £500, it found no purchaser until after her death, when the Boydells bought it for 56 guineas. It was exhibited, with others of Hogarth's pictures, at the Spring Gardens exhibition of 1761, for the catalogue of which Hogarth engraved a Head-piece and a Tail-piece which are still the delight of collectors; and finally, by the bequest of the late Mr J. H. Anderdon, it passed in 1879 to the National Gallery, where, in spite of theatrical treatment and a repulsive theme, it still commands admiration for its colour, drawing, and expression.

In 1761 he was sixty-five years of age, and he had but three years more to live. These three years were embittered by that unhappy quarrel with Wilkes and Churchill, over which most of his biographers are contented to pass rapidly, Having succeeded John Thornhill in 1757 as serjeant painter (to which post he was reappointed at the accession of George III.), an evil genius prompted him in 1762 to do some "timed" thing in the ministerial interest, and he accordingly published the indifferent satire of The Times, plate i. This at once brought him into collision with his quondam friends, John Wilkes and Churchill the poet; and the immediate result was a violent attack upon him, both as a man and an artist in the opposition *North Briton*, No. 17. The alleged decay of his powers, the miscarriage of Sigismonda, the cobbled composition of the *Analysis*, were all discussed with scurrilous malignity by those who had known his domestic life and learned his weaknesses. The old artist was deeply wounded, and his health was failing. Early in the next year, however, he replied by that squinting portrait of Wilkes which will for ever carry his features to posterity. Churchill retaliated in July by a savage *Epistle to William Hogarth*, to which the artist rejoined by a print of Churchill as a bear, in torn bands and ruffles, not the most successful of his works. "The pleasure, and pecuniary advantage," writes Hogarth, "which I derived from these two engravings" (of Wilkes and Churchill), "together with occasionally riding on horseback, restored me to as much health as can be expected at my time of life." He produced but one more print, that of Finis, or The Bathos, March 1764, a strange jumble of "fag ends," intended as a tail-piece to his collected prints; and on the 26th October of the same year he died of an aneurism at his house in Leicester Square. His wife, to whom he left his plates as a chief source of income, survived him until 1789. He was buried in Chiswick churchyard, where a tomb was erected to him by his friends in 1771, with a well-known epitaph by Garrick. Not far off, on the road to Chiswick Gardens, is the now tumble-down house in which, for many years of his life, he spent the summer seasons.

From such records of him as survive, Hogarth appears to have been much what from his portrait one might suppose him to have been—a blue-eyed, honest, combative, little man, thoroughly national in his prejudices and antipathies, fond of flattery, sensitive like most satirists, a good friend, an intractable enemy, ambitious, as he somewhere says, in all things to be singular, and not always accurately estimating the extent of his powers. With the art connoisseurship of his day he was wholly at war, because, as he believed, it favoured foreign mediocrity at the expense of native talent; and in the heat of argument he would probably, as he admits, often come "to utter blasphemous expressions against the divinity even of Raphael Urbino, Correggio, and Michelangelo." But it was rather against the third-rate copies of third-rate artists—the "ship-loads of manufactured Dead Christs, Holy Families, and Madonnas"—that his indignation was directed; and in speaking of his attitude with regard to the great masters of art, it is well to remember his words to Mrs Piozzi:—"The connoisseurs and I are at war you know; and because I hate *them*, they think I hate *Titian*—and let them!"

But no doubt it was in a measure owing to this hostile attitude of his towards the all-powerful picture-brokers that his contemporaries failed to adequately recognize his merits as a painter, and persisted in regarding him as an ingenious humorist alone. Time has reversed that unjust sentence. He is now held to have been an excellent painter, pure and harmonious in his colouring, wonderfully dexterous and direct in his handling, and in his composition leaving little or nothing to be desired. As an engraver his work is more conspicuous for its vigour, spirit, and intelligibility than for finish and beauty of line. He desired that it should tell its own tale plainly, and bear the distinct impress of his individuality, and in this he thoroughly succeeded. As a draughtsman his skill has sometimes been debated, and his work at times undoubtedly bears marks of haste, and even carelessness. If, however, he is judged by his best instead of his worst, his work will not be found to be wanting in this respect. But it is not after all as a draughtsman, an engraver, or a painter that he claims his pre-eminence among English artists—it is as a wit, a humorist, a satirist upon canvas. Regarded in this light he has never been equalled, whether for his vigour of realism and dramatic power, his fancy and invention in the decoration of his story, or his merciless anatomy and exposure of folly and wickedness. If we regard him—as he loved to regard himself—as "author" rather than "artist," his place is with the great masters of literature,—with the Thackerays and Fieldings, the Cervantes and Molières.

Additions to Hogarth literature have not been numerous of late years. In 1860 Mr G. A. Sala contributed some picturesque pages to the *Cornhill Magazine*, which were afterwards republished in book form. Much minute information has also been collected in Mr F. G. Stephens's *Catalogue of the Satirical Prints and Drawings in the British Museum*, now in course of issue. Pictures by Hogarth from private collections are constantly to be found at the annual exhibitions of the Old Masters in the Royal Academy; but most of the best known works have permanent homes in public galleries. Marriage *à la Mode*, Sigismonda, and his own portrait are in the National Gallery; the Rake's Progress and the Election Series in the Sloane Museum; and the March to Finchley and Captain Coram at the Foundling Hospital. There are also notable pictures in the Fitzwilliam Museum at Cambridge, and the National Portrait Gallery at South Kensington. The Lady's Last Stake, to which reference has been made, is at present (1880) in the possession of Mr Louis Huth. (A. D.)

HOGG, James (1770–1835), a Scottish poet, best known by his title of the "Ettrick Shepherd," was born on the banks of the Ettrick in Selkirkshire in 1770. His ancestors had been shepherds for centuries. He received hardly any school training, and seems to have had difficulty in getting books to read. After spending his early years under different masters, first as cow-herd and afterwards as shepherd, he was engaged in the latter capacity by Mr Laidlaw, tenant of Blackhouse, in the parish of Yarrow, from 1790 till 1799. He was treated with great kindness, and had access to a large collection of books, which he soon exhausted, and then subscribed to a circulating library in Peebles. While attending to his flock, he spent a great deal of time in reading. His first printed piece was "The Mistakes of a Night," which appeared in the *Scots Magazine* for October 1794, and was succeeded by *Scots Pastorals* in 1801. A year or two after this publication Hogg became acquainted with Sir Walter Scott—a connexion which had a powerful influence for good on the peasant poet. He again appeared before the public in 1807 as the author of the *Mountain Bard*, to which Scott wrote an introductory notice. By this work, and by a *Treatise on the Diseases of Sheep*, Hogg realized about £300. With this money he unfortunately embarked in farming in Dumfriesshire, and in three years was utterly ruined, and had to abandon all his effects to his creditors. He returned to Ettrick, and there found only cold and estranged looks. He could not even obtain employment as a shepherd; so he set off in February 1810 to push his fortune in Edinburgh as a literary adventurer. In the same year he published a collection of songs, which, being dedicated to the countess of Dalkeith, and recommended to her notice by Scott, was rewarded with a present of 100 guineas. He then commenced a weekly periodical, *The Spy*, which he continued from September 1810 till August 1811. The appearance of the *Queen's Wake* in 1813 established Hogg's reputation as a poet; it was followed by *Mador of the Moor*, *The Pilgrims of the Sun*, and *The Poetic Mirror*. The duchess of Buccleuch, on her death-bed in 1814, had asked the duke to do something for the Ettrick bard; and the duke gave him a lease for life of the farm of Altrive in Yarrow, consisting of about 70 acres of moorland, on which the poet built a house and spent the last years of his life. He took possession of it in 1817; but his literary exertions were never relaxed. Before 1820 he had written *The Brownie of Bodsbeck*, and two volumes of *Winter Evening Tales*, besides collecting, editing, and writing part of two volumes of *Jacobite Relics*, and contributing largely to *Blackwood's Magazine*. In 1820 he married Miss Margaret Phillips, a lady of a good Annandale family, and found himself possessed of about £1000, a good house, and a well-stocked farm. Hogg's connexion with *Blackwood's Magazine* kept him continually before the public. The wit and mischief of some of his literary friends made free with his name, and represented him in ludicrous and grotesque aspects; but the effect of the whole was favourable to his popularity. He visited London in 1831, and was feasted by the nobility, literati, and public men of the metropolis. On his return a public dinner was given to him in Peebles,—Professor Wilson in the chair,—and he acknowledged that he had at last "found fame." His health, however, was seriously impaired. With his pen in his hand to the last, Hogg in 1834 published a volume of *Lay Sermons*, and in 1835 two volumes of *Montrose Tales*. His illness ultimately assumed the form of dropsy, and after a short confinement he died November 21, 1835, having nearly completed his sixty-fifth year. He was buried in the churchyard of his native parish Ettrick. His fame had seemed to fill the whole district, and was brightest at its close; his presence was associated with all the Border sports and festivities; and as a man James Hogg was ever frank, joyous, and charitable.

His *Shepherd's Calendar* is the best of Hogg's prose works; but it is mainly as a great peasant poet that he lives in literature. Nothing can be more exquisite than some of his lyrics and minor poems—his "Skylark," "When the Kye comes Hame," his verses on the "Comet" and "Evening Star," and his "Address to Lady Ann Scott." The *Queen's Wake* unites his characteristic excellences—his command of the old romantic ballad style, his graceful fairy mythology, and his aerial flights of imagination. The story of Kilmeny stands at the head of all our fairy tales, and is inimitable for its scenes of visionary splendour, purity, and bliss, linked to the fairest objects of earthly interest and affection. In such compositions Hogg seems completely transformed; he is absorbed in the ideal and supernatural, and might have claimed over all his contemporaries the Delphic laurel for direct and immediate inspiration.

See a memoir by Professor Wilson, prefixed to an edition of Hogg's works published by Blackie & Co. in 1850; Wilson's *Noctes Ambrosianæ*; Gilfillan's *First Gallery of Literary Portraits*; Cunningham's *Biog. and Crit. Hist. of Lit.*; and the general index to *Blackwood's Magazine*. A collected edition of Hogg's *Tales* appeared in 1838 in 6 vols., and a second in 1851; his collected *Poems* were published in 1850 and in 1852. For an admirable account of the social entertainments Hogg used to give in Edinburgh, see *Memoir of Robert Chambers*, by Dr William Chambers, pp. 263-270.

HOHENELBE (Bohemian, *Vrchlabi*), the chief town of a government district in Bohemia, is beautifully situated on both banks of the Elbe, crossed there by five bridges, on the southern spurs of the Riesengebirge, and on the north-west Austrian railway, 16 miles north-east of Gitschin. The houses with lofty gables and arcades supported by wooden columns have a picturesque appearance; and among the principal buildings are the decanal church, the castle surrounded by a fine park, the Augustine monastery, the citizen school, and the trade school. Linen and cotton are the staple manufactures, and there are also bleach-works, dye-works, and a paper-mill. A splendid view is obtained from the Heidelberg, which rises to the height of 3120 feet immediately behind the town. The population in 1869 was 5316.

HOHENLOHE, a German princely family, who took their name from the territory of Hohenlohe in Franconia, which, originally a countship and afterwards a principality, lost its independence in 1806, and is now included partly in Würtemberg and partly in Bavaria. They are first mentioned as possessing in the 12th century the castle of Holloch near Uffenheim. At an early period they extended their influence into several of the Franconian valleys, including those of the Kocher, the Jagst, the Tauber, and the Gotlach. The first count of the name was Gottfried, who was on terms of intimacy with the emperor Henry VI., and whose sons founded the lines of Hohenlohe-Bruneck and Hohenlohe-Holloch. The former became extinct in the fourth generation, and the latter in 1340 divided into the lines of Hohenlohe-Hohenlohe and Hohenlohe-Speckfeld. Of these the former became extinct in 1412, after the most of the possessions had been alienated through the marriage of the female heir; and the latter in 1551 divided into the present lines of Hohenlohe-Neuenstein and Hohenlohe-Waldenburg, which were elevated, the former in 1764 and the latter in 1744, to principalities of the empire. Hohenlohe-Neuenstein, which adopted Protestantism, became divided into the lines Hohenlohe-Neuenstein-Oehringen and Hohenlohe-Neuenstein-Langenburg, the former of which separated into the branches of Hohenlohe-Weickersheim and Hohenlohe-Oehringen, the one becoming extinct in 1756 and the other in 1805, after which their possessions were inherited by the Hohenlohe-Neuenstein-Langenburg line, which latter became divided into three branches—the Hohenlohe-Langenburg, the Hohenlohe-Langenburg-Oehringen, and the Hohenlohe-Langenburg-Kirchberg, the last becoming extinct in 1861. The line of Hohenlohe-Waldenburg, which remained Catholic, and in which was established in 1754 the order of the Phœnix, divided itself into two branches, the Hohenlohe-Waldenburg-Bartenstein and the Hohenlohe-Waldenburg-Schillingsfürst, the former subdividing into the branches of Hohenlohe-Bartenstein and Hohenlohe-Jagstberg. Of the Hohenlohe family the following members are noted as having attained individual eminence.

I. FRIEDRICH LUDWIG (1746–1818), prince of Hohenlohe-Ingelfingen, a Prussian general, was born 31st January 1746. Entering the Prussian service at an early age he became colonel in 1788, and in the campaigns of 1792 and 1793, where he was commander of a division, he distinguished himself in several engagements. In 1794 he gained a brilliant victory at Kaiserslautern, and in 1796 he was promoted lieutenant-general and appointed to the command of the army of the Ems. In the same year he succeeded to the principality of his father. Having been appointed general of infantry in 1800, he in 1805 commanded a Prussian corps between the Saale and the Thuringian Forest. He was severely defeated at Jena in 1806, and after the duke of Brunswick was mortally wounded at Auerstädt, he succeeded to the chief command, and led to the Oder the fragments of the Prussian army which capitulated at Prenzlau on the 28th October. On account of the blame to which this disaster exposed him, he had to retire from the army. He died at Slawentzitz, Silesia, 15th February 1818.

II. LUDWIG ALOYSIUS (1765–1829), prince of Hohenlohe-Waldenburg-Bartenstein, marshal and peer of France, was born 18th August 1765. In 1784 he entered the service of the palatinate, which he quitted in 1792 in order to take the command of a regiment raised by his father for the service of the emigrant princes of France. He greatly distinguished himself under Prince Condé in the campaigns of 1792–1793, especially at the storming of the lines of Weissenburg. Subsequently he entered the service of Holland, and, when almost surrounded by the army of General Pichegru, conducted a masterly retreat from the island of Bommel. From 1794 to 1799 he served as colonel in the Austrian campaigns; in 1799 he was named major-general by the archduke Charles; and after obtaining the rank of lieutenant-general he was appointed by the emperor of Austria governor of the two Galicias. Napoleon offered to restore to him his principality on condition that he adhered to the confederation of the Rhine, but as he refused, it was united to Würtemberg. After Napoleon's fall in 1814 he entered the French service, and in 1815 he held the command of a regiment raised by himself, with which he took part in the Spanish campaign of 1823. In 1827 he was created marshal and peer of France. He died at Lunéville, May 30, 1829.

III. ALEXANDER LEOPOLD FRANZ EMMERICH (1794–1849), prince of Hohenlohe-Waldenburg-Schillingsfürst, priest and reputed miracle-worker, was born at Kupferzell near Waldenburg, 17th August 1794. By his mother, the daughter of an Hungarian nobleman, he was from infancy destined for the church; and she entrusted the care of his early education to the ex-Jesuit Riel. In 1804 he entered the "Theresianum" at Vienna, in 1808 the academy at Bern, in 1810 the archiepiscopal seminary at Vienna, and afterwards he studied at Tyrnau and Ellwangen. He was ordained priest in 1815, and in the following year he went to Rome, where he entered the society of the "Fathers of the Sacred Heart." Subsequently, at Munich and Bamberg, he was blamed for Jesuit and obscurantist tendencies, but obtained considerable reputation as a preacher. His first so-called miraculous cure was effected, in conjunction with a peasant Martin Michel, on a princess of Schwarzenberg who had been for some years paralytic. Immediately he acquired such fame as a performer of miraculous cures that multitudes from various countries flocked to partake of the beneficial influence of his supposed supernatural gifts. Ultimately, on account of the interference of the authorities with his operations, he went in 1821 to Vienna and then to Hungary, where he became canon at Grosswardein, and in 1844 titular bishop of Sardica. He died at Vöslau near Vienna, 17th November 1849. He was the author of a number of ascetic and controversial writings, which were collected and published in one edition by Brunner at Ratisbon in 1851.

See Paulus, *Quintessenz aus Anfang, Mitte, und Ende der Wundercurversuche, welche zu Würzburg und Bamberg durch Mart. Michel und den Prinzen von Hohenlohe-Schillingsfürst unternommen worden sind*, Leipsic, 1822.

HOHENMAUTH, the chief town of a government district in Bohemia, Austria, is situated on the Lautchna, and on the Austrian States Railway 16 miles E. of Chrudim. It possesses a beautiful old decanal church, and has cloth manufactures, a brewery, a tannery, a sugar work, and flour and sago mills. It depends for its prosperity largely on the agriculture of the neighbourhood. The population in 1869 was 6018.

HOHENSTEIN, a town of Saxony, circle of Zwickau, stands on the slopes of the Erzgebirge, and on the Saxon States Railway, 12 miles N.E. of Zwickau. Since 1875 Ernstthal has been included within its limits. Hohenstein proper possesses a beautiful parish church, a town-house restored in 1876, and a monument to those who fell in the Prussian war of 1870–71; and Ernstthal has also a fine parish church. The principal industry is the spinning and weaving of cotton, the manufacture of waxcloth, stockings, and woollen and silk fabrics, cotton printing, and dyeing. Many of the inhabitants are also employed in the neighbouring arsenic mines. Not far from Hohenstein there is a mineral spring, connected with which there are various kinds of baths. Hohenstein is the birthplace of the physicist G. H. von Schubert, and of Schröter, one of the inventors of the pianoforte. The building of Ernstthal was occasioned in 1680 by the presence of the plague at Hohenstein, and it received its name from Count Christian Ernst of Schönburg, who was the principal instigator of its erection. The population of Hohenstein in 1875, including Ernstthal with a population of 4118, was 9844.

HOHENZOLLERN, an old German princely house, from which the present dynasty of Prussia is descended, takes its name from the old castle of Zollern, or Hohenzollern, on the mountain of Zollern, about 1½ miles south from Hechingen. There is a vague tradition connecting the house with the Colonna family of Rome, or the Colalto family of Lombardy, and a more definite one which mentions a Swabian count, Thassilo of Burchardinger, as having built the castle of Zollern about the beginning of the 9th century. The first counts of Zollern of whom there is historical mention are Burchard and Wezel, apparently brothers, who in 1061 fell in one of the party feuds during the minority of the emperor Henry IV. Count Frederick III. of Zolre, who died in 1200, one of the trusted councillors of the emperors Frederick I. and Henry VI., became count of Nuremberg in 1191, through having married the heiress of Count Conrad II. of Nuremberg. His sons, Conrad III. and Frederick IV., succeeded to the joint possession of his titles and estates, and founded respectively the Frankish and the Swabian lines. The Frankish house steadily and uninterruptedly increased its possessions and its influence; in 1363 it was raised to princely rank in the person of Frederick V.; in 1415 it obtained through Frederick VI. the electorate of Brandenburg from the emperor Sigismund; and in 1701 its head, the elector Frederick III., became the first king of Prussia. The influence of the Swabian line was greatly weakened by partitions, but in the beginning of the 16th century it rose to some eminence through Count Eitel Frederick II., privy councillor of the emperor Maximilian I., who received from the emperor the district of Hargerloch in exchange for Rhäzüns, in the Grisons, which had come into his family by marriage. His grandson, Charles I., received in 1529 from the emperor Charles V. the countships of Sigmaringen and Vöhringen. Eitel Frederick III. and Charles II. divided their states, the former taking Hohenzollern with the title Hohenzollern-Hechingen, the latter Sigmaringen and Vöhringen with the title Hohenzollern-Sigmaringen. Count John George of Hohenzollern-Hechingen, son of Eitel Frederick III., was raised to princely rank by the emperor Ferdinand II. in 1623, and John of Hohenzollern-Sigmaringen received the same honour in 1638. In 1695 the two Swabian branches entered conjointly into an agreement with the Brandenburg line that, in case of the extinction of the male line of either of the Swabian branches, the states should be inherited by the other branch, and that if both branches became extinct the states should be inherited by the Brandenburg line. In consequence of the political troubles of 1848, Prince Frederick William of Hohenzollern-Hechingen, and Charles Anton of Hohenzollern-Sigmaringen resigned their principalities, which consequently fell to the crown of Prussia, by whom they were taken possession of, March 12, 1850. By royal decree of 20th May of the same year the title of highness was conferred on the two princes, with the prerogatives of younger sons of the royal house. The proposal to raise Prince Leopold of Hohenzollern-Sigmaringen to the throne of Spain in 1870 was the immediate occasion of the war between France and Germany. In 1852 the lands of Hohenzollern were formed into an administrative division of Prussia. It is composed of a long narrow strip of land bounded on the N.E. and W. by Würtemberg and on the W. and S. by Baden, with an area of 440 square miles, and a population in 1875 of 66,614.

See Stillfried, *Hohenzollernsche Forschungen*, Berlin, 1847; Stillfried and Märcker, *Monumenta Zollerana*, 1852–66; Riedel, *Die Ahnherren des preussischen Königshauses*, 1854; Riedel, *Geschichte des preussischen Königshauses bis* 1440, 1861; *Nachrichten über die Stammburg Hohenzollern*, 1863; Carlyle's *Frederick the Great.*

HOLBACH, Paul Heinrich Dietrich, Baron d' (1723–1789), *philosophe* of the Parisian school of the 18th century, was born at Heidelsheim in the palatinate in 1723. Of his family little is known; according to J. J. Rousseau, his father was a rich parvenu, who brought his son at an early age to Paris, where the latter spent most of his life. Much of Holbach's fame is due to his intimate connexion with the brilliant coterie of bold thinkers and polished wits whose creed, the new philosophy, is concentrated in the famous *Encyclopédie.* Possessed of easy means and being of hospitable disposition, he kept open house for such men as Helvetius, D'Alembert, Diderot, Condillac, Turgot, Buffon, Grimm, Hume, Garrick, Wilkes, Sterne, and for a time Rousseau, who, while enjoying the intellectual pleasure of their host's conversation, were not insensible to the material charms of his excellent cuisine and costly wines.

Although an atheist, or at least a materialist of the most material school, Holbach seems to have been endowed with a more than average share of virtue, and, whether by his courtesy, gentleness, or benevolence, inspired a warm affection in all he met. Even his failings, of which his simple credulity was perhaps the most prominent, were amiable. He was one of the best informed men of his day, and his excellent memory placed at his immediate disposal all the learning he had amassed. He visited England on one occasion, but the solemn stiffness of the British, even while amusing themselves, and the peculiar relations of society, disgusted as much as they surprised him. For the *Encyclopédie* Holbach compiled and translated a large number of articles on chemistry and mineralogy, chiefly from German sources. He attracted more attention, however, in the department of philosophy. In 1767 *Christianisme Dévoilé* appeared, in which he attacked Christianity and religion as the source of all human evils. Regarding religion as a blind superstitious bondage, maintained on men's minds by the self-interest of the priests, he tried to prove it not only unnecessary but absolutely prejudicial to human morality. This was followed up in 1770 by a still more open attack in his most famous book, *Le Système de la Nature*, in which it is probable he was assisted by Diderot. Denying the existence of a deity, and refusing to admit as evidence all *a priori* arguments, Holbach saw in the universe nothing save matter in spontaneous movement. What men call their souls become extinct when the body dies. Happiness is the end of mankind. "It would be useless and almost unjust to insist upon a man's being virtuous if he cannot be so without being unhappy. So long as vice renders him happy, he should love vice." Not less direct and trenchant are his attacks on political government, which, interpreted by the light of after events, sound like the first distant mutterings of the tempest that shortly after his death broke over the capital of France. The *Système de la Nature* struck horror into the minds of even the most "enlightened" of the Parisian philosophers. Charmed by the novelty of their own opinions, and dazzled by the glittering wit and argument with which they had supported them, they had never realized into what extremities they had hurried till this lurid torch revealed the hideous abyss from which they were so little removed. Voltaire hastily seized his pen to refute the philosophy of the *Système*, in the article "Dieu" in his *Dictionnaire Philosophique*, while Frederick the Great also drew up an answer to it. Though vigorous in thought and in some passages clear and eloquent, the style of the book is diffuse and declamatory, and asserts rather than proves its statements. Its principles are summed up in a more popular form in *Bon Sens, ou Idées naturelles opposées aux idées surnaturelles*, published at Amsterdam in 1772. In the *Système Social* (1773), the *Politique Naturelle* (1773-74), and the *Morale Universelle* (1776), Holbach attempts to rear a system of morality in place of the one he had so fiercely attacked, but these later writings had not a tithe of the popularity and influence of his earlier and more pernicious work. He published his books either anonymously or under a borrowed name, and was forced to have them printed out of France. He died in 1789. On the death of his first wife he obtained a papal dispensation to marry her sister, who survived him till 1814.

Holbach is also the author of the following and other works:—*Esprit du Clergé*, 1767; *De l'Imposture sacerdotale*, 1767; *Prêtres Démasqués*, 1768; *Examen Critique de la vie et des ouvrages de St Paul*, 1770; *Histoire Critique de Jésus Christ*, 1770; and *Ethocratie*, 1776. For further particulars as to his life and doctrines see Grimm's *Correspondance Litteraire*, &c., 1813; Rousseau's *Confessions*; Morellet's *Mémoires*, 1821; Madame de Genlis, *Les Dîners du Baron Holbach*, Madame d'Épinay's *Mémoires*; Avezac-Lavigne, *Diderot et la Société du Baron d'Holbach*, 1875; and Morley's *Diderot*, 1878.

HOLBEIN, HANS, the elder, belonged to a celebrated family of painters in practice at Augsburg and Basel from the close of the 15th to the middle of the 16th century. Though closely connected with Venice by her commercial relations, and geographically nearer to Italy than to Flanders, Augsburg at the time of Maximilian cultivated art after the fashion of the Flemings, and felt the influence of the schools of Bruges and Brussels, which had branches at Cologne and in many cities about the headwaters of the Rhine. It was not till after the opening of the 16th century, and between that and the era of the Reformation, that Italian example mitigated to some extent the asperity of South German painting. But this is not the place to give even an outline of this development. It must be sufficient to note that Flemish and German art was first tempered with Italian elements at Augsburg by Hans Holbein the elder. Hans first appears at Augsburg as partner to his brother Sigmund, who survived him and died in 1540 at Berne. Sigmund is described as a painter, but his works have not come down to us. Hans had the lead of the partnership at Augsburg, and signed all the pictures which it produced. In common with Herlen, Schongauer, and other masters of South Germany, he first cultivated a style akin to that of Memling and other followers of the schools of Brussels and Bruges, but he probably modified the systems of those schools by studying the works of the masters of Cologne. As these early impressions waned, they were replaced by others less favourable to the expansion of the master's fame; and as his custom increased between 1499 and 1506, we find him relying less upon the teaching of the schools than upon a mere observation and reproduction of the quaintnesses of local passion plays. Most of his early works indeed are taken from the Passion, and in these he obviously marshalled his figures with the shallow stage effect of the plays, copying their artificial system of grouping, careless to some extent of proportion in the human shape, heedless of any but the coarser forms of expression, and technically satisfied with the simplest methods of execution. If in any branch of his art he can be said to have had a conscience at this period, we should say that he showed it in his portrait drawings. It is seldom that we find a painted likeness worthy of the name. The drawings of which numbers are still preserved in the galleries of Basel, Berlin, and Copenhagen show extraordinary quickness and delicacy of hand, and a wonderful facility for seizing character; and this happily is one of the features which Holbein bequeathed to his son. It is between 1512 and 1522 that Holbein tempered the German quality of his style with some North Italian elements. A purer taste and more pleasing realism mark his work, which in drapery, dress, and tone is as much more agreeable to the eye as in respect of modelling and finish it is smoother and more carefully rounded. Costume, architecture, ornament, and colour are applied with some knowledge of the higher canons of art. Here too advantage accrued to Hans the younger, whose independent career about this time began.

The date of the elder Holbein's birth is unknown. But his name appears in the books of the tax-gatherers of Augsburg in 1494, superseding that of Michael Holbein, who is supposed to have been his father. Previous to that date, and as early as 1493, he was a painter of name, and he executed in that year, it is said, for the abbey at Weingarten, the wings of an altarpiece representing Joachim's Offering, the Nativity of the Virgin, Mary's Presentation in the Temple, and the Presentation of Christ, which now hang in separate panels in the cathedral of Augsburg. In these pieces and others of the same period, for instance in two Madonnas in the Moritz chapel and castle of Nuremberg, we mark the clear impress of the schools of Van der Weyden and Memling; whilst in later works, such as the Basilica of St Paul (1504) in the gallery of Augsburg, the wane of Flemish influence is apparent. But this altarpiece, with its quaint illustrations of St Paul's life and martyrdom is not alone of interest because its execution is characteristic of old Holbein. It is equally so because it contains portraits of the master himself, accompanied by his two sons, the painters Ambrose and Hans Holbein. Later pictures, such as the Passion series in the Fürstenberg gallery at Donaueschingen, or the Martyrdom of St Sebastian in the Munich Pinakothek, contain similar portraits, the original drawings of which are found in old Holbein's sketch-book at Berlin, or in stray leaves like those possessed by the duke of Aumale in Paris. Not one of these fails to give us an insight into the character, or a reflex of the features, of the members of this celebrated family. Old Holbein seems to ape Leonardo, allowing his hair and beard wildly to grow, except on the upper lip. Hans the younger is a plain-looking boy. But his father points to him with his finger, and hints that though but a child he is clearly a prodigy.

After 1516 Hans Holbein the elder appears as a defaulter in the registers of the tax-gatherers at Augsburg; but he willingly accepts commissions abroad. At Issenheim in Alsace, where Grünewald was employed in 1516, old Holbein also finds patrons, and contracts to complete an altarpiece. But misfortune or a bailiff pursues him, and he leaves Issenheim, abandoning his work and tools. According to Sandrart, he wanders to Basel and takes the freedom of its guild. His brother Sigmund and others are found suing him for debt before the courts of Augsburg. Where he lived when he executed the altarpiece, of which two wings with the date of 1522 are in the gallery of Carlsruhe, is uncertain; where he died two years later is unknown. He slinks from ken at the close of a long life, and disappears at last heeded by none but his own son, who claims his brushes and paints from the monks of Issenheim without much chance of obtaining them. His name is struck off the books of the Augsburg guild in 1524.

The elder Holbein was a prolific artist, who left many pictures behind him. Earlier than the Basilica of St Paul, already mentioned, is the Basilica of St Mary Maggiore, and a Passion in eleven pieces, in the Augsburg gallery, both executed in 1499. Another Passion, with the root of Jesse and a tree of the Dominicans, is that preserved in the Staedel, Saalhof, and church of St Leonard at Frankfort. It was executed in 1501. The Passion of Donaueschingen was finished after 1502, in which year was completed the Passion of Kaisheim, a conglomerate of twenty-seven panels, now divided amongst the galleries of Munich, Nuremberg, Augsburg, and Schleissheim. An altarpiece of the same class, commissioned for the monastery of St Moritz at Augsburg in 1504–8, has been dispersed and lost. 1512 is the date of a Conception in the Augsburg gallery, long assigned, in consequence of a forged inscription, to Hans Holbein the younger. A diptych, with a Virgin and Child, and a portrait of an old man, dated 1513, is in separate parts in the collections of Mr Posonyi and Count Lanckoronski at Vienna. The sketch-books of Berlin, Copenhagen, and Augsburg give a lively picture of the forms and dress of Augsburg residents at the beginning of the 16th century. They comprise portraits of the emperor Maximilian, the future Charles V., Kunz von der Rosen the fool of Maximilian, the Fuggers, friars, merchants, and at rare intervals ladies.

HOLBEIN, Hans, the younger (1497–1543), favourite son of Hans Holbein the elder, was probably born at Augsburg about the year 1497. Though Sandrart and Van Mander declare that they do not know who gave him the first lessons, he doubtless received an artist's education from his father. About 1515 he left Augsburg with Ambrose his elder brother to seek employment as an illustrator of books at Basel. His first patron is said to have been Erasmus, for whom, shortly after his arrival, he illustrated with pen-and-ink sketches an edition of the *Encomium Moriæ*, now in the museum of Basel. But his chief occupation was that of drawing titlepage-blocks and initials for new editions of the Bible and classics issued from the presses of Froben and other publishers. His leisure hours, it is supposed, were devoted to the production of rough painter's work, a schoolmaster's sign in the Basel collection, a table with pictures of St Nobody in the library of the university at Zurich. In contrast with these coarse productions, the portraits of Jacob Meyer and his wife in the Basel museum, one of which purports to have been finished in 1516, are miracles of workmanship. It has always seemed difficult indeed to ascribe such excellent creations to Holbein's nineteenth year; and it is hardly credible that he should have been asked to do things of this kind so early, especially when it is remembered that neither he nor his brother Ambrose were then allowed to matriculate in the guild of Basel. Not till 1517 did Ambrose, whose life otherwise remains obscure, join that corporation; Hans, not overburdened with practice, wandered into Switzerland, where (1517) he was employed to paint in the house of Jacob Hertenstein at Lucerne. In 1519 Holbein reappeared at Basel, where he matriculated, and, there is every reason to think, married. Whether, previous to this time, he took advantage of his vicinity to the Italian border to cross the Alps is uncertain. Van Mander says that he never was in Italy; yet the large wall-paintings which he executed after 1519 at Basel, and the series of his sketches and pictures which is still extant, might lead to the belief that Van Mander was misinformed. The spirit of Holbein's compositions for the Basel town-hall, the scenery and architecture of his numerous drawings, and the cast of form in some of his imaginative portraits, make it more likely that he should have felt the direct influence of North Italian painting than that he should have taken Italian elements from imported works or prints. The Swiss at this period wandered in thousands to swell the ranks of the French or imperial armies fighting on Italian soil, and the road they took may have been followed by Hans on a more peaceful mission. He shows himself at all events familiar with Italian examples at various periods of his career; and if we accept as early works the Flagellation, and the Last Supper at Basel, coarse as they are, they show some acquaintance with Lombard methods of painting, whilst in other pieces, such as the series of the Passion in oil in the same collection, the modes of Hans Holbein the elder are agreeably commingled with a more modern, it may be said Italian, polish. Again, looking at the Virgin and Man of Sorrows in the Basel museum, we shall be struck by a searching metallic style akin to that of the Ferrarese; and the Lais or the Venus and Amor of the same collection reminds us of the Leonardesques of the school of Milan. When Holbein settled down to an extensive practice at Basel in 1519, he decorated the walls of the house "Zum Tanz" with simulated architectural features of a florid character after the fashion of the Veronese; and his wall paintings in the town-hall, if we can truly judge of them by copies, reveal an artist not unfamiliar with North Italian composition, distribution, action, gesture, and expression. In his drawings too, particularly in a set representing the Passion at Basel, the arrangement, and also the perspective, form, and decorative ornament, are in the spirit of the school of Mantegna. Contemporary with these, however, and almost inexplicably in contrast with them as regards handling, are portrait-drawings such as the likenesses of Jacob Meyer and his wife, which are finished with German delicacy, and with a power and subtlety of hand seldom rivalled in any school. Curiously enough, the same contrast may be observed between painted compositions and painted portraits. The Bonifacius Amerbach of 1519 at Basel is acknowledged to be one of the most complete examples of smooth and transparent handling that Holbein ever executed. His versatility at this period is shown by a dead Christ (1521), a corpse in profile on a dissecting table, and a set of figures in couples; the Madonna and St Pantalus, and Kaiser Henry with the empress Kunigunde (1522), originally composed for the organ loft of the Basel cathedral, now in the Basel museum. Equally remarkable, but more attractive, though injured, is the Virgin and Child between St Ursus and St Nicholas (not St Martin) giving alms to a beggar, in the gallery of Solothurn. This remarkable picture is dated 1522, and seems to have been ordered for an altar in the minster of St Ursus of Solothurn by Nicholas Conrad, a captain and statesman of the 16th century, whose family allowed the precious heirloom to fall into decay in a chapel of the neighbouring village of Grenchen. Numerous drawings in the spirit of this picture, and probably of the same period in his career, might have led Holbein's contemporaries to believe that he would make his mark in the annals of Basel as a model for painters of altarpieces as well as a model for pictorial composition and portrait. The promise which he gave at this time was immense. He was gaining a freedom in draughtsmanship that gave him facility to deal with any subject. Though a realist, he was sensible of the dignity and severity of religious painting. His colour had almost all the richness and sweetness of the Venetians. But he had fallen on evil times, as the next few years undoubtedly showed. Amongst the portraits which he executed in these years are those of Froben, the publisher, known only by copies at Basel and Hampton Court, and Erasmus, who sat in 1523, as he likewise did in 1530, in various positions, showing his face three-quarters as at Longford, Basel, Turin, Parma, the Hague, and Vienna, and in profile as in the Louvre or at Hampton Court. Besides these, Holbein made designs for glass windows and prints, including subjects of every sort, from the Virgin and Child with saints of the old time to the Dance of Death, from gospel incidents extracted from Luther's Bible to satirical pieces illustrating the sale of indulgences and other abuses denounced by Reformers. Holbein, in this way, was carried irresistibly with the stream of the Reformation, in which, it must now be admitted, the old traditions of religious painting were wrecked, leaving nothing behind but unpictorial elements which Cranach and his school vainly used for pictorial purposes.

Once only, after 1526, and after he had produced the Lais and Venus and Amor, did Holbein with impartial spirit give his services and pencil to the Roman Catholic cause. The burgomaster Meyer, whose patronage he had already enjoyed, now asked him to represent himself and his wives and children in prayer before the Virgin; and Holbein produced the celebrated altarpiece now in the palace of Prince William of Hesse at Darmstadt, the shape and composition of which are known to all the world by its copy in the Dresden museum. The drawings for this masterpiece are amongst the most precious relics in the museum of Basel. The time now came when art began to suffer from unavoidable depression in all countries north of the Alps. Holbein, at Basel, was reduced to accept the smallest commissions—even for scutcheons. Then he saw that his chances were dwindling to nothing, and taking a bold resolution, armed with letters of introduction from Erasmus to More, he crossed the Channel to England, where in the one-sided branch of portrait painting he found an endless circle of clients. Eighty-seven drawings by Holbein in Windsor Castle, containing an equal number of portraits, of persons chiefly of high quality, testify to his industry in the years which divide 1528 from 1543. They are all originals of pictures that are still extant, or sketches for pictures that were lost or never carried out. Sir Thomas More, with whom he seems to have had a very friendly connexion, sat to him for likenesses of various kinds. The drawing of his head is at Windsor. The picture from that drawing belonged, and perhaps still belongs, to Mr Huth in London. A pen-and-ink sketch, in which we see More surrounded by all the members of his family, is now in the gallery of Basel, and numerous copies of a picture from it prove how popular the lost original must once have been. At the same period were executed the portraits of Warham (Lambeth and Louvre), Wyatt (Louvre), Sir Henry Guildford and his wife (Windsor and Mr Frewen), all finished in 1527, the astronomer Kratzer (Louvre), Godsalve (Dresden), and Bryan Tuke (Munich) in 1528. In this year, 1528, Holbein returned to Basel, taking to Erasmus the sketch of More's family. With money which he brought from London he purchased a house at Basel wherein to lodge his wife and children, whose portraits he now painted with all the care of a husband and father (1528). He then witnessed the flight of Erasmus and the fury of the iconoclasts, who destroyed in one day almost all the religious pictures at Basel. The municipality, unwilling that he should suffer again from the depression caused by evil times, asked him to finish the frescos of the town-hall, and the sketches from these lost pictures are still before us to show that he had not lost the spirit of his earlier days, and was still capable as a composer. His Rehoboam receiving the Israelite Envoys, and Saul at the Head of his Array meeting Samuel, testify to Holbein's power and his will, also proved at a later period by the Triumphs of Riches and Poverty, executed for the Steelyard in London, to prefer the fame of a painter of history to that of a painter of portraits. But the reforming times still remained unfavourable to art. With the exception of a portrait of Melanchthon (Hanover) which he now completed, Holbein found little to do at Basel. The year 1530, therefore, saw him again on the move, and he landed in England for the second time with the prospect of bettering his fortunes. Here indeed political changes had robbed him of his earlier patrons. The circle of More and Warham was gone. But that of the merchants of the Steelyard took its place, for whom Holbein executed the long and important series of portraits that lie scattered throughout the galleries and collections of England and the Continent, and bear date after 1532. Then came again the chance of practice in more fashionable circles. In 1533 the Triumphs of Wealth and Poverty were executed, then the portraits of Leland and Wyatt (Longford), and (1534) the portrait of Thomas Cromwell. Through Cromwell Holbein probably became attached to the court, in the pay of which he appears permanently after 1537. From that time onwards he was connected with all that was highest in the society of London. Henry VIII. invited him to make a family picture of himself, his father, and family, which obtained a post of honour at Whitehall The beautiful cartoon of a part of this fine piece at Hardwicke Hall enables us to gauge its beauty before the fire which destroyed it in the 17th century. Then Holbein painted Jane Seymour in state (Vienna), employing some English hand perhaps to make the replicas at the Hague, Sion House, and Woburn; he finished the Southwell of the Uffizi (copy at the Louvre), the jeweller Morett at Dresden, and last, not least, Christine of Denmark (Arundel and Windsor castles), who gave sittings at Brussels in 1538. During the journey which this work involved Holbein took the opportunity of revisiting Basel, where he made his appearance in silk and satin, and *pro forma* only accepted the office of town painter. He had been living long and continuously away from home, not indeed observing due fidelity to his wife, who still resided at Basel, but fairly performing the duties of keeping her in comfort. His return to London in autumn enabled him to do homage to the king in the way familiar to artists. He presented to Henry at Christmas a portrait of Prince Edward. Again abroad in the summer of 1539, he painted with great fidelity the princess Anne of Cleves, at Düren near Cologne, whose form we still see depicted in the great picture of the Louvre. That he could render the features of his sitter without flattery is plain from this one example. Indeed, habitual flattery was contrary to his habits. His portraits up to this time all display that uncommon facility for seizing character which his father enjoyed before him, and which he had inherited in an expanded form. No amount of labour, no laboriousness of finish—and of both he was ever prodigal—betrayed him into loss of resemblance or expression. No painter was ever quicker at noting peculiarities of physiognomy, and it may be observed that in none of his faces, as indeed in none of the faces one sees in nature, are the two sides alike. Yet he was not a child of the 16th century, as the Venetians were, in substituting touch for line. We must not look in his works for modulations of surface or subtle contrasts of colour in juxtaposition. His method was to the very last delicate, finished, and smooth, as became a painter of the old school.

Amongst the more important creations of Holbein's later time we should note his Duke of Norfolk at Windsor, the hands of which are so perfectly preserved as to compensate for the shrivel that now disfigures the head. Two other portraits of 1541 (Berlin and Vienna), the Falconer at the Hague, and John Chambers at Vienna (1542), are noble specimens of portrait art; most interesting and of the same year are the likenesses of Holbein himself, of which several examples are extant—one particularly good at Fähna, the seat of the Stackelberg family near Riga, and another at the Uffizi in Florence. Here Holbein appears to us as a man of regular features, with hair just turning grey, but healthy in colour and shape, and evidently well to do in the world. Yet a few months only separated him then from his death-bed. He was busy painting a picture of Henry the VIII. confirming the Privileges of the Barber Surgeons (Lincoln's Inn Fields), when he sickened of the plague and died after making a will about November 1543. His loss must have been seriously felt in England. Had he lived his last years in Germany, he would not have changed the current which decided the fate of painting in that country; he would but have shared the fate of Dürer and others who merely prolonged the agony of art amidst the troubles of the Reformation. (J. A. C.)

HOLBERG, Ludvig Holberg, Baron (1684–1754), the greatest of Scandinavian writers, was born at Bergen, in Norway, on the 3d of December 1684. Both Holberg's parents died in his childhood, his father first, leaving a considerable property; and in his tenth year he lost his mother also. Before the latter event, however, the family had been seriously impoverished by a great fire, which destroyed several valuable buildings, but notwithstanding this, the mother left to each of her six children some little fortune. In 1694 the boy Holberg was taken into the house of his uncle, who sent him to the Latin school, and prepared him for the profession of a soldier; but soon after this he was adopted by his cousin Otto Munthe, and went to him up in the mountains. His great desire for instruction, however, at last induced his family to send him back to Bergen, to his uncle, and there he remained, eagerly studying, until the destruction of that city by fire in 1702, when he was sent to the university of Copenhagen. But he soon exhausted his resources, and, having nothing to live upon, was glad to hurry back to Norway, where he accepted the position of tutor in the house of a rural dean at Voss. He soon returned to Copenhagen, where in 1704 he took his degree, and worked hard at French, English, and Italian. But he had to gain his living, and accordingly he accepted the post of tutor once more, this time in the house of Dr Smidt, vice-bishop of Bergen. The good doctor had travelled much, and the reading of his itineraries and note-books awakened such a longing for travel in the young Holberg that at last, in 1706, having scraped together 60 dollars, he went on board a ship bound for Holland. He proceeded as far as Aix-la-Chapelle, where he fell sick of a fever, and suffered so much from weakness and poverty, that he made his way to Amsterdam, and came back to Norway. Ashamed to be seen so soon in Bergen, he stopped at Christianssand, where he lived through the winter, supporting himself by giving lessons in French. In the spring he travelled, in company with a student named Brix, through London to Oxford, where he studied for two years, gaining his livelihood by giving lessons on the violin and the flute. He mentions, with gratitude, the valuable libraries of Oxford, and it is pleasant to record that it was while he was there that it first occurred to him, as he says, "how splendid and glorious a thing it would be to take a place among the authors." Through London and Elsinore he reached Copenhagen a third time, and began to lecture at the university; his lectures were attended, but he got no money. He was asked in 1709 to conduct a rich young gentleman to Dresden, and on his return journey he lectured at Leipsic, Halle, and Hamburg. Once more in Copenhagen, he undertook to teach the children of Admiral Gedde. Weary with this work, he took a post at Borch College in 1710, where he wrote, but did not print, his first work, *A Universal History*, and was permitted to present to King Frederick IV. two manuscript essays on Christian IV. and Frederick III. The king soon after presented him with the Rosenkrantz grant of 100 dollars for four years, the holder of which was expected to travel. Holberg accordingly started in 1715, and visited, chiefly on foot, a great portion of Europe. From Amsterdam he walked through Rotterdam to Antwerp, took a boat to Brussels, and on foot again reached Paris. Walking and skating, he proceeded in the depth of winter to Marseilles, and on by sea to Genoa. On the last-mentioned voyage he caught a fever, and nearly died in that city. On his recovery he pushed on to Civita Vecchia and Rome. When the spring had come, being still very poor and in feeble health, he started homewards on foot by Florence, across the Apennines, through Bologna, Parma, Piacenza, Turin, over the Alps, through Savoy and Dauphiné to Lyons, and finally to Paris, where he arrived in excellent health. After spending a month in Paris, he walked on to Amsterdam, took sail to Hamburg, and so went back to Denmark in 1716. He spent the next two years in extreme poverty, and published his *Introduction to Natural and Popular Law*. But at last, in 1718, his talents were recognized by his appointment as professor of metaphysics at the university of Copenhagen; and in 1720 he was promoted to the lucrative chair of public eloquence, which gave him a seat in the consistory. His pecuniary troubles were now at an end. Hitherto he had written only on law, history, and philology, although in a Latin controversy with the jurist Andreas Hover of Flensborg his satirical genius had flashed out. But now, and until 1728, he created an entirely new class of humorous literature under the pseudonym of Hans Mikkelsen. The serio-comic epic of *Peder Paars*, one of the great classics of the Danish language, appeared in 1719. This poem was a brilliant satire on contemporary manners, and enjoyed an extraordinary success. But the author had offended in it several powerful persons who threatened his life, and if Count Danneskjold had not personally interested the king in him, Holberg's career might have had an untimely close. During the next two years he published five shorter satires, all of which were well received by the public. The great event of 1721 was the erection of the first Danish theatre in Grönnegade, Copenhagen; Holberg took the direction of this house, in which was played, in September 1722, a Danish translation of *L'Avare*. Until this time no plays had been acted in Denmark except in French and German, but Holberg now determined to use his talent in the construction of Danish comedy. The first of his original pieces performed was *Den politiske Kandstöber* (The Pewterer turned Politician); he wrote other comedies with miraculous rapidity, and before 1722 was closed, there had been performed in succession, and with immense success, *Den Vægelsindede* (The Waverer), *Jean de France*, *Jeppe paa Bjerget*, and *Gert the Westphalian*. Of these five plays, four at least are masterpieces; and they were almost immediately followed by others. Holberg took no rest, and before the end of 1723 the comedies of *Barselstuen* (The Lying-in Room), *The Eleventh of July*, *Jakob von Thyboe*, *Den Bundeslöse* (The Fidget), *Erasmus Montanus*, *Don Ranudo*, *Ulysses of Ithaca*, *Without Head or Tail*, *Witchcraft*, and *Melampe* had all been written, and some of them acted. In 1724 the most famous comedy that Holberg produced was *Henrik and Pernille*. But in spite of this unprecedented blaze of dramatic genius the theatre fell into pecuniary difficulties, and had to be closed, Holberg composing for the last night's performance a *Funeral of Danish Comedy*. All this excessive labour for the stage had undermined the great poet's health, and in 1725 he determined to take the baths at Aix-la-Chapelle; but instead of going thither he wandered through Belgium to Paris, and spent the winter there. In the spring he returned to Copenhagen with recovered health and spirits, and worked quietly at his protean literary labours until the great fire of 1728. In the period of national poverty and depression that followed this event, a puritanical spirit came into vogue which was little in sympathy with Holberg's dramatic or satiric genius. He therefore closed his career as a dramatic poet by publishing in 1731 his acted comedies, with the addition of five which he had no opportunity of putting on the stage. With characteristic versatility, he adopted the serious tone of the new age, and busied himself for the next twenty years with historical, philosophical, and statistical writings. During this period he published his *Description of Denmark and Norway* (1729), *History of Denmark*, *Universal Church History*, *Biographies of Famous Men*, *Moral Reflections*, *Description of Bergen* (1737), *A History of the Jews*, and other learned and laborious compilations. The only poem he published at this time was the famous *Nicolai Klimii Iter Subterraneum*, 1741, afterwards translated into Danish by Baggesen. When Christian VI. died in 1748, the theatre was reopened and Holberg was appointed director, but he soon resigned this arduous post. His last published work was his *Epistles*, in 5 vols. In 1747 he was made Baron af Holberg. In August 1753 he took to his bed, and he died at Copenhagen on the 28th of January 1754, in the seventieth year of his age. He was buried at Sorö, in Zealand. He had never married, and he bequeathed all his property, which was considerable, to Sorö College.

Holberg was not only the founder of Danish literature and the greatest of Danish authors, but he was, with the exception of Voltaire, the first writer in Europe during his own generation. Neither Pope nor Swift, who perhaps excelled him in particular branches of literary production, approached him in range of genius, or in encyclopædic versatility. Holberg found Denmark provided with no books, and he wrote a library for her. When he arrived in the country, the Danish language was never heard in a gentleman's house. Polite Danes were wont to say that a man wrote Latin to his friends, talked French to the ladies, called his dogs in German, and only used Danish to swear at his servants. The single genius of Holberg revolutionized this system. He wrote poems of all kinds in a language hitherto employed only for ballads and hymns; he instituted a theatre, and composed a rich collection of comedies for it; he filled the shelves of the citizens with works in their own tongue on history, law, politics, science, philology, and philosophy, all written in a true and manly style, and representing the extreme attainment of European culture at the moment. Perhaps no author who ever lived has had so vast an influence over his countrymen, an influence that is still at work after 200 years.

The editions of Holberg's works are legion. During the last twenty-five years five complete editions of the *Comedies* have appeared, of which the best is that brought out in 3 vols. by F. L. Lichtenberg, in 1870. Of *Peder Paars* there exist at least twenty-three editions, besides translations in Dutch, German, and Swedish. The *Iter Subterraneum* has been three several times translated into Danish, ten times into German, thrice into Swedish, thrice into Dutch, thrice into English, twice into French, twice into Russian, and once into Hungarian. The life of Holberg was written by Welhaven in 1858. Among works on his genius by foreigners may be mentioned an exhaustive study by Robert Prutz, 1857, and *Holberg considéré comme imitateur de Molière*, by A. Legrelle, Paris, 1864. (E. W. G.)

HOLCROFT, Thomas (1745-1809), dramatist and miscellaneous writer, was born 10th December 1745 (old style) in Orange Court, Leicester Fields, London. His father, besides having a shoemaker's shop, kept riding horses for hire; but he fell into difficulties some six years later, and was reduced ultimately to the necessity of hawking pedlery from village to village. The son accompanied his parents in their tramps, and besides the hardships incident to such a life had often to endure the consequences of his father's passionate outbreaks of temper, which were, however, succeeded by equally violent transports of affection. In such circumstances he was disposed to regard it as an extraordinary piece of good fortune when he succeeded in procuring the situation of stable boy at Newmarket, an employment in which he manifested great coolness and courage, and acquired high proficiency. Previous to this he had received a pretty good education, and at Newmarket he spent his evenings chiefly in miscellaneous reading and the study of music. Gradually he also succeeded in obtaining a competent knowledge of French, German, and Italian. On the expiry of his term of engagement as stable boy he returned to assist his father, who had again resumed his trade of shoemaker in London; but after marrying in 1765, he procured the office of teacher in a small school in Liverpool. His subsequent career, like his earlier life, was hard and chequered, but it must suffice to state that, after failing in an attempt to set up a private school, he followed for several years the profession of an actor, often at a very meagre salary, and that he was more successful as a dramatist and novelist, but suffered much and frequent anxiety from pecuniary embarrassments and repeated disappointments. He died 23d March 1809 from enlargement of the heart, brought on, it is supposed, by the failure of several of his dramatic pieces. He was a member of the Society for Constitutional Reform, and on that account was, in 1794, indicted of high treason, but acquitted. The best known dramas of Holcroft are *Duplicity*, *The School for Arrogance*, *The Road to Ruin*, and *The Deserted Daughter*. Among his novels may be mentioned *Alwyn* and *Hugh Trevor*. He was also the author of *Travels from Hamburg through Westphalia, Holland, and the Netherlands to Paris*, and of some volumes of verse, and translated several works from the French and German with considerable elegance. The interest which still attaches to his career is, however, less on account of the intrinsic merit of his literary performances than his peculiarly chequered life and his persevering struggle to elevate himself above the ignorant and sordid condition of his early years. His *Memoirs written by himself and continued down to the time of his Death, from his Diary, Notes, and other Papers*, by William Hazlitt, appeared in 1815, and has gone into several editions.

HÖLDERLIN, JOHANN CHRISTIAN FRIEDRICH (1770–1843), German poet, was born March 29, 1770, at Lauffen on the Neckar. His mother removing, after a second marriage, to Nürtingen, he began his education at the classical school there, where Schelling was his schoolfellow and playmate. He was destined by his relations for the church, and with this view was later admitted to the free schools of Denkendorf and Maulbronn. At the age of eighteen, already an excellent classical scholar, he was sent to the university of Tübingen, where, however, he showed no inclination to the study of theology. He was already the writer of occasional verses, and had begun to sketch his first version of *Hyperion*, when he was introduced in 1793 to Schiller, and obtained through him the post of tutor to the young son of Frau von Kalb. A year later he left this situation to attend Fichte's lectures, and to become a disciple of Schiller in Jena. Schiller recognized in the young poet something of his own style of genius, and encouraged his early literary attempts by sending some of them to Goethe, and by superintending the publication of others in the *Thalia* and *Horen*. In 1796 Hölderlin obtained the post of tutor to the three young children of a banker named Gontard in Frankfort. Gontard's beautiful and gifted wife is the Diotima of Hölderlin's *Hyperion*. For this lady he conceived a foolish and hopeless passion; and she became at once his inspiration and his ruin. At the end of two years, during which time the first volume of *Hyperion* was published (1797), some kind of crisis appears to have occurred in their friendship, for the unhappy young poet suddenly left Frankfort and the Gontard family; but whether he was dismissed by the indignant husband of Diotima, or was impelled by his own better resolutions, has not been explained. In spite of ill health, he now completed *Hyperion*, the second volume of which appeared in 1799, and he began a tragedy, *Der Tod des Empedokles*, which is published in an unfinished condition among his works. Some of his verses appeared in the *Taschenbuch für Frauenzimmer* in 1799 and 1800; and he contemplated starting a new literary journal, of which he was to be the editor, but the scheme was a failure. His friends now became alarmed at the alternate depression and nervous irritability from which he suffered, and he was induced to go to Switzerland, as tutor in a family at Hauptwill. There his health improved; and several of his poems, among which are "Der blinde Sänger," "An Die Hoffnung," and "Dichtermuth," were written at this time. In 1801 he returned home to arrange for the publication of a volume of his poems; but, on the failure of this enterprise, he was obliged to accept another tutorship in the family of the Hamburg consul in Bordeaux. Diotima died a year later, in June 1802, and the news is supposed to have reached Hölderlin shortly afterwards, for in the following month he suddenly left Bordeaux, and travelled homewards on foot through France, arriving at Nürtingen destitute and insane. Kind treatment gradually alleviated his condition, and in lucid intervals he occupied himself by writing verses and translating Greek plays. Two of these translations—the *Antigone* and *Œdipus Rex* of Sophocles—appeared in 1804, and several of his short poems were published by Seckendorf in his *Musenalmanach*, 1807 and 1808. In 1804 Hölderlin obtained the post of librarian to the landgrave of Homburg, and went to live in Homburg under the supervision of friends; but the post was abandoned two years later, and he was taken to Tübingen, where he remained, irremediably but harmlessly insane, till his death, June 7, 1843.

Hölderlin's writings are the production of a beautiful and sensitive mind, a mind of high ideals and noble impulses; but they are intensely, almost morbidly, subjective, and they lack real human strength. Perhaps his strongest characteristic was his passion for Greek subjects, and the natural result of this was that he almost entirely discarded rhyme in favour of the ancient verse measures. His poems are all short pieces; of his tragedy only a fragment was written. *Hyperion, oder der Eremit in Griechenland*, is thus his one important work; and even to this a sequel is wanting. It may be called a prose poem, and is written in the form of letters. Its exquisite language, the purity of its tone, the sad philosophical vein which permeates it, together with its autobiographic character, claim for it a unique position among German classics.

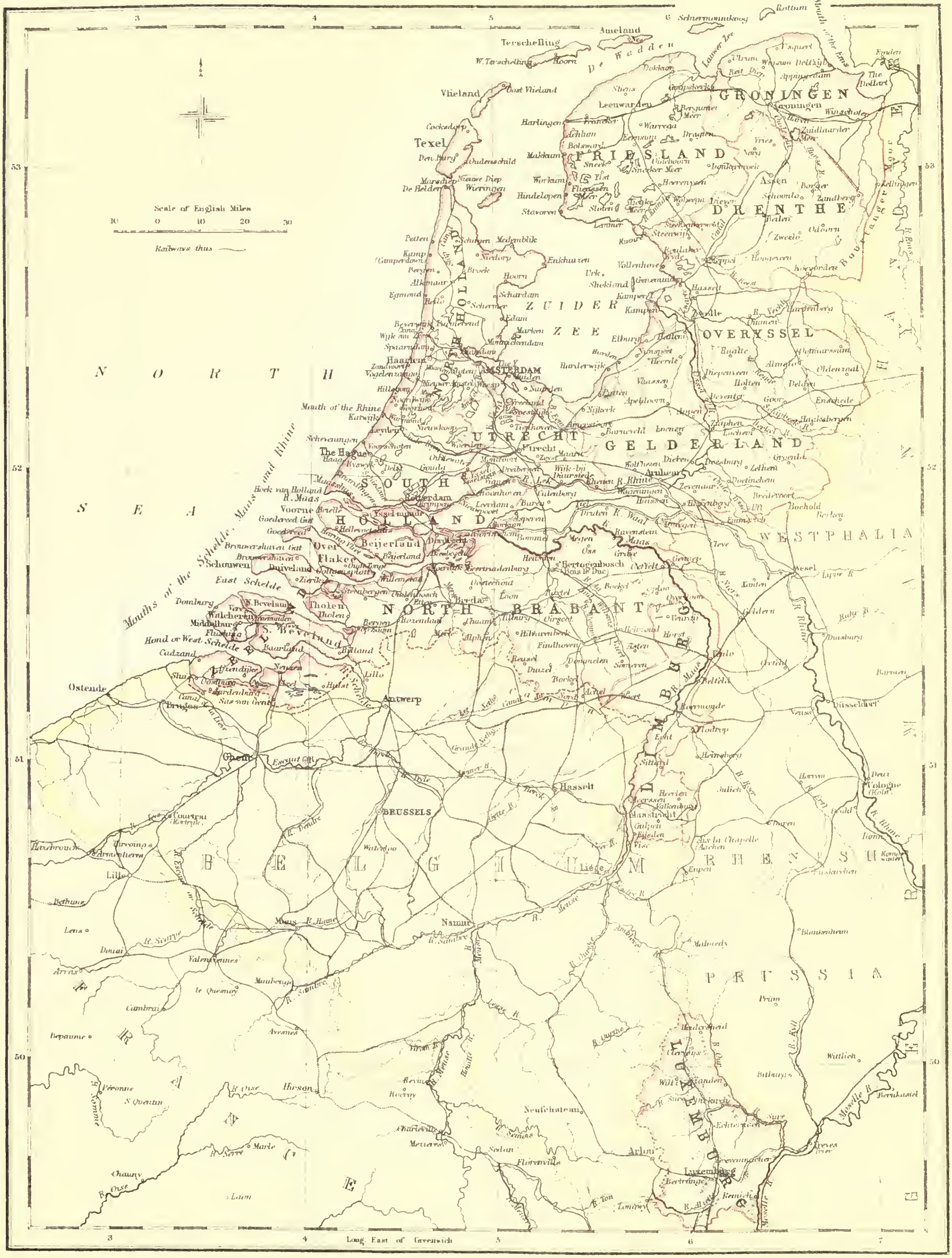
An edition of Hölderlin's complete works, with his letters and biography, appeared in 1846; and there is a cheap edition of his selected works, with a biography by Christoph Theodor Schwab, published in 1874.

HOLESCHAU, HOLLESCHAU, or HOLESOV, chief town of a government district in Moravia, Austria, circle of Hradisch, is situated on the Russawa, 20 miles N.N.E. of Hradisch. It has a large castle in the Italian style (with a fine garden), a beautiful decanal church, and a synagogue. Linen and cloth-weaving are carried on, and there is some trade in honey, wax, hides, and wool. The population in 1869 was 5282, more than a third being Jews.

HOLIBUT, or HALIBUT (*Hippoglossus vulgaris*), is the largest of all Flat-fishes, specimens of 5 feet in length and of 100 lb in weight being frequently exposed for sale in the markets. Indeed, specimens under 2 feet in length are very rarely caught, and singularly enough, no instance is known of a very young specimen having been obtained. The holibut is much more frequent in the higher latitudes of the temperate zone than in its southern portion; it is a circumpolar species, being found on the northern coasts of America, Europe, and Asia, extending in the Pacific southwards to California. On the British coasts it keeps at some distance from the shore, and is generally caught in from 50 to 150 fathoms. Its flesh is considered coarse, though white and firm.

HOLINSHED, or HOLLINSHED, RAPHAEL, author of *Chronicles of England, Scotland, and Ireland*, flourished in the 16th century. He belonged to a family settled at Bosley, in Cheshire, and according to Anthony Wood he was educated at one of the universities and took orders in the church. In the compilation of the *Chronicles* called by his name he bore a leading part, but he received extensive and important aid from Stow the antiquary, Harrison, chaplain to Lord Cobham, Hooker (*alias* Vowell), an uncle of the divine of that name, and Francis Boteville (*alias* Thin), a learned antiquary. Holinshed's share in the work comprised the history of England down to the year 1577, the date of the first edition. His will—printed in Hearne's preface to Camden's *Annales*—shows that in the latter part of his life he was in the service of Thomas Bendet of Bromcote, in Warwickshire. He died between 1580 and 1584. The notice of Elizabeth's reign contained matter so offensive to her and her court that in the second edition, which appeared in 1587, some of the sheets were cancelled altogether. The castrations were published separately by Dr Drake in 1728, and in subsequent reprints have been restored. The history of Scotland, incorporated by Holinshed in his *Chronicles*, is for the most part a translation from the Latin of Hector Boece, and is interesting as having furnished Shakespeare with the groundwork of his tragedy of *Macbeth*. The *Chronicles*, being the work of so many different hands, present great varieties of literary quality; but the learning and research they show have made them an invaluable aid in the illustration of the early annals of England. An edition in accordance with the original text was published in 1808, 6 vols.

HOLKAR, the title of the mahárájá of INDORE (*q.v.*), whose territories are often designated Holkar's Dominions.



Scale of English Miles
10 0 10 20 30
Railways thus
NORTH SEA
Mouths of the Schelde, Maas and Rhine
Mouth of the Rhine
Terschelling
Ameland
Schiermonnikoog
Rottum
Vlieland
Texel
De Wadden
GRONINGEN
FRIESLAND
DRENTHE
OVERYSSEL
GELDERLAND
UTRECHT
NORTH HOLLAND
SOUTH HOLLAND
ZEELAND
NORTH BRABANT
LIMBURG
LUXEMBURG
ZUIDER ZEE
WESTPHALIA
RHENISH
PRUSSIA
BELGIUM
FRANCE
HANOVER
Leeuwarden
Harlingen
Groningen
Assen
Zwolle
Kampen
Deventer
Zutphen
Arnhem
Nijmegen
Utrecht
Amersfoort
AMSTERDAM
Haarlem
Leyden
The Hague
Rotterdam
Dordrecht
Gouda
Briele
Schouwen
Walcheren
Middelburg
Flushing
Tholen
Breda
Tilburg
Eindhoven
s'Hertogenbosch
Venlo
Roermonde
Maastricht
Antwerp
Ostende
Bruges
Ghent
BRUSSELS
Hasselt
Liége
Namur
Lille
Cologne
Düsseldorf
Wesel
Aix la Chapelle
Treves
Luxemburg
Arlon
Sedan
Mezieres
Valenciennes
Mons
Cambrai
Long. East of Greenwich

HOLLAND

PART I.—GEOGRAPHY AND STATISTICS.

Plate I. HOLLAND is the most usual English name of the country which is nationally designated the Kingdom of the Netherlands (*Koningrijk der Nederlanden*). The word, which is popularly explained as if it were Hollow-land, and referred to the same physical fact which has given rise to the terms Netherlands and the Low Countries, appears in an older form as Holtland, and is thus evidently equivalent to Wood-land. In French the usual expression is Pays-Bas, and in German Niederlande.

There is no country in Europe in which the character of the territory has exercised so great an influence on the inhabitants as in the Netherlands; and, on the other hand, no people has so extensively modified the condition of its territory as the Dutch. In a description of Holland, consequently, the greatest importance must be attached to the physical conformation of the country as it was and is; and most of the peculiarities of the political and social condition of the people must be considered in connexion with this conformation.

Extent. The size of Holland, being subject to perpetual diminution and increase, cannot be indicated by a definite figure except as at some definite period; on the one hand, there is loss of area still going on in consequence of the erosion of the coasts, and, on the other hand, this is more than counterbalanced by a continual acquisition of new ground due more especially to "impoldering" and draining operations. In 1833 the surface of the Netherlands was only 2,270,959 hectares (5,611,860 acres, 8768 square miles); on the 20th Oct. 1877, at the time of the conclusion of the cadastral survey, it was 3,297,268 hectares (8,148,020 acres, 12,731 square miles).

The kingdom extends from 53° 32′ 21″ (Groningen Cape on Rottum Island) to 50° 45′ 49″ N. lat. (Mesch in the province of Limburg), and from 3° 23′ 27″ (Sluis in the province of Zealand) to 7° 12′ 20″ E. long. (Langakkerschans in the province of Groningen). The greatest length from north to south, viz., that from Rottum Island to Eysden near Maestricht is estimated at 164 miles, and the greatest breadth from south-west to north-east, or from Zwin near Sluis to Losser in Overyssel at 144 miles. If the Zuyder Zee, the parts of Prussia which encroach on the eastern side, and the projecting portions of Limburg and Zealand are disregarded, the general form is almost an oblong. With the exception of Greece and Great Britain, no country of Europe has so many inlets of the sea as Holland.

Boundaries. The Netherlands are bounded on the E. by the Prussian provinces of Hanover, Westphalia, and the province of the Rhine, and on the S. by the Belgian provinces of Liége, Limburg, Antwerp, and East and West Flanders. A purely geographical boundary is formed to the W. and the N. by the North Sea, at the N.E. corner by the Dollart, and from Stevensweert southward to the extreme corner of Limburg (near Eysden) by the Maas or Meuse.[1] Natural ethnographic frontiers, such as occur where two neighbouring peoples of different origin, race, character, customs, and language are sharply marked off from each other, do not exist in the case of the Netherlands. The Low German element, indeed, of which the Netherlands form as it were the kernel, spreads beyond Dutch limits both north-east along the coast of the German Ocean and south-west into Belgium.

[1] At Maestricht, however, a portion lies on the left bank of the river, measured, according to the treaty with Belgium, 19th April 1839, art. 4, by an average radius of 1200 Dutch fathoms (7874 feet) from the outer glacis of the fortress.

Coast-line. As regards the seaward boundary—the coasts, river-mouths, and islands—it is necessary, for a just comprehension of its character and of its influence on the formation of the soil, to bear in mind that the coasts of the Netherlands shared in the general vicissitudes of the southern shores of the German Ocean at the time when the English Channel was still closed. Three periods may be distinguished in the history of these changes. During the first a row of dunes was formed on the sandy tongue of land which, beginning at Ostend, cut off and formed into an inland lake a portion of the German Ocean, at that time washing the diluvial strata; these are still indicated along the Dutch and the German coasts by a series of dune-formations, sandbanks, and islands. In the second period the separation between ocean and lake was still maintained, the river-water gained the upper hand over the sea-water in the lake, the matter brought down by the river began to settle, and the morasses and beds of marsh-plants, reeds, and rushes (*derrie*) were formed which are now found above the old sand beds and below the present clay beds. When in the third period the coasts subsided, the dunes were here and there carried away by the rise of the waters, portions of the land were submerged, and, mud being extensively piled up by the sea, the fertile clay (*zeeklei*) of the maritime provinces was formed, and at the same time the mouths of the rivers were changed in position. And all this took place on a still greater scale when the limestone rocks which united Calais and Dover at last gave way and the great ocean with its heavier incidence of billows and tides drove into the smaller sea. According to Dr Hartogh Heys van Zouteveen,[2] 150,000 hectares (370,670 acres) of land were lost on the coast of the German Ocean, 385,000 hectares (951,390 acres) on the Zuyder Zee and the Wadden, 8432 hectares (20,836 acres) in the Dollart, 10,000 hectares (24,711 acres) in the Biesbosch, and about 27,000 hectares (66,720 acres) more in other parts. According to Dr Staring, the province of Groningen, even during the 18th and 19th centuries, has been harassed with inundations once in every 155 years, Utrecht and North Holland south of the Y once in 83 years, South Holland once in 55 years, Friesland, Overyssel, North Holland north of the Y, and the coast of North Brabant every 40 years; while the Netherlands in general have been visited by such disasters in 1702, 1715, 1717, 1741, 1755, 1756, 1791, 1808, 1809, and 1825, or on an average once in every eleven years. In this last period, however, of the history of the land the lordship of man ultimately began to make itself felt. The formation of the first dykes to prevent inundations was quickly followed by the construction of a connected system of earthen ramparts, behind which the country lies secure, while at the same time hundreds of thousands of acres of fertile land have been recovered from the sea. The area gained from 1833 to 1877 has been already stated. The following table shows the amount reclaimed by endyking down to the dates given:—

In North Holland,	to 1864	72,283 acres.
,, South Holland Islands,	to 1850	168,302 ,,
,, Friesland,	,,	36,368 ,,
,, Groningen,	,,	86,838 ,,
,, North Brabant,	to 1843	95,391 ,,
,, Zealand,	to 1859	220,411 ,,

To return to the present condition of the seaboard of the Netherlands,—it follows from what has been said

[2] *Algemeene Statistiek van Nederland*, p. 61.

that it consists (1) of coasts still protected by dunes or fringed with sandbanks and islands indicating the direction of ancient lines of dunes; (2) of low coasts of sea-clay provided with dykes which in more than one quarter have been repeatedly extended so as to enclose land conquered from the sea (the sea-polders); and finally (3) of some high diluvial strata which rise far enough above the level of the sea to make dykes unnecessary. The dunes follow the west and north-west coast almost without a break, except in a few quarters where they have been removed and their place supplied by dykes or rubble, as in North Holland between Huisduinen and Nieuwe Diep and between Kamp and Petten, in South Holland on Voorne, and in Zealand on Schouwen and Walcheren, where the famous Westkappel dyke unites the village of Westkappel with the watering-place of Domburg. The breadth of the line of dunes naturally varies greatly—from 600 to 7000 feet; and there is a similar variety in the height of the individual dunes proper, called dune-hills (*duinheuvels*) as compared with the dune-pans (*duinpannen*) or depressions. The elevation of the High Blinkert near Haarlem (196 feet) is an extreme exception, for the average is not more than 50 or 60 feet even in the case of the high dunes which lie nearest the shore and are known as "sea-runners" (*zeelooper*) or the "shore-ridge" (*strandreeks*). The dunes show a tendency, except where the Dutch prevent it by planting wood or sand-oats, to wear away on the side towards the sea, and to "overstuiven" or drift off on the landward side. There is, indeed, a general degradation of the coast, and a recession towards the east, corresponding to the subsidence which may be observed along the German seaboard, and probably traceable also, in part at least, to the Channel current, which at mean tide has a velocity of 14 or 15 inches per second, and especially during strong west or north-west winds carries off large quantities of material. This alteration of coast-line appears at Loosduinen, where the moor or fenland formerly developed behind the dunes now crops out on the shore amid the sand, being pressed to the compactness of lignite by the weight of the sand drifted over it. Again, the remains of the Roman camp at Brittenburg or Huis te Britten, which originally lay within the dunes and, after being covered by them, emerged again in 1520, were, in 1694, 1600 paces out to sea, opposite Katwijk; while, besides Katwijk itself, several other villages of the west coast, as Domburg, Scheveningen, Egmond, have continually to be removed further inland. Two things special to Holland are worthy of particular notice, the artificial formation of dunes, as at Koegras, Callantsoog, Petten, Katwijk, Scheveningen, and Zandvoort, and the carrying away of the sand (*afzanderij*, "offsanding") by ship or rail, as in the "Westland," for example, to the south of the Hague, to serve elsewhere for engineering operations and the improving of the soil. Mingled with marsh-earth the sand forms a soil suited to the culture of flower-bulbs; with clay it produces that excellent soil for vegetable gardens for which the Westland is so famous. It must be further remarked that both the "dune pans," which are naturally marshy through their defective drainage, and the "geest" grounds—that is, the grounds along the foot of the downs—have been in various places either planted with wood or turned into arable and pasture land; while the numerous springs at the base of the dunes rise at such a height above the ordinary level of the country that the water is conveyed by canals to the great cities, and an improvement is thus effected at once in the agricultural condition of the coast-land and in the sanitary condition of the cities.

Sea-dykes.

The sea-dykes are found along the northern coasts, the coasts of the provinces which border on the Zuyder Zee, and the coasts of the islands of Zealand and South Holland so far as they are not protected by dunes. Only in a few places, it will be seen, are the sea-dykes unnecessary; as for example, in Friesland between Stavoren and Olde Mirdum (the bold and steep Roode and Mirdum cliffs) and near Doornspijk, 3 miles south of Elburg, where there are high grounds which stretch 6 miles to the south-west of Harderwijk. The earthen dykes are protected by stone-slopes and by piles, and at the more dangerous points also by "zinkstukken" (sinking pieces), artificial structures of bulrushes, reeds, and branches, laden with stones, and measuring some 400 yards in circuit, by means of which the current is to some extent turned aside. The Westkappel dyke already mentioned is 12,468 ft. long and 23 high, has a seaward slope of 300 ft., and is protected by rows of piles and basalt blocks. On its ridge, 39 ft. broad, there is not only a roadway but a service railway. When it is remembered that the woodwork is infested by the pile worm (*Teredo navalis*), the ravages of which were discovered in 1731, the enormous expense incurred in the construction and maintenance of the 1550 miles of sea-dykes now existing may be imagined. The cost of construction is not overestimated at 150,000,000 guilders or £12,500,000.

Islands.

The Dutch islands may be divided into two main classes —(1) those surrounded on all sides by the German Ocean or its inlets, and (2) those surrounded entirely or in great part by river arms, and separated by these from the mainland or from each other. The first division again comprises two groups—(*a*) the islands Texel, Vlieland, Terschelling, Ameland, Schiermonnikoog, and Rottum, which stretch in a long arc from the north point of North Holland to the mouth of the Ems, and indicate the old coast-line, so that they belong to the same physico-geographical group with the islands along the German coast; and (*b*) the islands Wieringen, Marken, Urk, and Schokland, which are the relics of the stretch of country formerly comprising the present bed of the Zuyder Zee. In the second class are to be reckoned the delta of the river Yssel (Camper Island) and the islands belonging to the contiguous deltas of the Rhine, the Meuse, and the Scheldt, including the island of Betuwe between the Rhine and the Waal and the archipelago of South Holland and Zealand.

River mouths.

As the river mouths of Holland must also be regarded as gulfs or inlets of the sea, they may be noticed here. The average breadth of the Haringvliet at Helvoetsluys is 8860 ft. and at Goedereede 18,045; that of the West Scheldt at Ter Neuzen 15,420 ft., and at Flushing (Vlissingen) 13,780; that of the East Scheldt at the harbour of Goes 13,780, and at the harbour of Zierikzee 13,450; and that of the Roompot 21,650 to 29,530 ft.

Influence of the coasts on industry.

The varying characteristics of the coasts in different places give rise to correspondingly different industries. As regards trade and navigation, the west coasts with their shallows and sandbanks can be approached only by small vessels of light draught (visscherspinken) unless where access is afforded by the inlets of the sea, especially the mouth of the West Scheldt at Flushing, that of the East Scheldt at Zierikzee, the Brouwershaven inlet between the islands of Schouwen and Goeree, the Goeree inlet at Helvoetsluys, the Marsdiep at the Helder, and the mouth of the Ems at Delfzijl, or where a way has been opened up by engineering works as at Rotterdam and Amsterdam (by the new waterway to the sea and the canal to Ymuiden). As we proceed from south-west to north-east the places along the coast become less and less important; in the provinces of Groningen and Friesland the approach to the mainland is obstructed by the Wadden or Shallows; and on the coast of the Zuyder Zee are those harbours, for the most part rendered useless by alluvial accretions, which have been so well described by Havard in his *Villes Mortes du Zuyderzee.* Along the greater part of these coasts the population is engaged in the fisheries rather than in trade, especially when the neighbourhood of a great town (as Alkmaar for Egmond, Haarlem for Zandvoort, Leyden for Katwijk, the Hague for Scheveningen) secures a good market or a ready means of exportation. Many fishing villages on the west coast, *e.g.*, Scheveningen, Domburg, and Zandvoort, have in recent years acquired repute as watering-places with both natives and foreigners.

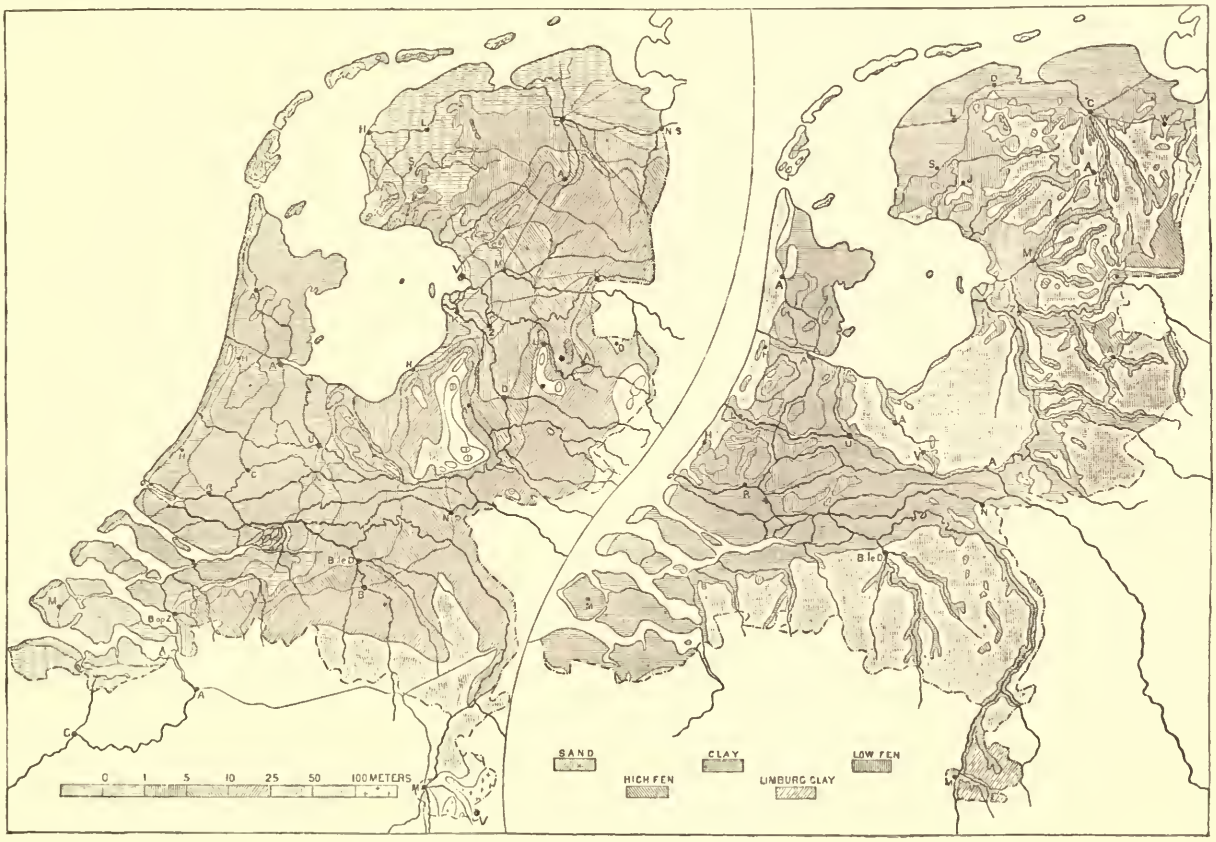
The availability of the flat coasts for trade and navigation is to a large extent dependent on the range of the rise and fall of the tides. As shown in the following table, this steadily decreases from south-west to north-east. In the Zuyder Zee it is naturally very small.

Places.	Range of Tides.	Places.	Range of Tides.
	Feet.		Feet.
Off Sluis	11·9	Petten	5·1
Flushing	12·1	Kijkduin	4·1
Westkapelle	11·2	Nieuwediep	3·7
Brouwershaven	9·8	Terschelling	5·2
Goedereede	5·9	Ameland	6·4
Helvoetsluys	5·7	Rottum	7·6
Briel	4·9	Amsterdam[1]	1·2
Coast of Delfland	5·7	Zwanenburg[1]	1·1
Katwijk	5·5	Spaarndam[1]	1·2

The Shallows (Wadden) of the German Ocean between Groningen and Friesland and the islands Rottum, Schiermonnikoog, and Ameland are usually left in great measure dry at ebb-tide.

The elevation of the surface of the country ranges from about 650 ft. above to 16 or 20 ft. below the Amsterdam zero, which marks the mean high-water level in the Y in front of the city. The circumstance that so much of it is below the sea-level necessarily exercises a very important influence on the drainage, the climate, and the sanitary condition of the country, as well as on its defence by means of inundation. From the history of the formation of the soil already given, and from the course of the rivers, it may be gathered that the low grounds are in the west, and the higher in the south and east. According to the relief map published by the minister of war (scale 1 : 600,000), the provinces of North and South Holland, the western portion of Utrecht as far as the Vaart Rhine, Zealand, except the southern part of Zealand-Flanders, and also the north-west corner of North Brabant, all lie, with the exception of the dunes, below the Amsterdam zero; while the eastern portion of the country, except a small strip along the Zuyder Zee in the provinces of Guelderland, Overyssel, and Friesland, as well as the lands in the neighbourhood of the Dollart, is situated above it. The regular slope of the ground from south-east to north-west, and the position of the highest and the lowest points, are indicated by the same authority. At Vaals, in the extreme south-east, the altitude is 656 ft., at Valkenberg 525, at St Pietersberg near Maestricht

Relief.



Relief and Geological Charts of Holland.
The positions of the chief towns are indicated by the initials of their names. In the left-hand chart the undivided horizontal lines show the tracts that lie below the Amsterdam zero, the broken horizontal lines those under 1 metre, &c.

403, at the Imbosch near Dieren and the Hettenheuvel near Heerenberg respectively 360 and 345, at Meerwijk near Nimeguen 318, at Apeldoorn 233, at Zeist 164, at Oldenzaal 154, at Wageningschenberg and Grebsohenberg respectively 151 and 131, at Hoenderloo and Kootwijk in the Veluwe 118 and 98, at Groenlo 78, in the "high fens" of Drenthe near Barge 85, at Lochen and Almelo 39, at Coevorden 31, at Steenwijk and Boertange 19, at Groningen 18, at Heerenveen 0·65. Below the Amsterdam zero lie naturally many impoldered districts, especially the marshes and meres which have been drained dry, as for example the Schermer and Purmer polders and the

[1] Before the construction of the canal to Ymuiden.

Haarlem lake, which are respectively – 10·66, – 12·46, – 13·61, the Schieveen polder near Schiedam – 16·27, the polders at Wo''brugge, the Bergschenhoek, and the Zuidplas – 16·86, – 17·58, and – 18·49.

Geology and soil. Of equal importance with the relief of the country is the geological composition of the soil. It is evident from the history of the origin of the land that Quaternary formations—alluvium and diluvium—must be well represented. In fact they constitute no less than 99·9 per cent. of the surface of the Netherlands, only ·1 per cent. thus remaining for all the older formations—the Tertiary and the Secondary, including the extremely limited Jurassic.

Fens. To the alluvial strata belong, in the first place, the fen (veen) strata, which are subdivided into low fens, high fens, marsh fens, and the "dalgronden" or "reclaimed high fens." The low fens, which are found in Groningen, Friesland, Overyssel, North and South Holland, and North Brabant (about the Langstraat), have been formed of aquatic plants, and, in the upper layers, of moss; their elevation is that of the mean sea-level; from them the "short turf," the best quality of peat, is obtained by dredging, and, when the standing water which collects after the peat has been dug out has been drained off, they may be turned into very productive arable land. The subsoil, on which the fertility then depends, consists usually of clays and alluvial sand or dune strata, rarely of diluvial sand strata. These low fens extend to no less than 904,597 acres, or about 11 per cent. of the surface. The high fens, of which the greater part have been "disfenned" or stripped of peat, are found in Groningen, Friesland, Drenthe, Overyssel, and the "Peel" or Marsh of North Brabant, in the more elevated plains or valleys. They have been formed of trees, heath-plants, and moss, and furnish the softer, inferior kind of peat, the "long turf." As the removal of the peat has been followed by the construction of canals to carry off the standing water, the high fens are of course free from marshes, but, resting as they do almost everywhere on diluvial gravel and sand, they do not furnish so fertile a soil as the low fens. They comprise 226,107 acres, or only about 2·8 per cent. of the surface of the country. The marsh fens are composed almost exclusively of a few species of sedge or carex, and constitute, not only in their method of formation, but also in their character and situation, the transition between the high and the low fens. They are widely scattered, especially along small streams which carry off water mingled with fenny materials, and are nowhere more numerously represented than in Drenthe, where all the drainage is of this character. The marsh fens occupy 168,551 acres, considerably less than the high fens. The "dalgronden" are formed where regular peat-fields are laid out along specially constructed canals, and the denuded surface is usually grubbed up for arable or pasture land, or on rare occasions planted with wood. They comprise about 207,576 acres, and naturally increase in proportion to the decrease of the high fens. We shall return to these "dalgronden" in connexion with the canals. Besides the fens, the clay lands and certain of the sand-strata belong to the alluvium. The clays—which

Clays furnish the richest arable soils, the most luxuriant meadowland, and in some places the material for bricks and earthenware—may be divided into the sea-clay, the river-clay, the stream-clay or green earth, and the old sea-clay of the districts recovered from the water. The exceptionally fertile sea-clay in the provinces of Groningen, Friesland, North and South Holland, and Zealand occupies no less than 1,676,860, or about 20 per cent. of the surface, while the river-clay, naturally situated along the banks of the larger rivers, takes up 854,284 acres, or about 10 per cent. The boundary between the sea-clay and the river-clay is formed in the case of these rivers by the maximum high-water line. The stream-clay or green earth, which is found, as the former name implies, on the banks of the smaller rivers or streams, is formed of course on a much smaller scale, and consists of a stratum on an average from 3 to 5 feet thick, resting almost exclusively on the sand diluvium, from which it is occasionally separated by a fenny stratum. It occurs in the east of Drenthe, Overyssel, and Guelderland, along the small tributaries of the Vecht, along the Vecht, Regge, and Schipbeek in Overyssel, and in like manner in North Brabant along the Dommel, Aa, Mark, and other unimportant streams. The green earth not unfrequently contains iron ore; from this the metal is extracted in Overyssel and Guelderland, and it is asserted that in thirty years the natural processes replace the excavated mineral. The stream deposits occupy about 2 per cent. of the surface—157,187 acres. Finally the old sea-clay of the reclaimed districts covers 127,518 acres, or 1½ per cent. of the surface. As already stated, the subsoil of the low fens is not everywhere clay. It is so in the main in the provinces of North and South Holland, where the drainage operations were consequently much more remunerative than in Friesland, and in the east of Utrecht, where the fens rested upon sand. Estimating the total area of the recovered districts at 197,690 acres, about five-eighths of this consists of old sea-clay; and these portions, such as the Haarlem lake grounds, the Beemster and Purmer polders in North Holland, and the Nieuwkoop and Zuidplas polders in South Holland, are reckoned among the richest and most fertile. How these low-lying areas have been endyked and drained, surrounded by canals and kept dry by gigantic steam-pumps, has been explained under the heading HAARLEM LAKE.

Alluvial sand. The alluvial sand-strata (to be distinguished from the diluvial sand) may be divided into (1) sand-drifts, (2) river-sand, river-downs, and "heibanen," and (3) old sea-sand and the sea-dunes with the geest-grounds. The last of these classes has already been considered in dealing with the sea-coast. The rivers bring down their sand as well as their gravel, not so much from the more elevated districts as from the diluvial valleys in which they have excavated their channels. The beds of the rivers themselves consist likewise of sand, mingled here and there with gravel or rolled and polished pebbles, and, where the current is not too strong, covered with a layer of clay. If sand has been accumulated on the shore, the wind soon transforms it after the retreat of the river into hillocks or river-dunes. When these contain a proportion of clay they are more fertile than the sea-dunes. They occur on both sides of the Guelderland Yssel (between Zalk and Oest), and on the Waal below Hulhuizen and opposite Rossum; and various eminences in other parts of the country, such as Agnietenberg near Zwolle, and the heights near Deventer, near Grafthorst opposite Kampen, and along the Meuse between Venlo and Mook, must be considered as of similar origin. "Heibanen," *i.e.*, heath-tracks, so called on account of their sterility, are beds of river gravel easily distinguished from the diluvial gravel by the smooth, worn, and uniform appearance produced ages ago by the action of the current. They are found, for example, in the Betuwe, about Avezaat, and between Lienden and Waddenoijen. Sand-drifts are dune formations originated by the action of the wind on the diluvial sand, where in one way or other it has been stripped of the heath-crust. They extend to 179,220 acres, or about 2¼ per cent. of the surface. The fen strata occupy in all 1,508,300 acres, or 18½ per cent.; the clay strata 2,815,850 acres, or about 35 per cent.; the alluvial sand strata 475,477 acres, or about 6 per cent.; and the whole alluvium 4,799,627 acres, or 59 per cent.

Diluvial strata. The diluvial or sand and gravel strata of the Netherlands are far from being of such economic importance as the alluvial strata. The agricultural products—mainly buckwheat and rye—are neither so abundant nor so valuable as the wheat and rape-seed of the clay soils; and neither stock-breeder nor dairy-farmer obtains so satisfactory results. The boundary of the diluvial strata may be roughly indicated by a line running through Winschoten, Groningen, Dokkum, Leeuwarden, Heerenveen, Steenwijk, Zwolle, Elburg, the coast of the Zuyder Zee, Naarden, Utrecht, Rhenen, Bois-le-Duc, Breda, Bergen-op-Zoom, and Antwerp. South and east of this line lies the diluvium, for the most part on the surface, except in the places already mentioned where the fens, the river-clay, the stream deposits, and the sand-drifts are situated, or in the extreme south and east where the older strata make their appearance. To the north and west of the line the only diluvial strata are those of the Zuyder Zee islands: in Texel, Wieringen, and Urk the soil is of diluvial origin; and this probably holds true also in whole or in part in Vlieland, Ameland, and Terschelling.

The diluvial formations are subdivided into gravel-strata and sand-strata. To the former belong (1) the Scandinavian diluvium, in which occur granites and chalk flints derived from Scandinavia, situated to the north of the Overyssel Vecht (that is, in Groningen, Drenthe, the south-west of Friesland, and the islands); (2) the mixed diluvium, which, besides the Scandinavian gravel contains stone-grit from Munster, the Teutoburger Wald, and the districts along the Rhine (it is situated between the Vecht and the Rhine, in Overyssel, Utrecht, the Gooiland,[1] and Guelderland); (3) the Rhine diluvium, destitute of granite, but with many fragments of white quartz, basalt, and other kinds of stone from the mountains along the river between Bonn and Coblentz (it lies between the Waal and the Meuse); (4) the Meuse diluvium, containing materials brought from the mountains higher up the stream; and finally (5) the Limburg flint diluvium, like the preceding variety destitute of any plutonic or volcanic rocks, but nevertheless consisting almost exclusively of flints occurring in the neighbouring chalk formation.

The sand-diluvium, which is of later date than the gravel, is found in great level stretches at the foot of the hills of diluvial gravel, and contains no pebbles or coarse gravel. It also occurs in the maritime provinces under all the marine and fluvial formations. According to some authorities it owes its origin to the influence of rain, or frost, or wind; according to others it has been formed by the sea like the Kempen sand and that of the dunes, and then transported by the south-westerly currents.

[1] A district formerly called Naardingerland, on the southern shores of the Zuyder Zee, including Naarden, Bussum, Huizen, Blaricum, Laren, Hilversum, and Muiderberg.

In the diluvium must also be included the loess, which occupies a large proportion of the province of Limburg. The whole diluvium comprises 3,308,330 acres, or about 40½ per cent. of the country, distributed thus:—Scandinavian 4½ per cent., mixed diluvium 4½, Rhine and Meuse diluvium and Limburg flint diluvium 1, loess 1½, and lastly the sand diluvium, which includes the diluvial river-banks, 2,376,770 acres, or about 29 per cent.

The older formations, which occupy a very limited area, occur in the east of Guelderland and Overyssel, in the south of Limburg, and in Zealand-Flanders. That they also form the substratum elsewhere, *e.g.*, in Zealand and Brabant, is not improbable. The area of the Tertiary strata is 3425, and of the Secondary 3746 acres.

As regards the capabilities of the soil, Holland does not hold an exceptionally favourable position,—34 per cent. of the country consisting of good and about 2 per cent. of inferior clay land, while more than 45 per cent. is poor and partially reclaimed sand, and fully 18·5 per cent. is covered with fens. The following figures show the account to which the soil is actually turned:—64·3 per cent. consists of arable and pasture land, gardens, hay-fields, and orchards; 6 per cent. is occupied by water and roads; 7 per cent. is woodland; 0·7 is covered with buildings; and the rest, or 22 per cent., must consequently be assigned to the waste lands, shores, and dunes, the reed-beds, heaths, and fens. The extent of this uncultivated area is of course being gradually diminished by the more general employment of improved methods of drainage, by prevention of the progress of the sand-drifts, by reclamation of the fens, by the extension of facilities for the carriage of manures, and by the parcelling out of the mark-lands or commons which are now used only as public pastures or for the digging of turf (*plaggen*). The distribution of the cultivated lands in the several provinces is considered below in connexion with the density of the population.

The Netherlands are watered by three main rivers—the Rhine, the Meuse or Maas, and the Scheldt or Schelde, besides a great number of smaller streams. How the Rhine breaks up into Rhine and Waal, Rhine and Yssel, Crooked Rhine and Lek, Old Rhine and Vecht, and finally reaches the sea at Katwijk, may be seen from the map; and also how the Meuse at Gorcum forms a junction with the Waal, flowing on to Dort under the name of the Merwede, and thence continuing to the sea between the South Holland Islands and South Holland, under the names of the North, the Old, and the New Meuse. There too may be traced the course of the Scheldt, with its broad mouths bounding the Zealand Islands and separating them from the mainland of Flanders, or that of the Yssel by Deventer, Zutphen, and Kampen to the Zuyder Zee. These great rivers render very important service as water-ways, as the following statistics may show:—

Name.	Breadth. Maximum.	Breadth. Minimum.	Discharge per Second at Mean Level.	Depth (Minimum). At Mean Level 1875.	Depth (Minimum). At lowest Level 1874.	Slope of the Surface per 1000 ft. At Mean Level.	Slope of the Surface per 1000 ft. At Flood.
	Ft.	Ft.	Cu. ft.	Ft.	Ft.		
Upper Rhine	2483	1260	88,250	5·08[1]	1·96[1]	0·10[1] to 0·13[1]	0·10[1] to 0·15[1]
Waal	2588	941	61.775	7·44	3·70	0·10 to 0·15	0·12 to 0·15
Lek	1240	410	17,650	6·36	2·23	...	...
Yssel	984	203	8,825	6·13	0·98	0·10 to 0·13	0·1 to 0·14
Meuse	656	541	4,412	4·62[2]	1·77[2]	Maestricht to Roermond...0·40	0·38
						Roermond to Venlo ......0·18	0·09
						Venlo to Grave 0·06	0·11
						Grave to Crèvecœur..........0·05	0·07

The depths are those of the fairway. The mean velocity seldom exceeds 4·9 feet, but rises to 6·4 feet when the river is high. In the lower reaches of the streams the velocity and slope are of course affected by the tides. In the Waal ordinary high water is perceptible as far up as Bommel; in the Lek the maximum limits of ordinary and spring tides are at Vianen and at Kuilenburg respectively, in the Yssel above the Katerveer and past Wijhe, and in the Meuse near Heusden and at Well. The following table shows the fall at ebb and flood tide respectively in the rivers named:—

	Ft.		Ft.
Lower Rhine and Lek, from Pannerden to Krimpen	38·827	and	32·638
Waal and Merwede, from Pannerden to Hardinxveld	33·479	,,	31·585
Guelderland Yssel, from Westervoort to Mond Ganzediep	31·06	,,	31·00
Meuse, from Grave to Woudrichem	13·97	,,	12·56

The fall in the Meuse from Maestricht to Venlo is 107·05 feet.

The total length of the navigable channels is 1135 miles, but in certain places sand-banks and shallows not unfrequently impede the shipping traffic at low water during the summer. As a drawback to the services rendered by the rivers must be mentioned the damage inflicted by their inundations and ice-drifts, for protection against which river-dykes were constructed as early as the days of the Romans, and, in the lower reaches, more especially in the course of the 11th, 12th, and 13th centuries. It is only in a few places—for example, on the right-hand side of the Rhine—that elevated banks are found. Elsewhere between the dykes and the stream lie "forelands" or "outwerders," which are usually submerged in winter. That the rivers cannot at all times, any more than the sea, be kept under control by the dykes is shown by the floods of 1775, 1776, 1784, 1799, 1809, 1820, 1861, &c.

The smaller streams are often of great importance. Except where they rise in the fens, they call into life a strip of fruitful verdure in the midst of the barren sand, and thus lead to the existence of many villages. The low-lying spaces at the confluences, being readily laid under water, have been not unfrequently chosen as sites for fortresses. As a matter of course, the streams are also turned to account in connexion with the canal system,—the Holland Yssel, the Gouwe, the Rotte, the Schie, the Spaarne, the Zaan, the Amstel, the Dieze, the Amer, the Mark, the Vecht, the Zwarte Water (Black-water), the Kuinder, and the numerous Aas in Drenthe and Groningen being the most important in this respect. Largely by means of these natural water-ways the Dutch have formed for themselves a network of canals, small and great, the united length of which amounts to 1522 miles. The canals differ greatly in character in the different provinces. In North Brabant and Limburg the Zuid Willemsvaart (South William's canal) unites Maestricht *via* Weert and Helmond with Bois le Duc ('s Hertogenbosch), communicates by a side branch with Eindhoven, and has a connexion with the canal from Maestricht to Liége. In Zealand the canals give the towns of the interior communication with the sea or the river mouths; for example, canals lead respectively from Terneuzen to Sas van Gent and to Ghent, from Middleburg to Veere and from Middleburg to Flushing, from Goes to the Eastern Scheldt, and from Zierikzee also to the Eastern Scheldt. The canal from Hansweert to Wemeldinge has been cut to allow ships to pass between the East and the West Scheldt. In South Holland many canals serve the like purpose; thus the Voorn canal unites the Haringvliet with the New Meuse, which does not allow the passage of large vessels above Briel; and similarly on account of the many banks and shallows in front of Helvoetsluys a new waterway has been opened up to Rotterdam by widening the channel of the Scheur north of Rozenburg, and cutting across the Hoek van Holland. The Goeree inlet unites that place with the Haringvliet. Of a different character is the Zederik canal, which unites the principal river of central Holland—the Lek—(at Vianen) by means of the Linge with the Merwede (at Gorcum). As Rotterdam has its new water-way, so in North Holland Amsterdam is connected with Nieuwe Diep by the canal *via* Purmerend and Alkmaar; and, this canal being too shallow for the largest class of vessels in cargo, the canal to Ymuiden has been constructed across Holland-op-zyn-smalst (*i.e.*, Holland at its narrowest). Amsterdam is further connected with the Vecht by the Keulsche Vaart, and with the Lek and the Zederik canal *via* Utrecht by the Vaart Rhine. In the province of Guelderland Nijkerk inlet unites that town with the sea, and Apeldoorn communicates with Hattem north-east through the Grift canal and south-east with the Yssel through the Dieren canal. A totally different character belongs to the canals in the east and north-east of the country, where, in the absence of great rivers, they form the only water-ways which render possible the drainage of the fens and the export of peat, and unite the lesser streams with each other. Thus in Overyssel the Willemsvaart connects Zwolle and the Zwarte Water with the Yssel, the Dedemsvaart connects the Vecht with the Zwarte Water near Hasselt, and a canal connects Almelo with Zwolle. In Drenthe the Smildervaart

[1] These figures have reference to the Lower not to the Upper Rhine.
[2] Below Grave.

or Drenther Hoofdvaart unites Assen with Meppel, and receives on the eastern side the drainage canals of the Drenthe fens (the Orange canal, the Beilerstroom, and the Hoogeveen Vaart), while the North Willemsvaart unites Assen with Groningen. In the province of Groningen the chief town communicates with Delfziji and the Dollart both by the Damsterdiep and by the new ship canal, while the canal to Winschoten brings it into connexion with the flourishing fen colonies, such as Wildervank and Veendam, which have sprung up in the east of the province and in Drenthe. In Friesland, finally, there are three ship canals :—that from Harlingen to the Lauwer Zee *via* Franeker, Leeuwarden, and Dokkum; that from Leeuwarden to the Lemmer, whence there is a busy traffic with Amsterdam; and that from Stroobos in the east of the province (in connexion with Groningen) to Stavoren in the south-west. It would be superfluous to enumerate the barge canals by which almost all the large towns communicate with each other; and it is equally unnecessary to mention all the lakes, which exist in great numbers, especially in Friesland and Groningen, and are connected with rivers or streamlets. Those of Friesland are of note for the abundance of their fish and their beauty of situation, on which last account the Uddelermeer in Guelderland is also celebrated. The Rockanje Lake near Briel is remarkable for the strong chalky solution which covers even the growing reeds with a hard crust. Many of the lakes are nothing more than deep pits or marshes from which the peat has been extracted.

Lakes.

Climate.

The climate of Holland[1] is such as might be conjectured from its geographical position and its generally low level. Situated in the temperate zone between 50° and 53° N. lat., it shows a difference in the lengths of day and night extending in the north to nine hours, and there is a correspondingly wide range of temperature; it also belongs to the region of variable winds. The following table, from the observations of Professor C. D. Buys Ballot, the well-known director of the Meteorological Institute at Utrecht, shows the average temperatures and the barometric heights re corded there during 1849–1878 :-

Month.	Thermometer.		Barometer.		Month.	Thermometer.		Barometer.	
	C.	Fahr.	Mill.	Inches.		C.	Fahr.	Mill.	Inches.
Jan.	1·94	35·49	759·88	29·916	July ...	18·52	65·33	760·53	29·943
Feb.	2·99	37·38	761·20	29·968	August	17·96	62·32	760·11	29·925
March ..	4·96	40·92	758 95	29·879	Sept. ...	14·99	58·98	760·70	29·948
April ...	9·39	48·90	759·71	29·909	Oct.	10·39	50·70	758 83	29 870
May.....	13·10	55·58	759·90	29 917	Nov.	4 98	40·96	758·97	29·880
June ...	16·99	62·58	760·90	29·956	Dec. ...	2·65	36·77	760·05	29·923

The mean annual temperature was 9·91° C., or 49·83° Fahr.

How largely the westerly winds predominate is shown by the following statistics. On an average of ten years 5 per cent. of the winds were N., 5 N.N.W., 7 N.W., 6 W.N.W., 7 W., 10 W.S.W., 12 S.W., 7 S.S.W. (total 59 per cent.), and 7 S., 5 S.S.E., 5 S.E., 2 E S.E., 3 E., 6 E.N.E., 8 N.E., 5 N.N.E. (total 41 per cent.). The west winds of course increase the moisture, and moderate both the winter cold and the summer heat, while the east winds blowing over the Continent have an opposite influence. The following table, derived from observations taken at Utrecht, shows that, as might be expected, the rainfall is large :—

Months.	Average Evaporation (1855–64).		Rainy Days (1848–78)	Average Rainfall (1848–78).	
	Millim.	Inches.		Millim.	Inches.
January	12·8	0·51	401	50·3	1·98
February	23·3	0·91	380	46·2	1·81
March	50·5	1·99	375	43·9	1·72
April	87·3	3·43	319	40·5	1·59
May	124·3	4·89	338	49·7	1·95
June	134·2	5·28	306	50·6	1·99
July	125·5	4·94	358	74·4	2·93
August	117·3	4·62	392	85·9	3·38
September	69·5	2·74	381	69·1	2·72
October	38·1	1·50	390	68·7	2·70
November	15·3	0·60	409	58·3	2·29
December	12·1	0·47	406	58·8	2·31
Yearly average...	810·2	31·88	148	695·4	27·37

It cannot be said that the climate is particularly good; indeed to strangers it is rather the reverse of pleasant. Fevers, colds, and, when proper precautions are not taken, chest disease and consumption, are results of the changeableness of the weather, which may alter completely within a single day. The heavy atmosphere likewise, and the necessity of living within doors or in confined localities, cannot but exercise an influence on the character and temperament of the inhabitants. Only of certain districts, however, can it be said that they are positively unhealthy; to this category belong some parts of Holland, Zealand, and Friesland, where the inhabitants are exposed to the exhalations from the marshy ground, and the atmosphere is burdened with the sea-fogs. To what extent the healthiness of the different provinces varies may be seen from the following table of the annual death-rate for the twenty-five years from 1840 to 1865 :—

Provinces.	Males.	Females.	Both Sexes.
Guelderland	1 in 42·10	1 in 44·00	1 in 42·95
North Brabant	,, 41·69	,, 43·03	,, 42·69
Limburg	,, 42 82	,, 42 61	,, 42·68
Drenthe	,, 41·98	,, 43 62	,, 42 54
Friesland	,, 40 84	,, 43·67	,, 42·07
Groningen	,, 40·00	,, 42·94	,, 41·24
Overyssel	,, 39·01	,, 40·54	,, 39·75
Utrecht	,, 33·68	,, 36·14	,, 34·90
North Holland	,, 30 33	,, 34·32	,, 32·35
Zealand	,, 29·51	,, 32·24	,, 30·84
South Holland	,, 29·04	,, 32·81	,, 30·60

For the whole kingdom the annual death-rate was 1 in 36·73—that for the males being 1 in 35·49, and for the females 1 in 38·14.

Density of population.

That the density of the population must, apart from other causes, increase through the acquisition and cultivation of new land, and that it visibly differs very greatly according to the difference of the soil in the different provinces, may be seen from the following table, wherein the increase of the percentage of cultivable land and of the population is indicated :—

Provinces	Waste Lands.		Buildings and Pleasure Grounds.		Arable Land.		Under Grass.		Orchards and Nurseries.		Population.		Mean Density per Sq. Mile.
	1833.	1876.	1833.	1876.	1833.	1876.	1833.	1876.	1833.	1876.	1829.	1878.	
Groningen	16	14·7	0·9	0·9	49·3	51·4	24·9	26·7	...	...	157,504	249,124	271
Friesland	11·2	10·6	0·8	0·7	15·6	16	59·2	59·3	0·3	0·3	204,909	323,872	249
Drenthe	67·5	57·5	0·3	0·3	8·7	12·3	20·5	24·5	...	0·2	63,868	117,026	111
Overyssel	44·5	35·6	0·5	0·8	15·6	17·5	30·4	32·2	0·08	0·1	178,595	273,770	208
Guelderland	32·4	24·7	0·7	0·8	22·6	25·2	26·9	27·7	1	0·9	309,793	463,840	231
Utrecht	11·9	9·4	1·5	1·8	21·1	20·7	46·0	46·5	1·5	1·6	132,359	191,370	349
North Holland	15·7	10·2	1·5	1·5	4·4	13·1	56·3	56·0	0·4	0·4	413,988	667,946	609
South Holland	6	4·5	1·5	1·6	23·7	23·4	47·3	53·2	1	0·8	479,737	796,109	653
Zealand	9·5	6·9	1·1	1·2	54	58	21·8	21·2	1·1	0·9	137,762	189,666	274
North Brabant	35·3	35·4	0·7	0·6	26·1	26·2	26·1	21·0	0·2	0·2	348,891	468,667	230
Limburg	31·7	22·9	0·5	0·6	38·6	41	9·6	10·9	2·9	3·1	186,281	240,497	276
	27·9	23·3	0·8	0·9	23·9	25·7	32·5	34·1	0·6	0·7	2,613,487	3,981,887	302

[1] See Dr F. W. C. Krecke, *Het Klimaat van Nederland*, Haarlem, 1863–64, and the *Jaarboek* of the Kon. Ned. Meteor. Inst.

The greater density of population in the Holland provinces as compared with Drenthe cannot be explained, however, merely by the character of the soil; the variety of industries and the great number of large towns contribute to the inequality. All the towns with 100,000 inhabitants and upwards (Amsterdam, Rotterdam, and the Hague) are situated in the provinces of Holland; of the 36 communes with more than 10,000, 9 are in Holland, none in Drenthe; of the 35 communes between 10,000 and 4000, 9 are in Holland and 2 in Drenthe. The reason why in the west, and especially in the district between Amsterdam and Rotterdam, there is such a clustering of large towns, only surpassed in a few parts of England and Belgium, is to be found in the facilities there afforded for earning a subsistence. Holland is emphatically a country of large towns. According to the census of 1869 there were forty-four which had a population of upwards of 5000. The greatest of all was Amsterdam, with 256,154 inhabitants; and next in order came Rotterdam, with 113,734. Two others had upwards of 50,000, the Hague and Utrecht, respectively 81,881 and 57,085. Arnheim, Leyden, Haarlem, Groningen, and Maestricht were all above 25,000; and Bois-le-duc, Delft, Dort, and Leeuwarden above 20,000. The five towns of Nimeguen, Gouda, Helder, Deventer, and Zwolle had each between 15,000 and 20,000; and Breda, Zutphen, Zaandam, Amersfoort, and Kempen were all above 10,000, though less than 15,000. Since that date many of these have considerably increased in size. In 1879 Amsterdam had about 300,000 inhabitants, Rotterdam 140,000, the Hague 100,000, and Utrecht 70,000.

ation- ties.

As the density of the population varies within the narrow limits of the Netherlands, so varies likewise the origin of the people. Although ethnographically the whole population belongs to the Indo-Germanic family, or more definitely to the Teutonic branch of it, the descendants of the Frisians may be clearly distinguished in the north-west. The mouths of the Meuse separate these from the descendants of the Franks, who pushed eastward across the Meuse but never settled beyond the Waal, while the territory of the Saxons, who came later from the east, extends no further than to the Utrecht Vecht. The descendants of the Saxons consequently lie between those of the two first-named peoples, although naturally much commingling has taken place between Frisians and Saxons, and Saxons and Franks, especially in the towns and on the newly-acquired lands. The representatives of the Semitic stock (Portuguese or German Jews), though their influence is not unimportant, number only 50,000 or 60,000, of whom about 40,000 reside at Amsterdam. The descendants of the three Teutonic peoples above named are very slightly distinguished from each other by their physical, intellectual, and moral characteristics, and all the less so because the Dutch type is not itself strongly marked and bears the traces of foreign commixture; for many Flemings and Brabanters settled in the country at the time of the revolt against Spain, many Germans, Englishmen, and Scandinavians during the prosperity of the republic, and many Frenchmen after the revocation of the edict of Nantes. The differences most clearly discernible are in the old local laws, in the peculiar customs, and above all in the dialects. Among these last must be distinguished the Holland dialect (Hollandsch) spoken in the provinces of Holland and part of Utrecht; the Zealand dialect (Zeeuwsch, in Staats Flanders inclining towards Flemish); the Brabantine (modified), also spoken in a part of Limburg and the south of Guelderland; the Lower Rhenish, which is again subdivided into the Guelderland, the Overyssel, and the Drenthe dialects; and, finally, the Groningen dialect. The peasant or country Frisian forms a completely separate language with a literature of its own. It has not been at all satisfactorily determined in what parts of the Netherlands the remains of a pre-German population are to be found, nor to what extent they are to be distinguished from the Germans by the form of the skull; but investigations are being carried on in this department of inquiry, and a map is being prepared to indicate the boundaries of the various dialects.

Government.

The government of the Netherlands is regulated by the constitution of 1815, revised in 1848, under which the king's person is inviolable and the ministers are responsible. The crown is hereditary in both the male and the female line according to primogeniture; but it is only on the complete extinction of the male line that females can come to the throne. The crown prince or heir apparent is the first subject of the king, and bears the title of the Prince of Orange. The king alone has executive authority. To him belong the ultimate direction of foreign affairs, the power to declare war and peace and to make treaties and alliances, the supreme command of the army and navy, the supreme administration of the finances and of the colonies and other possessions of the kingdom, and the prerogative of mercy. By the provisions of the same constitution he establishes the ministerial departments, and shares the legislative power with the first and second chambers. The heads of the departments to whom the especial executive functions are entrusted are eight in number,—ministers respectively of the interior, of public works (the "waterstaat," including trade and industry, railways, post-office, &c.), of justice, of finance, of war, of marine, of the colonies, and of foreign affairs. They are appointed and dismissed at the pleasure of the king, usually determined, however, as in all constitutional states, by the will of the nation as indicated by its representatives. The members of the first chamber are chosen by the provincial states from among those who bear the greatest burden of direct taxation in each province, the proportion of persons thus eligible being 1 to every 3000 of the population. North Brabant sends 5, Guelderland 5, South Holland 7, North Holland 6, Zealand 2, Utrecht 2, Friesland 3, Overyssel 3, Groningen 2, Drenthe 1, Limburg 3—or altogether 39. The duration of parliament is nine years, a third of the members retiring every three years. The retiring members are eligible for re-election. The members of the second chamber are chosen in the electoral districts by all citizens of full age who pay direct taxes varying according to local circumstances from 20 to 160 guilders. One member is elected for every 45,000 of the population. At present (1880) there are eighty-six; they must be at least thirty years old, and they cease to be members if they take a salaried Government appointment. They discuss all laws, and have the right of proposing amendments. Their term is four years, but they are re-eligible. All communications from the king to the states-general and from the states to the king, as well as all general measures relating to internal administration or to foreign possessions, are first submitted to the consideration of the council of state, which also has the right of making suggestions to the king in regard to subjects of legislation and administration. The king appoints the vice-president of the council, which consists of fourteen members; he is himself the president, and can name councillors, to the number of not more than fifteen, for special service.

Provincial administration.

The provincial administration is entrusted to the provincial states, which are returned by direct election by the same electors as vote for the second chamber. The term is for six years, but part of the members retire every three years. The president of the assembly is the royal commissioner for the province. As the provincial states only meet a few times in the year, they name a committee of deputy-states to which the management of current general business is entrusted, and which at the same time administers the affairs of the communes. At the head of every commune stands a communal council, whose members are chosen by the inhabitants for a definite number of years. The president of the communal council, the burgomaster, is named by the king in every instance for six years, and along with the magistrate to be chosen by and from the members of the council is charged with the ordinary administration. The provinces, as already stated, are eleven in number (the grand-duchy of Luxembourg, over which the king has control, is not incorporated with the kingdom); the number of communes at 31st December 1878 was 1128.

Justice.

The administration of justice is entrusted (1) to the high council, the supreme court of the whole kingdom, which holds its sessions at the Hague, and is the tribunal for all high Government officials and for the members of the states-general; (2) to the five courts of justice for criminal cases, and for appeal in more important police and civil cases; (3) to courts established in each arrondissement; (4) to cantonal judges appointed over a group of communes, whose jurisdiction is restricted to claims of small amount (under 200 guilders), and to breaches of police regulations, and who at the same time look after the interests of minors.

Finance. The following statement of the revenue for the year ending the middle of 1878, and of the expenditure for 1877, is taken from the *Staats Courant* for 1879, No. 6:—

Revenue.		*Expenditure.*	
Direct taxation	£2,000,748	Royal household	£72,916
Export and import duties	381,942	Superior authorities of the state	49,112
Excise	3,248,293	Department of foreign affairs	50,311
Gold and silver wares	30,410	,, justice	349,201
Indirect taxation	1,703,364	,, interior	496,391
State domains	131,231	,, marine	1,176,317
Post-office	302,583	National debt	2,187,651
Government telegraphs	69,290	Department of finance	1,411,162
State lotteries	36,146	,, war	1,895,563
Game and fisheries	12,534	,, waterstaat	2,043,588
Pilot dues	76,746	,, colonies	124,724
		Unanticipated expenses	3,163
Total	£7,992,430	Total	£9,871,792

The following table shows the revenue and expenditure for the provinces and communes, and the contributions received from the Dutch Indies:—

Years.	Provincial.		Communal.		Contributions of Dutch Indies.
	Revenue.	Expenditure.	Revenue.	Expenditure.	
1867	£279,090	£261 646	...	...	...
1868	273,461	244,325	...	...	£897,613
1869	261,205	242,998	...	...	1,122,916
1870	322,909	315,477	...	...	1,083,973
1871	314,760	290,127	...	...	899,307
1872	278,983	261,537	£3,502,640	£3,169,554	1,832,100
1873	312,193	297,250	3,758,827	3,479,869	868 974
1874	322,256	322,256	3,547,573	3,277,634	878,714
1875	390,617	385,963	5,180,414	3,565,700	1,925,973

We append the total receipts of the ten years 1868–77, including the ordinary revenue, the Indian contributions, balances from previous budgets, proceeds of sale of domains, &c., and the total expenditure for the same years, including, besides the ordinary budget, the outlays in payment of annuities, in funding and discharging debt, in railway extension, &c.:—

	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Revenue	fl.95,669,484	96,257,333	94,144,872	94 001,483	108,932,184	109,507,189	105,263,637	119,837,573	105,733,172	102,238,081
	£7,972,457	8,021,444	7,953,739	7,833,456	9,077,673	9,125,599	8,772,469	9,986,464	8,811,097	8,519,756
Expenditure	fl.96,131,448	94,424,869	99,107,750	94,460,038	108,932,183	108,033,523	99,352,356	118,911,278	112,635,219	118,461,511
	£8,010,954	7,952,080	8,242,312	7,873,336	9,077,673	9,002,793	8,279,363	9,909,273	9,386,268	9,871,709

Army. The amount expended on the war and marine departments is given above. The standing army consists of infantry, cavalry, artillery, engineers, and gendarmerie, forming together a force of 60,000 men, with 3000 horses. Less than half, however, is kept in arms the whole year. The soldiers are raised partly by voluntary enlistment, and partly by conscription. In 1876, 1877, and 1878 the conscripts amounted to 10,808, 10,878, and 10,772 respectively. They are selected from the males who have entered their twentieth year and are not exempted for special reasons. The term of service in time of peace is five years, but may be extended in time of war; the conscript recruits, however, so far as the number of volunteers permits, are kept under arms for a few months only. A portion of the annual contingent is appropriated to the marine service. In the communes there are "schutterijen," militia "trainbands," which in time of war serve for the defence of the country, and at all times for the maintenance of order. Their actual term of service lasts only five years, but every male inhabitant from his twenty-fifth to his thirty-fourth year is liable to be called out. On the 1st of January 1879 there were of these on duty, in 88 communes, 212 companies, or 41,714 men, including 573 officers.

Navy. The strength of the navy in 1879 was—home service, 17 ships with 3162 men; Indian military marine, 23 ships with 1793 hands; auxiliary squadron, 4 ships with 900 hands; in the West Indies, 2 ships with 206 men. The fleet for the protection of the "seagates," or estuaries, coasts, roadsteads, and rivers on the 1st August 1878 amounted to 61 ships, of which 23 were armour-plated; 21 ships for general service, of which 2 were armour-plated; besides 7 guardships and tenders and 7 training vessels. The strength of the marine corps was in July 1878 returned at 2055, and the number of guns carried by the navy at about 500.

Fortifications. In accordance with the law of April 18, 1874, the military and naval defences are supported by a system of fortification which embraces the following lines:—the Nieuwe Hollandsche water-line from the Zuyder Zee by Utrecht, the Lek, and the Merwede, through the district of Altena to the New Merwede; the line of the Guelders valley and the Lower Betuwe; the lines of the Hollandsche Diep and the Volkerak, of the mouth of the Meuse and the Haringvliet, and of the Helder; the works for the protection of the river-crossings and the reception of troops on the Yssel, the Waal, and the Meuse; the Amsterdam line from the German Ocean, near Ymuiden, to the Zuyder Zee and the Nieuwe Hollandsche water-line; the southern water-line from the Meuse above St Andries to the Amer below Geertruidenberg; and the works on the Western Scheldt. As already mentioned, in many cases the fortifications can be supplemented by extensive inundations.

Relig[ion]. The inhabitants of Holland enjoy full religious as well as political liberty. Not only is the free profession of his religious opinions guaranteed to every one by the constitution; the same protection is accorded to all the various ecclesiastical bodies; all the adherents of the different creeds have equal civil and political rights, and equal claims to public offices, dignities, and appointments; and all denominations possess perfect freedom of administration in everything relating to their religion and its exercise.

At the census of 1869 the population was classified thus as regards religion:—

			Congregations.
Low-Dutch Reformed	1,956,852	with	1,343
Walloons	10,258	,,	17
Remonstrants	5,486	,,	20
Christian Reformed	107,123	,,	390
Baptists	44,227	,,	126
Evangelical Lutherans	57,545	,,	50
Old Lutherans	10,525	,,	8
Moravians	311	,,	2
English Episcopalians	456	,,	2
Scotch Church	84	,,	1
English Presbyterians	417	,,	4
Total Protestants	2,193,284	with	1963
Roman Catholics	1,307,765	,,	982
Old Catholics	5,287	,,	16
Greek Church	32	,,	2
Low-Dutch Jews	64,748	,,	167
Portuguese Jews	3,525	,,	2
Unknown	5,161	,,	...

Altogether there are about 2800 churches and chapels. The following table shows the percentage of Protestants, Catholics, and Jews in the several provinces:—

	Groningen.	Friesland.	Drenthe.	Overyssel.	Guelderland.	Utrecht.	North Holland.	South Holland.	Zealand.	North Brabant.	Limburg.	Holland.
Protestants	90·5	90	93·5	66·5	61	62	67·5	73·5	73·5	11·5	2·5	59
Roman Catholics	7·5	9	4·0	32·0	38	37	27·5	24·5	26·0	88·0	97·0	39
Jews	2·0	1	2·5	1·5	1	1	5·0	2·0	0·5	0·5	0·5	2

From this it appears that in the north-east the Protestant creed greatly preponderates, and that the majority of the Roman Catholics are found in the south, while both are fairly represented in the central provinces. That in the last fifty years there has been over the whole population a steady increase in the proportion of Protestants and Jews, and a corresponding decrease of Roman Catholics, is evident from the following table:—

Year of Census	Protestants.		Roman Catholics.		Jews.		Unknown.	
	Number	Per ct.	Number.	Per ct.	Number.	Per ct.	Numb.	Per ct.
1829	1,541,887	59·11	1,019,109	38·99	46,408	1·78	3,083	·012
1839	1,701,275	59 58	1,100,616	38·48	52,245	1·83	3,314	·011
1849	1,824,860	59·69	1,171,924	38 34	58,626	1·92	1,469	·005
1859	2,007,026	60·65	1,234,486	37 30	63,790	1·93	3,826	·012
1869	2,193,281	61·27	1,313,052	36·68	68,003	1·90	5,193	·015

The government of each of the Protestant bodies (with the exception of the Baptists, who have no central authority) is in the hands of an assembly or "synod" of deputies from the provincial judicatures. In the case of the Reformed Church the affairs of the community are entrusted to the provincial synods. The provinces are subdivided into "classes," and the classes again into "circles" (ringen), each circle comprising from 5 to 25 congregations, and each congregation being governed by a "church council" or session. The provincial synods are composed of ministers and elders deputed by the classes; and these are composed of the ministers belonging to the particular class and an equal number of elders appointed by the local sessions. The meetings of the circles have no administrative character, but are mere brotherly conferences. The financial management in each congregation is entrusted to a special court (kerk-voogdij) composed of "notables" and church wardens. In every province there is besides, in the case of the Reformed

Church, a provincial committee of supervision for the ecclesiastical administration. For the whole kingdom this supervision is entrusted to a common "collegium" or committee of supervision, which meets at the Hague, and consists of 11 members named by the provincial committee and 3 named by the synod. Some congregations have within recent years withdrawn from provincial supervision, and have thus free control of their own financial affairs. As a Roman Catholic province Holland is divided into 5 dioceses—the archbishopric of Utrecht, and the suffragan bishoprics of Haarlem, Bois le Duc, Breda, and Roermund, which are severally divided into deaneries (dekanaten).

The various denominations are subsidized by the state. The total thus expended in 1877 was £65,654.

ıca- ı. Primary education is being more widely diffused year after year, and at the same time receiving increased support from the state. While in 1868 there were 3675 schools, attended by 437,311 pupils, and conducted by 10,375 teachers, the corresponding figures for 1877 were respectively 3813, 522,861, and 12,292; and while in 1858 the state, the provinces, and the communes expended only 1,278,894 guilders (=1s. 8d. sterling) on the schools, the expenditure for education in 1877 was 7,271,484 guilders. In 1875, 1876, and 1877 there were 841, 848, and 847 in every thousand boys between six and eight years of age at school, and 786, 796, and 803 out of every thousand girls; and from nine to eleven years of age 881, 890, and 910 out of every thousand boys, and 812, 815, and 827 out of every thousand girls. There is thus a steady decrease of non-attendance. The improvement of primary education is shown by the growing decrease in the proportion of conscripts who could neither read nor write: from 1846 to 1858 this was 22·82 per cent.; 1859–62, 19·79; 1863–67, 17·74; 1868–71, 15·46; 1872–76, 13·13; and in 1876 only 11·99 per cent. There are no bilingual schools in Holland, and teachers discourage the use of the dialects.[1]

For secondary education there were in 1877 39 "burgher schools" (partly day schools, partly night schools), with 372 teachers and 4319 pupils; 43 industrial art and technical schools, with 203 teachers and 4145 pupils; 53 higher class "burgher schools," having courses of 5 or 6, of 4, and of 3 years, with 620 teachers and 4000 pupils; the polytechnic school, with 12 professors and 13 teachers, and attended by 319 pupils; and the national school of agriculture at Wageningen, with 100 pupils. Schools of navigation were maintained at Rotterdam, Amsterdam, Helder, Terschelling, Vlieland, Harlingen, Schiermonnikoog, Groningen, Delfzijl, and Veendam, with a total of 536 pupils and 26 instructors. The secondary school for girls (with courses of 5 and of 4 or 3 years) were 12 in number, and had about 900 pupils and a teaching staff of 140. For secondary education in 1876 the state expended 933,721 guilders, the provinces 24,329, and the communes 906,618, making a total of 1,864,668, or £155,389 sterling.

The higher education is provided for in the four universities of Leyden (founded in 1575), Utrecht (1636), Groningen (1614), and Amsterdam (1877), with 45, 34, 31, and 41 professors, and 627, 401, 189, and 389 students respectively. Instruction is also given by about 100 teachers to 1400 pupils in various seminaries and theological schools; the number of Latin or grammar schools and gymnasia in 1877–78 was 51, with 240 teachers and 1503 pupils. The total cost of the higher education amounted to 1,057,694 guilders.

A national institution at Leyden for the study of the languages, geography, and ethnology of the Dutch Indies has given place to communal institutions of the same nature at Delft and at Leyden, founded in 1864 and 1877. Military and naval instruction are provided for by corps schools, by a training battalion at Kampen, an artillery training company at Schoonhoven, and scientific courses for the several corps, by the royal military academy (founded 1828), the "school of war" for officers, the royal navy institute at Willemsoord (1856), and by training ships at Amsterdam, Rotterdam, and Helvoetsluys for apprentice boatswains, sailors, cabin-boys, pilots, and engineers. For the education of medical practitioners, civil and military, the more important institutions are the national obstetrical college at Amsterdam, the national veterinary school at Utrecht, the national college for military physicians at Amsterdam, and the establishment at Utrecht for the training of military apothecaries for the East and West Indies.

entific l art titu- ıs. Of the numerous institutions in Holland for the encouragement of the sciences and the fine arts, the following are strictly national—the royal academy of sciences (1855), the royal Netherlands meteorological institute (1854), the national academy of the plastic arts, the royal school of music, the national archives, the royal picture gallery at the Hague, and the national gallery of modern masters in the Pavilion at Haarlem, the national museum of antiquities, the national museum of ethnography at Leyden, the royal collection of curiosities at the Hague, &c. Provincial scientific societies exist at Middelburg, Utrecht, Bois le Duc, and Leeuwarden, and there are private and municipal associations, institutions, and collections in a large number of the smaller towns. Among others of general utility are the society for the service of the community (*Maatschappij tot nut van't algemeen*, 1784), and the geographical society at Amsterdam (1873), Teyler's Stichting or foundation, and the society of industry at Haarlem, the royal institute of languages, geography, and ethnology of the Dutch Indies (1851) and the Indian society at the Hague, the royal institute of engineers at Delft (1848), the association for the encouragement of music at Amsterdam, &c.

The agricultural methods vary according as the soils are sandy or clay. In the first the "three-crop" system (two crops of rye and one of buckwheat) differs widely from the careful Flemish method of cultivation, in which even the pastures are manured. On the clay there is still greater variety both in the modes of treatment and in the amount of care bestowed on weeding and draining. The produce of the land is thus very different in the various provinces for the same soil. The general value of the crops is gradually rising, as may be seen from the following statistics, in which the higher figures cannot be altogether ascribed to the greater extent of land brought under cultivation: improved education and the influence of local associations for the advancement of the interests of agriculture have contributed to the result. In 1851–60 there was under cultivation in grain and other marketable crops 1,637,512 acres, in 1861–70 1,770,890 acres, and in 1871–75 1,860,850 acres. The total value of the crops was £8,311,666 in 1851, £13,445,672 in 1862, £15,870,586 in 1871, and £19,001,598 in 1875. Of the total acreage just mentioned about 25·9 per cent. was devoted to rye, 17·3 to potatoes, 13·5 to oats, 8·6 to buckwheat, 7 to beans and pease, 7·1 to barley, 5 to rape seed, 3 to flax and hemp, 0·8 to madder, 0·6 to garden seeds, 0·2 to tobacco; while the rest is set apart for the special cultivation of chicory, hops, beetroot, mangold wurzel, market-garden produce, flowers, pharmaceutical plants, grapes, &c. The woods or rather the plantations, covering 6 per cent., consist—of (1) the so-called forest timber (opgaandhout; French, arbres de haute futaie),—including the beech, oak, elm, poplar, birch, ash, willow, and coniferous trees; and (2) the copse wood (akkermaal or hakhout),—embracing the alder, willow, beech, oak, &c. This forms no unimportant branch of the national wealth. Agriculture.

Stock-breeding varies in the different provinces. For cattle, Friesland and North and South Holland take the lead as regards both quality and numbers; sheep are best in Texel and North Holland, and most numerous in Drenthe, where their preponderance is due to the number of commons which still remain unbroken up. Pigs, for which the low lands are peculiarly favourable, are reared in all the provinces. Goats, mainly kept for their milk, are most numerous in Guelderland and North Brabant. Guelderland, Friesland, Zealand, and Groningen possess the greatest number of horses. Poultry, especially fowls, are generally kept. Bee culture is mainly carried on in buckwheat and heath districts (Guelderland, Overyssel, Drenthe, the Gooiland, and Utrecht). A bee market is held at Veenendaal in Utrecht. Stock breeding is mainly carried on along with dairy-farming and hay-making on the alluvial soils; and there the cereal crops give way to fodder plants. The permanent pasture in recent years extends to some 2½ millions of acres, and clover, artificial meadows, &c., occupy about 400,000. The production of milk, butter, and cheese amounts to the value of 90 millions of guilders (1s. 8d. each); butcher meat produces 35 millions, and wool, hides, fowls, and game 10 millions; while horse-breeding also yields a total of 10 millions. In 1870 the number of horses was 252,200; cattle, 1,410,800; sheep, 900,200; goats, 156,900; and pigs, 329,100; whereas in 1876 the horses numbered 268,000; cattle, 1,439,257; sheep, 891,090; goats, 150,000; and pigs, 352,000. The value of this live stock in 1870 was £22,087,375, and in 1876 £29,799,905. Live stock.

In the densely peopled Netherlands, with no extensive forests, hunting forms rather an amusement than a means of subsistence, the only exception being the pursuit of wild-fowl (ducks, geese, and snipes). Hares, partridges, wood-snipes, finches, and thrushes are the only form of game; a few roebucks and deer are found in Overyssel and Guelderland; rabbits are numerous in the dunes, and sea-gulls' eggs are gathered in the north of Texel, which consequently bears the name of Eijerland (*i.e.*, Eggland). Game.

Much more important as a means of subsistence are the fisheries, which, however, are not at present in a flourishing state. They are divided into the "deep-sea fishery" (buitengaatsch) in the German Ocean, and the "inner" fisheries (binnengaatsch) in the Zuyder Zee, the rivers of Zealand, and the inland waters. The deep-sea fishery may be further divided into the great (the so-called "salt-herring") fishery, mainly carried on from Vlaardingen and Maassluis, and the "fresh-herring" fishery, chiefly pursued at Scheveningen, Katwijk, and Noordwijk. The deep-sea fisheries also yield cod and flat fish. In the Zuyder Zee flat fish, herrings, anchovies, and shrimps are caught off the islands of Urk and Marken and the coast towns of Vollenhove, Kampen, Harderwijk, Huizen, and Vollendam; and there are oyster banks near Texel. In the Zealand rivers oysters Fisheries.

[1] See *Geschiedkundig overzigt van het lager onderwijs in Nederland*, Leyden, 1849; *De wet op het lager onderwys, met aanteekeningen door S. Blaupot ten Cate en A. Moens*, Gron., 1879; and Dr J. Stein Parvé, *Organisation de l'instruction primaire, secondaire, et supérieure dans le roy. des Pays-Bas*, Leyden, 1878.

and mussels are obtained at Bruinisse, Philippine, and Graauw, and anchovies at Bergen-op-Zoom; while salmon, perch, and pike are caught in the Meuse, the Lek, and the Merwede, and eels in the Frisian lakes. The fisheries not only supply the great local demand, but allow exports to the value of £250,000.

The numbers of men and vessels employed are as follows:—

	Vessels	Men.
Great "salt herring" fishery	114	1678
German Ocean fishery	410	2965
Zuyder Zee fishery	1282	3269
Groningen and Friesland fishery	183	524
Zealand fishery	472	1026
Total	2461	9462

In 1877 the produce (in cwts.) amounted to—

	Home Consumption.	Exported
Herrings, cured and salted	10,648	274,670
Red herrings	291	97,757
Various fresh sea-fish	72,941	83,546
Salt cod	2,020	19,957
Shrimps	...	15,174
Other smoked, salted, or dried fish	1,231	102,522
Oysters, lobsters, and crabs	405	13,694
Mussels	2,015	161,813
Stock-fish	56,160	31,790
River-fish	2,518	29,471
Anchovies	384	21,253
	148,613	851,557

Trade.

To obtain a correct idea of the trade of the Netherlands greater attention than would be requisite in the case of other countries must be paid to the inland traffic. It is impossible to state the value of this in definite figures, but an estimate may be formed of its extent from the number of ships which it employs in the rivers and canals, and from the quantity of produce brought to the public markets or daily transported by thousands of carts and delivered by the peasant direct to the salesman. Of the market traffic, even in places of secondary rank, the following facts may give some idea. There are yearly brought to market at Gorcum and Hoorn from 10,000 to 13,000 head of cattle; at Barneveld, more than 20,000 sheep; at Alkmaar about 10 million and at Hoorn 5½ million ℔ cheese; at Delft 1½ million ℔ butter and 2 million ℔ cheese; at Meppel 3 million ℔ butter; at Leeuwarden 9 to 11 million ℔ butter, 2 million ℔ cheese, and 7½ million ℔ of grain and seeds; at the Overyssel markets Zwolle, Deventer, and Kampen, and at Steenwijk and Almelo, 7½ million ℔ butter; at Utrecht 770,000 and at Groningen 330,000 bushels of grain and seeds. The turn-over at the cattle market at Leyden in 1877 was £639,278. In 1877 there were 700 steamboats afloat on the rivers and canals in the service of the inland traffic.

The foreign trade, although less than it was formerly, still continues to be considerable in proportion to the size of the country. In 1878 the merchant marine consisted of 1277 vessels of 958,652 cubic metres (the register ton is equal to 2·83 cubic metres); of which 79 were steamships of about 200,000 cubic metres. In 1877 there entered 8166 vessels with 3,000,000 tons, and cleared 4936 vessels with 1,800,000 tons; to which must be added 20,500 vessels with 2,400,000 tons, which came down the rivers in cargo from foreign countries, and 11,850 vessels, with 1,500,000 tons, which passed the frontier upward bound.

The extent of the trade and its increase or decrease from year to year is shown approximately in the following table:[1]—

Years.	Total Imports.	Imports for Home Use.	Total Exports.	Transit Trade.
	£	£	£	£
1846–1850	17,183,000	...	18,660,000	...
1851–1855	27,458,000	18,418,000	23,500,000	9,083,000
1856–1860	34,918,000	25,208,000	29,292,000	9,583,000
1861–1865	40,542,000	30,000,000	33,833,000	8,750,000
1866–1870	48,183,000	38,375,000	40,125,000	9,500,000
1871	65,418,000	48,918,000	54 083,000	15,750,000
	Tons.	£	Tons.	Tons.
1872	3,200,000	51,500,000	1,467,000	439,000
1873	3,450,000	56,813,000	1,742,000	592,000
1874	3,132,000	55,918,000	1,572,000	627,000
1875	3,290,000	59,918,000	1,614,000	569,000
1876	3,780,000	59,418,000	1,717,000	705,000
1877	3,949,000	62,583,000	1,712,000	594,000

The six ports which take the largest share in the foreign trade are Amsterdam, Rotterdam, Helder, Dort, Schiedam, and Harlingen; at a considerable distance follow Groningen, Middelburg, Vlaardingen, Purmerend, Zaandam, Edam, Zwolle, Kampen, and Delfzijl. The returns of recent years show best in the case of the South Holland towns; but it must be kept in view that the direct imports, the so-called "proper trade," are most important at Amsterdam, while a great part of the commercial business at Rotterdam belongs to the commission and transit trade. For exports Rotterdam is by far the most important, sending out nearly thrice as much as Amsterdam.

An examination of its lists of exports and imports will show that Holland receives from its colonies its spiceries, coffee, sugar, tobacco, indigo, cinnamon; from England, Prussia, and Belgium its manufactured goods and coals; grain from the Baltic provinces, Archangel, and the ports of the Black Sea; pease and beans from Prussia, timber from Norway and the basin of the Rhine, yarn from England, wine from France, hops from Bavaria and Alsace; while in its turn it sends its colonial wares to Germany, its agricultural produce to the London market, its fish to Belgium and Germany, and its cheese to France, Belgium, and Hamburg, as well as England. The briskest trade is carried on with Germany and England; then follow Java, France, Russia, the United States, &c.

The mineral resources of Holland give no encouragement to industrial activity, with the exception of the coal mining in Limburg, the smelting of iron ore in four furnaces in Overyssel and Guelderland, the use of stone and gravel in the making of dykes and roads and of clay in brick works and potteries, the quarrying of stone at St Pietersberg, &c. Still the industry of the country has developed itself in a remarkable manner since the separation of Belgium, and that in spite of the lack of iron and coal, and the rivalry of other productive forms of labour. The greatest activity is shown in the cotton industry, which especially flourishes in Twenthe (in Overyssel) and also at Haarlem and Veenendaal. In the manufacture of woollen goods Tilburg ranks first, followed by Leyden, Utrecht, and Eindhoven; that of half woollens is best developed at Roermond and Helmond. The cotton and woollen manufactures together furnish employment to 20,000 hands. The linen manufacture is carried on especially in Meierij van den Bosch, Helmond, Boxtel, Woensel, &c. Even iron works and machine factories have greatly increased since the free importation of the raw material was permitted—for example, at Amsterdam and at Fijenoord opposite Rotterdam; and in this department more than 6000 workers are employed throughout the country. It need hardly be said that shipbuilding is of no small importance in the Netherlands, not only in the greater but also in the smaller towns along the rivers and canals; and it is naturally associated with rope-spinning and other auxiliary crafts. Among the less noteworthy branches of industry are the making of cigars and snuff, especially at Eindhoven, Amsterdam, Utrecht, and Kampen; diamond-cutting at Amsterdam; beetroot-sugar refining at Amsterdam; paper-making in the Veluwe, on the Zaan, and in Limburg; shoemaking and leather-tanning in Brabant (Langstraat); mat-plaiting and broom-making at Genemuiden and Blokzijl; the manufacture of glass, crystal, and earthenware at Maestricht; carpet-weaving at Deventer; working in gold and silver in North and South Holland and on a smaller scale at Schoonhoven; and the distillation of brandy, gin, and liqueurs at Schiedam, Rotterdam, and Amsterdam. The number of hands occupied in the manufactories throughout the whole of the Netherlands is estimated at about 100,000, of whom three-fourths are settled in North and South Holland, North Brabant, and Overyssel. The following table shows how great has been the industrial development of the last thirty years:—

Years.	Steam Engines.	Horse-Power.	Workshops with Steam Engines.	Steam-boats.	Locomotives.	Boilers.
1852	364	6,537	...	...	...	..
1862	983	15,824	...	...	...	...
1872	1,815	20,918	...	...	...	...
1876	2.873	76,271	2,393	707	617	4,691
1878	5,140	87,338	2,612	622	822	5,396

As the development of trade and industry and agriculture was promoted by the improvement of education and the abolition of transit and export dues and the lessening of import dues, so also has it been advanced by the improvement of the means of communication, and of the postal and telegraph systems. The waterways of the country have been already considered. The roads are divided into national or royal roads, placed directly under the control of the "waterstaat" and supported by the state; provincial roads, under the direct control of the states of the provinces, and almost all supported by the provincial treasuries; communal and polder roads, maintained by the communal authorities and the polder boards; and finally, private roads. The system of national roads, mainly constructed between 1821 and 1827, but still in process of extension, brings into connexion nearly all the towns. The construction of railways was long deferred and slowly accomplished: the "Holland Railway" was laid down in 1839–47, the Rhine Railway in 1843–56, the Aix-Maestricht-Landen line in 1853–56, and the Dutch-Belgian in 1853–54. All the other lines, *e.g.*, that from Maestricht to Liége, the Central Railway, the Nimeguen line, the Almelo-Salzberg line, the State Railway system, &c., have been constructed since 1861, a large number of them having been opened about 1863 and 1864. A great improvement has in consequence been effected in the communication. The town of Utrecht, which

[1] The value of the total imports, exports, and transit trade cannot be given after 1871 in consequence of a royal decree of 1872, providing for the simplification of the formalities of fiscal registration, in virtue of which the quantities are in certain cases given only in bulk-weight.

is the centre both of the country and of the railway system, may be approached by six different lines. From Amersfoort, Zutphen, Zwolle, Hengelo, Boxtel, Rosendaal, Venlo, and Maestricht lines stretch out in four directions, while Groningen, Leeuwarden, Meppel, Enschede, Hilversum, Amsterdam, Haarlem, Uitgeest, the Hague, Rotterdam, Moerdijk, Breda, Tilburg, and Eindhoven are each the meeting place of three lines. With foreign countries the Netherlands communicate from Groningen by the Winschoten and Nieuwe Schans line; from Overyssel by the Almelo-Salzberg line; from Guelderland by the Arnhem-Emmerik and Nimeguen-Cleves lines, from Limburg by the Gennep-Goch, Venlo-Gladbach, and Maestricht-Aix-la-Chapelle lines; and in the south with Belgium by the Terneuzen-Ghent, Hulst-St-Nikolaas, Rosendaal-Antwerp, Tilburg-Turnhout, Eindhoven-Hasselt, Maestricht-Liége, &c. Among the lines at present projected or in construction may be mentioned the works at Amsterdam by which the Holland Railway along the Y is to be brought into connexion with the Eastern Railway and the Rhine Railway; the line between Zaandam and Enkhuizen *via* Purmerend and Hoorn; the Groningen-Delfzijl line; and those from Zwolle to Almelo, and from Rotterdam or Schiedam by Vlaardingen to Maassluis and the mouth of the New Waterway.

…t- …ce …n tele- …phs. The extent of the mail service routes was 26,898 miles in 1873, and 29,773 miles in 1877; and in the same years the post-office staff numbered 3026 and 3525 respectively. The number of letters (exclusive of newspapers, printed matter, and official letters), which in 1850 was only 7,000,000, had increased by 1877 to 50,000,000. The number of inland post-cards rose from 4,000,000 in 1871 to about 10,000,000 in 1877; the number of inland newspapers was in 1860 about 5,000,000, and in 1877 about 27,000,000. The following are the statistics for 1853 and 1877 of the national telegraph system, originated in 1852:—

	Miles Line.	Miles Wire.	Messages.	Receipts.	Expenditure.
1853	208	346	45,700	£4,325	£17,775
1877	2186	80,050	2,985,000	65,900	104,775

…onies. The Dutch colonies, originally mere trading communities, have so much increased in importance, through the cultivation of their various vegetable products, the reclaiming of their waste lands, and the working of their mines, that they cannot be left altogether out of view in considering the trade and finances of the mother country. The Dutch colonies in the East Indies, situated between 30° N. lat. and 6° S. lat., and between 95° and 141° E. long., comprise an area of 600,000 square miles, with a population of about 23,000,000, among which are 35,000 Europeans, 319,000 Chinese, 15,000 Arabs, and 10,000 other immigrant Asiatics. For convenience of supervision they are divided into the Great Sunda (Soenda) Islands, the Smaller Sunda Islands, and the Moluccas—a division which is based neither on political nor on ethnological considerations, nor on the phenomena of animal or vegetable distribution. The Great Sunda Islands are Java, Sumatra, Celebes, and Borneo, all with subsidiary islands; the Smaller Sunda Islands comprise Bali, Lombok, Soembawa, Flores, Sandalwood Island, and Timor; the Moluccas include Halmaheira, Ceram, Buru (Boeroe), Amboyna, Banda, and the south-eastern groups, besides Western New Guinea. The West Indian possessions of Holland include Dutch Guiana or the government of Surinam, and the Dutch Antilles or the government of Curaçoa and its dependencies (St Eustatius, Saba, the southern half of St Martin, Curaçoa, Bonaire, and Aruba), a total area of 60,000 square miles, with 90,000 inhabitants, of whom a small portion are Europeans, and the rest negroes and other people of colour, Chinese, and other emigrants. The East Indian possessions yield an annual average contribution, as already stated, of over £800,000; the West Indian, on the other hand, require aid to the amount of £500,000 or £600,000 yearly.

National character. The character of the Dutch people may be largely explained by their history, the conformation of the country, their means of subsistence, their strife with the sea, and their struggles to maintain their independence against Spain and against hostile neighbours. The love of freedom and independence is the leading element in their character; the peculiarity of their soil has constrained them to be industrious and economical; their contest against the sea, their wars, and their distant expeditions, have trained them to bravery and self-possession; and their liberality has been stimulated by the disasters which, falling upon one to-day, might be the lot of any other to-morrow. Of course the virtues of the Dutch are apt to be distorted to vices: their composure not seldom becomes indifference; their tendency to reflexion makes them laggard in action and deficient in enterprise; their love of liberty degenerates into an extravagant sense of independence that is more concerned about rights than about duties. Sociability is by no means a dominant characteristic of the Dutch; they speak little and laugh less. But their appearance and expression give a poor indication of their sterling qualities. Their general sincerity and uprightness are evident to every one whose own respectability gains him admission, on terms of familiar intercourse, to the respectable circles of Dutch society.

Bibliography.—The first place in a bibliography of Holland is due to the *Algemeene Statistiek van Nederland* (Leyden, 1st part, 1870, 2d part, 1873), a work of much vaster compass than is indicated by its title,—consisting, as it does, of separate articles on every scientific aspect of the country, contributed by specialists of high authority. The geodetic portion, for example is furnished by J. H. A. Kuijper; Dr H. Hartogh Heys van Zouteveen treats of the soil, rivers, islands, &c., the geology, and the fauna; the flora is described by Professor Hugo de Vries, Dr C. M. van der Sande Lacosta, and Professor W. F. R. Suringar; the meteorology is by Professor C. H. D. Buys Ballot, the account of the provinces and communes by Professor S. Vissering, and the vital statistics by M. von Baumhauer. As supplements to this, their greatest work, the Government Society for Statistics also publish *Bydragen en Mededeelingen voor die Stat. van het Kon. der Nederlanden*; *Staatkundig en Staathuishoudkundig Jaarboekje*; and *Stat. Jaarboek voor het Kon. der Nederlanden*. The following are convenient manuals:—Dr A. A. van Heusden, *Handboek der Aardrijkskunde, &c., van het Kon. der Nederlanden*, Haarlem, 1866, J. Kuijper, *Nederland, zijne Provincien en Kolonien*, Leeuwarden, 1878, Rijkens, *Aardrijkskunde van Nederland*, Groningen, 1879; M. H. J. Plantenga, *Militaire Aardrijkskunde van Nederland*, new ed., 1880; J. Craandijk and P. A. Schipperus, *Schetsen met pen en potlood*, Haarlem, 1874. The excellent works of W. C. A. Staring—*De Bodem van Nederland*, Haarlem, 1856-60, *Natuurkunde en Volksvlijt van Nederland*, Amsterdam, 1870; and *Voormaals en thans*, Haarlem, 1877—are of a more descriptive cast. For the fauna and flora of the country the reader may consult Professor Schlegel, *De dieren van Nederland*, Haarlem, 1862, C. A. J. A. Oudemans, *De Flora van Nederland*, Haarlem, 1871-74, Van Halls, *Neerlands Plantenschat*, Gron., 1855. Among the more recent of foreign publications in regard to Holland the following rank high:—Alph. Esquiros, *La Neerlande et la vie Hollandaise*, Paris, 1859 (English translation, *Dutch at Home*, London, 1863); J. G. Kohl, *Reisen in den Niederlanden*, Leipsic, 1850, Dr A. Wild, *Die Niederlande: ihre Vergangenheit und Gegenwart*, Leipsic, 1862; Henry Havard, *La Hollande Pittoresque: Voyage aux villes mortes du Zuiderzee*, Paris, 1874, *Les Frontières Menacées*, Paris, 1876; and *Au cœur du Pa s*, Paris 1878, and Edmondo de Amicis, *Olanda* (Dutch translation by D. Lodeesen, *Nederland en zijne bewoners*, Leyden, 1876). The most important maps and atlases are the topographic maps of the kingdom of the Netherlands, issued by the War Department, the Hague, 62 sheets, lithogr. scale 1:50,000; the *Waterstaats Kaart van Nederland* (1:50,000), issued by the Ministry of the Interior under the supervision of P. Caland and H. Rodi de Loo, W. C. H. Staring's *Geologische Kaart*, executed by the topographical office of the War Department (1:200,000), *Kaart voor de Natuurkunde en Volksvlijt*; and *Landbouwkaart van het Kon. der Nederlanden* (1:200,000); J. Kuijper, *Gemeente Atlas van Nederland, naar officieele bronnen ontworpen* (1205 commun al maps and one large general map); and *Natuur en Staathuishoudkundige Atlas van Nederland*. There are three good gazetteers:—A. J. van der Aa, *Aardrijksk Woordenboek*, Gouda, 1855; S. Gilie Heringa, *Handwoordenboek van Nederland*, 3d ed., Utrecht, 1874; and P. H. Witkamp *Aardrijksk. Woordenbock van Nederland*, Thiel, 1871-76. (C. M. K.)

PART II.—HISTORY.

…ly …abit-…s. The oldest inhabitants of Holland of whom anything is known were of Celtic origin; so much may be gathered from scanty remains found in cairns, from a few proper names, such as Nimeguen (Nimwegen) and Walcheren, and from the Druid altars found in that island. In Cæsar's day the whole district between the Rhine and the Scheldt was occupied by Belgæ, the bravest of Celts, while the Betaw, the "good meadow," the Insula Batavorum, was peopled by a portion of the Germanic tribe of the Chatti, and provided first the stoutest foes and then the most serviceable allies of the Roman empire. But if the Batavi were the most distinguished of the Germanic tribes in the country, the "free Frisians" (see FRISIANS), who filled the whole northern portion of it, were by far the most important; in addition to them, and mostly on the borderland, were others, Usipetes, Bructeri, Sicambri, Chamavi, Eburones, and the like, of whom we know little but the names.

Their struggles with Rome. From 28 to 47 A.D. a struggle went on between the Romans and the Frisians, which ended in the latter year in the complete reduction of the tribe by the vigour of Domitius Corbulo; the Batavi and Frisians were probably, in the earlier days of their connexion with Rome, admitted, if not to the more honourable position of "socii," at least to the lower grade of "auxilia," their relation to the empire doubtless varying from time to time. This friendly state of things did not last long; for in 70 A.D. Rome had dismissed her Batavian cohorts, and had turned Claudius Civilis, the "Mithridates of the West," into a bitter foe. This remarkable patriot had served for many years in the armies of Rome, and had learnt the secrets of the imperial strength and weakness. Taking advantage of the wrongs of Germans and Gauls, and skilfully using the divisions within the empire, he displayed high statesmanlike ability, while his energy and success in war placed him in the rank of great captains. He declared for Vespasian against Vitellius, and grouped together Celt and Teuton in an effort to sweep the tyrant Roman out of Gaul. At first all went well with them, and the Romans were driven out of all modern Holland, Belgium, and from the left bank of the Rhine as far as Alsace. Then the Roman power began to assert itself once more. An able general, Cerealis, was sent into the north-west, and after a chequered and exhausting struggle, in which both suffered greatly, the Batavian hero gave way. Peace was made on easy terms; Civilis laid down arms, and the Batavians submitted and resumed their old position towards Rome. The Batavian island was lined with forts, and became for the Romans the frontier between Gaul and German; much as in far later days the Spanish Netherlands were the barrier between the Dutch and the French.

The Franks.

For a time all was quiet on this north-western frontier, till late in the 3d century the Franks appeared (see FRANKS). In the course of the 5th century the Salian Franks had occupied a great part of the Netherlands, and when Hlodowig (Clovis) was lifted (481) on his warriors' shields, they were possessors of South Holland, the Veluwe, Utrecht, Brabant, Antwerp, Limburg, Liége, Hainault, Namur, and Luxembourg. After his death (511) these districts for the most part belonged to the Austrasian kingdom. Behind the Salians came the Saxons, who had made themselves felt in the Batavian island by the middle of the 4th century; in the course of the 5th and 6th centuries they had settled firmly in Overyssel and Drenthe, lying between the Frisians to the north and the Franks to the south. There they shared, in alliance with the Frisians, the varying fortunes of that struggle against the Frankish power which lasted 400 years, and was ended only by the genius and persistency of Charles the Great.

Spread of Christianity.

The first Christian church in the Netherlands was founded in the time of Dagobert I., who had reduced the Frisians and Saxons at the town of Wiltenberg, afterwards Utrecht, between 622 and 632. But the true apostle of the Netherlands was Willibrord the Northumbrian, first bishop of that see (695). He made Utrecht the centre from which Christian light spread across a wide circle of heathendom; and under the protection of Pippin of Heristal, the new faith was so firmly planted in those parts, that when Willibrord died Limburg, North Brabant, Utrecht, and other districts had accepted the faith of the Franks. After Willibrord, Christianity had in that part of Europe another stout champion, Wolfram of Sens, who had nearly persuaded the Frisian king, Radbod, to be a Christian; and lastly in 755, St Boniface, "the apostle of the Germans," was martyred at Dokkum in Friesland while preaching among the heathen. Towards the end of the century the stern methods of Charles the Great completed the conversion of the Netherlands.

Government and divisions of the country.

As an integral part of the Frankish empire, the land under Charles and his immediate successors was divided into "landschafts" and "gaus," ruled over by dukes and counts, by the side of whom the church also asserted her territorial rights. Hence sprang the dukedom of Brabant, the countships of Flanders, Holland, Guelderland, and the bishopric of Utrecht; and these, under the later Carolings, were independent in all but the name. Ecclesiastically the northern portion of the Netherlands, with South Holland and part of Zealand, was under the bishop of Utrecht; while the eastern districts were under the Saxon bishops of Münster and Osnabrück, and the southern parts under the Frankish bishops of Cologne, Liége, and Doornick. The original dukedoms were subdivided politically into countships, and geographically into gaus; each gau had a chief town, girt with a wall, wherein count and judges administered justice; such towns were also market-places. These districts were again subdivided into marks or villages, each with its headman, who acted as judge in lesser and local cases. These gaus were Frisian in the north, Saxon in the middle (about Drenthe, &c.), and Frankish in the south.

Char... of lo... ship 9th cent...

In the great partition of Verdun (843), Lothar, eldest son of Louis the Pious, became lord of North Brabant (as it is now called), Guelderland, Limburg, and all modern Belgium; Charles the Bald got Flanders and part of Zealand, while Louis the German had whatever lay on the right bank of the Rhine: this district (called Lotharingia in the days of his son Lothar II.) thus became a borderland between Gaul and Germany. When Lothar II. died without heirs in 869, his uncle Charles the Bald got all the northern Netherlands, with Friesland; but the Mersen agreement (870) redistributed these lands,—to Louis the German the districts south of the present Zuyder Zee, including Utrecht and the Veluwe; to Charles the Bald, Holland, Zealand, and modern Belgium. Eventually in 879 Louis, son of Louis the German, got these districts also. In 912 they accepted Charles the Simple of France as overlord; in 924 Henry I. brought them again under German lordship; afterwards Otto the Great granted them as a fief to his brother Bruno, archbishop of Cologne, who, dividing the land into Upper and Lower Lotharingia, set Gottfried, count of Verdun, over the latter as duke, and himself took the title of archduke. Thus, during this period, the Netherlands from 843 to 869 were a part of Lotharingia (as it came to be called); from 869 to 870 they were under French lordship, from 870 to 879 partly French partly German, from 879 to 912 altogether German, from 912 to 924 French again, and finally after 924 German.

The Nor... men

Throughout this time the country was swamp below and woodland above; and though much forest was cleared from time to time, it was still a difficult tangle, with little communication except down the rivers and by the old Roman roads. Yet, backward as they were, the Netherlands were rich enough to attract the Northmen, who ravaged the shores and river sides, and carried with them southward many a willing Saxon and Frisian warrior. Under Louis the Pious they got firm footing on the coast, and received the district from Walcheren up to the Weser as a group of fiefs under the emperors; they even took and sacked Utrecht. In 873 Rolf, founder of Normandy, seized Walcheren; in 880 the Northmen took Nimeguen, and spread up the left bank of the Rhine as far as Cologne; in the chapel of the Great Charles at Aix they stabled horses and held heathen revel, till bribed to withdraw by Charles the Fat. Their great leader Siegfried had the emperor's daughter to wife, with lands in Friesland; he was willing to become a Christian, though this put no stop to his demands; "as the lands granted him hitherto produced no wine," he demanded also Rhine towns and districts for the sake of their vintages. His father-in-law, however, sent instead men to murder him, and, this being done, the lord ship of the Northmen in the Netherlands came to an end.

The effect of these viking incursions on Frankish feudalism was great. "Eighty years of plunder and murder," says Gerlache (*Essai sur les grandes Epoques*, p. 94), "had turned the fields into a wilderness; the towns rose like oases in the desert; the wealth of the monasteries perished; the people were either slain with the sword or had taken to the sword as robbers; all the elements of political life, kingship, nobility, clergy, were confounded together, and every tie of civil society relaxed." The impoverished natives took refuge under the nobles, whose power made great advance. Now arose, too, a new title of nobility, that of margrave,—each margrave being bound to defend a piece of frontier, receiving in return an almost complete independence: such was the marquis of Antwerp, who guarded the mouth of the Scheldt. The towns also became as sanctuaries against the ravager; the serf who took refuge there presently became free; the burghers began to trade, and found encouragement in their traffic even from the Northmen themselves.

[…nts …lland.] Thus the whole district came to be covered with prosperous towns; it was also divided into independent lordships, among which the countship of Holland, as it soon afterwards was called, was the most prominent and important. The title "count of Holland" does not appear in history till the 11th century. In the latter part of the 9th century there was a certain Count Dirk, [...k I.] to whom, early in the 10th, Charles the Simple granted the abbey of Egmond near Alkmaar. Of his history almost nothing is known; he was dead before 942, as there exists still a document of that year signed by Dirk II. [...k II.] Dirk II. was a man of weight; he got for his younger son the archbishopric of Treves, and Arnulf his elder son married a kinswoman of the emperor Otto II. He himself received in 983 a broad district, that now covered by the Zuyder Zee, from Texel to the north, and the mainland southward down to Nimeguen. He died in 988; and Arnulf was count till 993. His son, Dirk III., [...k III.] a boy, on his accession found things in great confusion; the fiefs held under France were gone, and much besides. But the young count was full of vigour, and grew at last so strong that in 1018 the emperor ordered the duke of Nether Lotharingia to crush him. Dirk, however, completely defeated his assailant, and not only retained the disputed lands and powers, but added thereto Bodegrave, the Merwede, and Swammerdam, as fiefs of the church at Utrecht. It is here that the true history of Holland begins; for Dirk III. now firmly settled himself in this district, and became lord of the rich woodland ("Holt-land," *i.e.*, Holland) on the Rhine and Meuse. Having also subdued the Frisians and set his brother over them, he next went on pilgrimage to Jerusalem, and after his return in 1034 ruled in peace till his death in 1039. [...k IV.] His son, Dirk IV., was also a man of vigour; he began the long strife with the counts of Flanders as to the lordship over Walcheren and the other islands of Zealand, the quarrel was important, as dealing with the borderland between French and German overlordship. This strife, which lasted 400 years, did not at first break out into actual warfare, because both Dirk and Baldwin V. of Flanders had a common danger in the emperor Henry III., who in 1046 occupied the lands in dispute; but while other opponents gave in, Dirk, after the manner of his house, stood out, and in the winter of 1047 with his light boats took the imperial fleet, ruined the imperial army, and dictated his own terms. In 1049, in a fresh contest with the bishop of Utrecht and his allies, Dirk met with his death at Dort. [...ris I.] His brother, Floris I., succeeded, and carried on the quarrel; in 1061 he was slain on the battlefield, after having won a decisive victory over the bishop. [...k V.] His son, Dirk V., was a child, and the neighbouring princes thought the end of the house of Holland at hand; and though the boy had stout friends, especially Robert "the Frisian," who had married his widowed mother, his prospects were at first very gloomy. The battle of Cassel, however, in 1072, in which Robert the Frisian defeated Philip of France and Richilda of Flanders, secured his possessions for Dirk, who henceforth saw better days, and ruled in peace till his death in 1091. [...ris II.] His son, Floris II., the Fat, had also peace, and at his death in 1122 left Holland in great prosperity. His widow, [...k VI.] Petronilla of Saxony, governed for her young son Dirk VI., and continued the joint resistance of Holland and Saxony to the Franconian emperors. But when, on the death of Henry V., Lothair of Saxony became emperor, this quarrel came to an end, and the fortunes of the house of Holland rose greatly; the Frisian Ostergow and Westergow were transferred from the bishop of Utrecht to Count Dirk in 1125. The Hohenstaufen, on the contrary, favoured the bishop, and gave back the two "gows"; and thus, with gain and loss, Dirk VI. ruled till he died in 1157. It was in his time that Holland sent out her first colonists; invited by Adolf of Holstein and Albert the Bear of Brandenburg, Hollanders settled on the Elbe and the Havel, and by their skill in reclaiming marshlands, and their thrift and vigour, created a flourishing district out of a waste of wood and water.

[Floris III.] Floris III., the next count, allied himself with Frederick Barbarossa, thus reversing the traditional policy of his house. He was less fortunate than his fathers; the count of Flanders carried off a slice of his territory; he scarcely held his own against West Friesland and Groningen; his reign was marked by the great flood of 1170, which swept over Holland, Friesland, and Utrecht, and helped to form the Zuyder Zee. Later in life Floris followed the emperor on crusade, and soon after the death of the latter, perished in 1190 of pestilence at Antioch. [Dirk VII.] His son, Dirk VII., had a stormy time, losing rather than gaining in the long-run. He died in 1203, leaving an only daughter, Ada, with whom came up the question as to female succession to a male fief. Zealand mainly declared for William, the late count's brother, while Holland went with Ada; by 1206, however, William had beaten down all opposition, and was undisputed count. [William I.] He sided with the emperor Otto IV., and was present at Bouvines (1214), where Philip Augustus crushed the allied forces of Otto, John of England, Flanders, Holland, and Brabant. Soon after this William changed sides, and, attaching himself to Philip Augustus, accompanied Louis to England. After King John's death he joined the fourth crusade, in which his men distinguished themselves greatly at the siege of Damietta in 1219. Returning thence he reigned in peace till his death in 1224. His reign is notable by reason of the civic charters he granted,—one to Geertruidenberg in 1213, another celebrated one to Middelburg in Zealand in 1217. These charters were the models on which later ones were framed; they secured the existing liberties of towns, gave the burghers the right of being ruled by law, and established equal justice within the walls.

[Floris IV. William II.] William was succeeded by Floris IV., murdered at Corbie in 1235; his son, William II., was a man of mark. Pope Innocent IV. having deposed Frederick II., and wanting a prince to set up against the Hohenstaufen, thought that the young count of Holland might serve, and accordingly had him elected king of the Romans by an assembly composed chiefly of German ecclesiastics. He took Aix-la-Chapelle, and was there crowned king in 1248; and after Frederick's death in 1250 he had a considerable party in Germany. His foreign ambitions were, however, crossed by troubles at home, and before he received the imperial crown he perished in West Friesland, going down, horse and armour, through the ice. It was he who fixed the seat of government at the Hague. [Floris V.] His successor was Floris V., a babe. The father had been a young man of unusual promise, ruined by German politics; the son was destined to play a considerable part in Netherland history. Hitherto Holland had dealt only with smaller neighbours, Flanders, Friesland, Utrecht, or Guelderland; henceforward she takes part in European questions, interfering in the great strife between Edward I. of England and France. For when he came of age Floris allied himself closely with the English king, and secured great trading advantages for his people; the staple of wool was placed at Dort, and the Hollanders and Zealanders got fishing rights on the English coast. To balance the power of the nobles, which more and more took the form of oppression, he also granted charters to towns (notably to Amsterdam), and forwarded their growth. In 1296, finding that Edward of England was dealing with his rival of Flanders, Floris joined Philip the Fair of France; but this act and his severities towards the nobles led to a conspiracy, to which he fell a victim; the burghers and people, who knew him to be their best friend, took such vengeance on his slayers as permanently reduced the power of the nobles.

John I. John I., his son, was in England when his father was murdered; he was a feeble boy in body and mind, married to the daughter of Edward I. His reign was a struggle between Zealand, led by Wolfart van Borselen, and Holland, guided by John of Avennes, the young count's guardian and next heir. In 1299 Van Borselen was killed by the Hollanders, and soon after Count John died. John of Avennes was at once recognized as count by the Hollanders, and with John I. ended the first line of counts, after a rule of nearly 400 years. Europe has perhaps never seen an abler series of princes; excepting the last, there is not one weak man among them; they were ready fighters, brave crusaders, handsome well-built persons, with high chivalrous gifts tainted with corresponding chivalrous vices; they were all ready to advance the commerce of the country; they were the friends of the people, the supporters of the growing towns. They made their marsh lands fertile, and raised Holland to be a companion of kings.

The independence of Holland. During this time Holland became independent of the imperial authority. The fragments of Nether Lorraine, Holland, Guelderland, Utrecht, Brabant, and Flanders paid little heed to their nominal lord; Holland especially, so far from the centre of the empire, so nearly forgotten in the greater troubles of Italy or Switzerland, was left to herself. She made her own laws, imposed river-dues (a recognized imperial right), named her own officers, held high court of justice, coined money, made peace or war at will. Even the *de jure* authority of the empire over Holland is a matter of doubt, much debated by publicists and historians.

Constitution of her cities. The independent development of the country took, as we have said, a municipal form; and as the constitutions of her cities have throughout affected her history, they demand some consideration. Before the 14th century there were in Holland no estates, nor any general political life; the count was all powerful. Over the country districts he set his "baljews" or bailiffs, and in towns and villages his "schouts" or local judges. In the 13th century, when any greater matter had to be discussed in a city, all citizens were summoned by ring of the great bell to the public square, and there decided the question by democratic vote. Justice was administered "by a man's peers," according to the Saxon code in the east, the Frisian in the north, and the Frankish or Salian in the south,—each district having also its several uses or customs. Taxation for the count's benefit was styled his "beden" or prayer for supplies, and fell chiefly on the towns. And as the towns paid most, and were generally built on the count's lands, they claimed his protection, receiving charters and liberties from him in return for their dues and levies of men. In time the vague civic democracy gave place to an oligarchical government. While the Flemish towns were opposed to their feudal lord, in the north it was the other way; the counts of Holland were with the cities against the other classes of society. Consequently, though the Dutch towns began later, they in the end enjoyed far more steady prosperity than their southern neighbours. Thus under William II. and Floris V., Dort and Delft, Haarlem, Alkmaar, Middelburg, Leyden, Schiedam, and others began their prosperous career. Each of these cities was at first ruled by the count's "schepenen" or judges, supported by councillors, one from each quarter of the town, from whom sprang the title of burgomaster, by which they became known in later days. The "schepenen" administered justice, while the councillors or burgomasters attended to civil affairs, and by degrees threw the judges into the background. Peace and defence were entrusted to a local militia, armed with the cross-bow. Dort was the earliest of these prosperous towns; it enjoyed a very strict staple-right; the commerce of the northern districts was compelled to pass through its market. Two centuries later came the prosperity of Amsterdam, and with it the European fame of Dutch butter and cheese; then the wealth arising from the herring-fishery, of which the centre was Enkhuysen. In the 14th century the chief towns had joined the Hansa, and though that exclusive body in the 15th century ejected them, they far more than recovered the loss of their trade through the newly opened worlds of India and America.

John of Avennes. When John of Avennes succeeded in 1299 as first count of the house of Hainault, the Hollanders were willing to receive him, the Zealanders not; and a long struggle between the provinces ensued. In 1301 he coerced Utrecht into alliance, and got the bishopric for his brother Guy. In 1304 the Flemings were driven out of Holland, and John II. was for a few months real lord of the county. He died that year, and was succeeded by his son William

William III. III., "the Good" (1304-1337), who made peace with Flanders in 1323, settled the outstanding quarrel between Holland and Zealand, united the Amstelland and its city Amsterdam to his territories, encouraged civic life, and developed the resources of his country. He also entered into close relations with the states of Europe, having married Johanna of Valois, niece of the French king; in 1323 the emperor Louis the Bavarian wedded his daughter Margaret, and in 1328 his third daughter, Philippa of Hainault, was given to Edward III. of England. William III. was in all respects a great prince, and an acute statesman. In 1337 he died, and was succeeded by his son

William IV. William IV., who was killed fighting against the Frisians in 1345. He left no children, and the question as to the succession now brought on Holland a time of violent civil commotions. The county was claimed by Margaret, William's eldest sister, as well as by Philippa of Hainault, or, in other words, by Edward III. of England.

Margaret. Margaret eventually succeeded, siding with the older nobles, and being, therefore, not well received by the towns. These are the days in which came up the famous parties of "Kabbeljaus" and "Hooks," the "Cods" and the "Hooks," the fat burgher fish and the sharp steel-pointed nobles who wanted to catch and devour them. After much buffeting and many changes of fortune, Margaret resigned her lordship in 1349 in favour of her second son William,

William V. but again resumed it in 1350. Then the struggle between nobles and cities broke into open war. Edward III. came to Margaret's aid, winning a sea fight off Veere in 1351; a few weeks later the Hooks and the English were defeated by William and the Cods at Vlaardingen—an overthrow which ruined Margaret's cause. She made peace with her son in 1354, and died two years later. He, however, shortly after fell mad; so that in 1358 the Hooks had to

Albert of Bavaria. call in his younger brother, Albert of Bavaria, to be stadtholder or "ruwaard" in his stead; he ruled well, and restored some order to the land. In the latter part of his life he went over to the Cods, a step which led to another outbreak of civil war which lasted until 1395. In 1404

William VI. he died, and was succeeded by his son William VI. who upheld the Hooks with all his power, and secured their ascendency. He died in 1417, leaving only a daughter,

Jacoba. Jacoba (or Jacqueline), wife of John of France, who died that same year. Again was Holland rent with civil strife; the Hooks, as before, readily accepting a female sovereign, while the Cods declared for John of Liége. Jacoba was granddaughter of Philip of Burgundy, who behaved very ill towards her; her romantic and sad life has rendered her the most picturesque figure in all the history of Holland; she struggled long against her powerful kinsfolk, nor did she know happiness till near the end of her life, when she abandoned the unequal strife, and found repose with Francis of Borselen, ruwaard of Holland, her fourth husband. Him Philip the Good of Burgundy craftily seized, and thereby in 1433 Jacoba was compelled to cede her rights over the counties of Holland, Zealand, Friesland, and Hainault. Consequently, at her death in 1436, as she left no children, Philip seized on all her lands. He already held much of the Netherlands; he had inherited Flanders and Artois, had bought Namur, had seized Brabant, with Limburg, Antwerp, and Mechlin; he now got Holland, Zealand, and Hainault, with a titular lordship over Friesland; a few years later he became lord also of Luxembourg. By this incorporation with the possessions of the house of Burgundy, the commercial and artistic life of Holland was quickened, but political liberties suffered; for the rule of the "good duke" was far from being good. It was a time of luxury and show, of pageants and display, of the new and brilliant Order of the Golden Fleece (1430), and of the later days of feudalism, with all its brilliancy, corruption, and decline in the presence of the new monarchical spirit of Europe. Duke Philip on his accession declared that the privileges and constitutions of Holland, to which he had taken oath as ruwaard for Jacoba, should be null, unless he chose to confirm them as count. From that moment till the latter part of the next century the liberties of the Netherlands were treated with contempt. Holland, however, at first contented herself with growing material prosperity: her herring fishery, rendered more valuable than ever by the curing process discovered or introduced by Beukelzoon, brought her fresh wealth; and her fishermen were unconsciously laying the foundations of her maritime greatness. It was in the days of Duke Philip that Lorenz Koster of Haarlem contributed his share to the discovery of printing; the arts and learning of the Renaissance began to flourish greatly. The Burgundian dukes rivalled their contemporaries the Medici; under them grew up the Flemish school of painters, headed by the Van Eycks and Memling; architecture advanced as stately churches and town-houses were built; the dukes collected priceless manuscripts, founded libraries, and encouraged authors. But this speedy growth in art and letters belonged more to Flanders and Brabant than to Holland or Zealand.

In short, throughout the Burgundian time Holland plays but an insignificant part; and it may merely be remarked that the friendship of the dukes for the nobility did that class more harm than their hostility to civic liberties hurt the towns; for the lavish waste of Philip's court impoverished the nobles, and the wars of Charles destroyed them. After their days the Netherlands nobility were never again powerful. The church also suffered: it was enriched and corrupted by Philip, and was consequently very loyal to him; but his favour instead of strengthening it made the Reformation necessary. The cities, though oppressed and heavily taxed, grew stronger; and, when Duke Charles perished at Nancy, they at once stood out for their rights, and obliged his sole heir the duchess Mary, not unwillingly, to grant them the "Great Privilege" of March 1477, which affirmed the power of the cities and provinces to hold diets, and reserved to the estates a voice in the declaration of war, and authority to approve of the choice she might make of a husband. It was declared that natives alone might hold high office; no new taxes should be laid without the approval of the estates; one high court of justice was established for Holland, Zealand, and Friesland; the Dutch language was made official. Thus came to an end the centralizing despotism of the Burgundian dukes. This period is also remarkable for a reconstruction of the civic government, and for the appearance of the States General, first summoned by Philip the Good. In the states of Holland many nobles sat in person, though they had but one collective vote. At first all towns, larger and smaller, also sent representatives, but after a time the smaller ceased to appear, and only such larger cities as Dort, Haarlem, Leyden, Amsterdam, Gouda, were represented, each having one vote. The president was the "advocatus," or "vogt," of the country, afterwards styled "the pensionary," an officer regarded as the champion of the estates against the counts. In Zealand and elsewhere, clergy, nobles, and cities sat separately, each order having a single vote. The estates, under the Burgundians, had little power; they could not even control the taxation. Duke Philip in 1464 summoned them to meet him at Bruges, and, though some of the more distant held aloof, the majority obeyed. These States General, however, expressed no national feeling or union of the provinces: that was a far later state of things.

The States General.

After Mary of Burgundy had granted the Great Privilege, the provinces warmly supported her against Louis XI.; they approved her union with Maximilian of Austria in August 1477, though it brought them no rest; for the old parties still survived, and Hooks and Cods fought savagely in almost every town. Maximilian had allied himself with the Cods, and the Hooks were defeated at Leyden and Dort, and finally in their last stronghold, Utrecht, of which city the archduke was made temporal protector in 1483. Before that time (March 1482) Mary of Burgundy had died, and Maximilian, acting for his son Philip, became governor of the Netherlands. After fresh Hook and Cod troubles at Haarlem, he finally made peace with France in December 1482, and after the death of Louis XI. brought the Flemings to complete obedience by the peace of Frankfort in 1489. The provinces were still very uneasy, partly through the turbulence of the Hooks, partly because of the autocratic character of his rule, and partly through the so-called "Bread and Cheese" war, caused by famine in the northern provinces. War with France also complicated matters, and the government over the Netherlands was entrusted to Albert of Saxony. In 1494 Maximilian, having been elected emperor, laid down his office as guardian, and had Philip the Handsome declared of age. He was at once accepted by Brabant, and the estates of Holland even let him sweep away the Great Privilege. He ruled over them quietly, and got back their English trade. In 1496 he married Joanna of Aragon, daughter of Ferdinand and Isabella, and afterwards heiress to the new monarchy of Spain. On Philip's death in 1506, leaving two sons, Charles and Ferdinand, and four daughters, Maximilian again became guardian for his grandson Charles, then but six years old; he named Margaret of Savoy, his daughter, governess of the Netherlands in 1507.

Maximilian of Austria.

In 1515 Charles was declared of age, and received the homage of Holland and Zealand, Brabant and Flanders, as Count Charles II. In consequence of his friendly relations with Francis I. of France, Henry of Nassau, his comrade and trusted follower, was wedded to Claude, sister of Philibert, prince of Orange, and from this union springs the great house of Orange-Nassau. On his accession to the Spanish and imperial thrones successively, Charles continued his aunt Margaret of Savoy as governess of the Netherlands, with a privy council to assist her.

Count Charles II. (emperor Charles V.).

He brought all the provinces under one hand, having in 1524 become lord of Friesland by purchase, and in 1528 acquired the temporalities of Utrecht. He now ruled over seventeen provinces: that is, over four duchies—Brabant, Guelderland, Limburg, and Luxembourg; seven counties—Flanders, Artois, Hainault, Holland, Zealand, Namur, and Zutphen; the margraviate of Antwerp; and five lordships—Friesland, Mechlin, Utrecht, Overyssel, and Groningen with the Ommeland.

After the death in 1530 of Margaret, who had continued to act for him with her accustomed wisdom and prudence, Charles V. at first treated the provinces with studied moderation: he redressed some of their griefs, reformed the administration and the coinage, issued sumptuary edicts, regulated their commerce, while he also re-enacted the severe laws against heresy, and gave full powers to the supreme court of Holland—a body completely under his control. He then appointed his sister Mary, queen of Hungary, regent of the Netherlands. She had at first no easy task; for the provinces had on hand a war with Denmark, and Anabaptist troubles at home; before long also she had to ask for increased supplies; and while the Hollanders granted a large annual subsidy, they refused her a hearth tax which she demanded. Similar monetary questions in 1539 produced that famous struggle between the court and Ghent which was only ended by the personal intervention of the emperor; after punishing severely the rebellious burghers, he passed on into Holland, and in 1540, in defiance of the acknowledged rights of the provinces, established a foreigner, René of Chalons, prince of Orange, as stadtholder of Holland, Zealand, and Utrecht. He thus forced on them that great family which has both shed lustre on the history of Holland, and defended there and elsewhere the liberties of Europe. René himself ruled but a short time; he perished in France in 1544, leaving his territories to a little cousin, William of Nassau.

Mary of Hungary regent.

House of Orange-Nassau.

In 1545-46 the estates gave the emperor men and money for his war against the Protestant princes of Germany; after Mühlberg, the Netherlanders hoped that they might now be freed from the foreign troops Charles had quartered among them. He, however, had other plans on hand, and determined to place permanently in the provinces 4000 horse, entirely at his own orders; he also laid before the estates in 1548 a scheme of incorporation, which aimed at making the Netherlands an integral portion of the empire, under the name of the circle of Burgundy, and which he abandoned only after the refusal of the seven electors to make Philip king of the Romans. In 1549 he revisited the provinces and called Philip thither also, that they might see their future master; the young prince swore to maintain their rights and customs; and so began between the Netherlands and him the formal relation which under circumstances elsewhere related (vol. v. 416, 417) became so real on October 25, 1555.

Philip of Spain.

After appointing Margaret of Parma, a natural daughter of Charles V., to be regent in the Netherlands, in 1559 Philip set sail for Spain, leaving, in spite of the remonstrances of the estates, 4000 foreign troops, nominally to protect the frontiers, really to check the independence of the people, and to support the policy of religious persecution which had been resolved on. The real direction of all affairs was in the hands of the Burgundian churchman Antony Perrenot, bishop of Arras (afterwards so well known as Cardinal Granvella), who was chief of the "consulta" or secret council of three. A sharp attack on the Reformers now began. The first step, the proposal (which had originated with Charles) to reorganize the bishoprics of the Netherlands, was announced at once. Hitherto ecclesiastical affairs had been in the charge of four bishops,—Arras, Cambray, Tournay, Utrecht,—the last under the archbishop of Cologne, the others under Rheims. It was proposed now to establish a new and national hierarchy, independent of Germany and France, with three archbishops and fifteen bishops:—Mechlin, the chief archbishopric, having under it Antwerp, Herzogenbusch, Roermond, Ghent, Bruges, and Ypres; Cambray, with Tournay, Arras, St Omer, and Namur; Utrecht, with Haarlem, Middelburg, Leeuwarden, Groningen, and Deventer. Each bishop was to appoint nine new prebendaries to help him in his diocese; of the nine two should be inquisitors, specially told off to sniff out and hunt down heresy. Nor was this all; it was believed that not merely would these new bishoprics strengthen the old episcopal inquisition, but that a more stringent form of inquisition was to be introduced, organized after the Spanish system, which had been long known for its efficient severity. The Netherlanders regarded the change, in fact, as part of a general plan for the subjection of the provinces from abroad, by means of foreign troops and ecclesiastics, with contempt of their feelings, rights, and liberties. All classes—nobles, clergy, burghers, peasants—disliked the new ecclesiastical system, and regarded Granvella, who became first archbishop of Mechlin, with detestation. Though the Spanish troops were withdrawn in 1560, the ferment was not quieted; the nobles were uneasy, and, finding their position uncertain between the court and the populace, began to form confederacies and to head the resistance. Even such leading men as William of Orange, who tried to mediate between Government and the provinces, were driven into opposition; in 1561 Granvella's overbearing acts alienated them still more, and Orange and Horn withdrew from the council. Even Margaret felt she could no longer rule with Granvella at her side; and he at last, seeing that a crisis was coming on, withdrew into Burgundy in 1563. Now things were easier; party badges were dropped, and men felt cooler.

Granvella.

The new bishoprics.

But at this moment the long labours of the Council of Trent were ending; and, when in 1565 it finally promulgated its decrees, Philip determined to enforce their acceptance throughout his dominions. Accordingly, he now made a more vehement attack on the Reformers; and then it was that, in 1566, the Netherland nobles, led by Count Brederode, signed the famous "Compromise," with which the open rebellion of the provinces begins. Orange, Egmont, and Horn stood aloof. When, in their first interview with the regent, the nobles appeared on foot, in sedulously plain guise and without arms, Berlaymont standing by her side begged her not to be alarmed, "for they were but a pack of beggars;" and the phrase being overheard, at Brederode's banquet that night it was gaily adopted by the young nobles as a party name, "les gueux," and it became the fashion for patriots to wear beggar's garb, and a medal round the neck, bearing Philip's image on one side and a wallet on the other, with two hands crossed, and the legend "Fidèles au roy jusqu' à la besace." Orange, Egmont, and Horn, who dropped in on the revelry at Brederode's house, joined the merry scene and drank the beggars' health.

Tridentine decrees.

The "Compromise."

To deprecate Philip's anger at the "Compromise," the council of state sent the marquis of Bergen and Horn's brother, the lord of Montigny, Knights of the Golden Fleece and men of high repute, to Spain, where Philip received them kindly, but took good care that they should never again see their homes. Meanwhile he gathered forces with which to suppress the disturbances, which had become very serious. Open air preachings, guarded by armed men, were taking place throughout the provinces, and raised the excitement to such a height that it at last found vent in iconoclastic tumults, similar to those of France. This gave the court party only too good an excuse; it could now interpose with authority on behalf of public order. Matters threatened war. Margaret played with the discontented nobles, having orders from Spain to decoy

Deputation to Philip.

and capture the chief men, and so to break up the confederacy. Hereon Orange withdrew into Holland; Horn, in moody opposition, conscious of his integrity, retired to his country house; while Egmont still hovered, a bright flutterer, round the fatal taper of the court. The confederacy was in fact broken up; and Margaret saw with satisfaction a considerable body of German mercenaries enter the provinces to inflict punishment, in all its ghastliest and most brutal forms, on the iconoclasts. In 1567 it came to blows: the undisciplined rabble of Calvinists, who tried to raise the siege of Valenciennes, were cut to pieces by the troops of Egmont and other loyal nobles. William of Orange withdrew to Nassau, after vainly warning Egmont of the imminent peril which he ran.

...ir ...tgins.

...e duke ...Alva.

In spite of Margaret, who assured Philip that the heretics were completely put down, and their worship abolished, and that consequently there was no need of an army, and that on the contrary the time for mercy had come, the plan for the utter subjugation of the provinces was adhered to, and the duke of Alva, already famous for his harshness and bigotry, was named commander of the forces, with almost unlimited powers. He set forth in May 1567, and all hopes of peace or mercy fled before him. There was a great and desperate exodus of the inhabitants; thousands took refuge in England, Germany, and Denmark, carrying with them, it was thought, the last relics of their faith and party. The nobles' confederacy had already been broken up; now the popular movement was dispersed, despair and helplessness alone remained to greet the cold Spaniard and his train of orthodox executioners. He entered the Netherlands with about 20,000 men, all tried troops, ready for any cruelties. Their weakness lay in the fact that they were after all mere mercenaries,—Spaniards, Italians, Germans,—and as such ever ready for a mutiny, if pay fell short, or if there were none to plunder.

...rrest of ...gmont ...d ...orn.

Egmont and Horn were arrested at once; the Council of Troubles—the "Blood-tribunal"—was established; Margaret, thrust aside by the imperious general, resigned her weary office, and carried away with her the last hopes of the wretched people. Alva was now appointed governor-general, and the executions of his council filled the land with blood. Orange was outlawed on his non-appearance; it was about this time that he declared his conversion to Calvinism, and so fitted himself in every respect to lead the people when the time came. The hostilities of 1568 led to the execution of Egmont and Horn. Though the Gueux under Louis of Nassau won a considerable victory over the Spaniards at Heiligerlee, the arrival of Alva compelled him to raise the siege of Groningen, and to withdraw towards the Ems. At Jemmingen Louis was at last utterly defeated, and though the prince of Orange did his utmost to raise the country, and skilfully avoided a fatal battle, the campaign ended in his being obliged to withdraw out of the country. Alva was now at the highest point of his success; his statue, cast from cannon taken at Jemmingen, was set up at Antwerp; the exodus of the inhabitants continued incessantly, especially to England. The advice of Admiral Coligny, that the provinces should wage war from the sea, was hardly listened to at the first. In 1570, however, Orange turned his attention that way, and his little navy under William de la Marck annoyed Spanish commerce and took rich prizes. In 1572, being unable to find refuge in any ports,—for neither England, nor Denmark, nor Sweden, would allow them harbourage, and they were treated not merely as rebels but as pirates,—William de la Marck, with his "Water-Beggars," suddenly seized on Briel, at the mouth of the Meuse, and the face of the struggle began from that moment to change. Alva, partly from the general requirements of his position, partly from lack of funds and desire of his recently-imposed tenth penny, had at this moment driven the Netherlanders to desperation. He was engaged in a struggle with Brussels and Utrecht, in which city, to punish the inhabitants, he had collected his Spanish soldiery from all the neighbouring towns. The news of the capture of Briel woke him from his security. Flushing also fell into the hands of the "Water-Beggars," who surprised under its walls a rich convoy from Spain. About the same time, Louis of Nassau, who had been at La Rochelle with the Huguenots, and had received help and encouragement from Charles IX. of France, suddenly seized Mons in Hainault, thus giving the French sympathizers with the revolt the means of entering safely into the Walloon provinces. Alva, now seriously alarmed, withdrew from Zealand the whole of the forces with which he had intended to check the movement of the "Water-Beggars," in order that he might repair the great breach thus made in his southern system of defence, and so left the province free to develop its resistance. Holland followed quickly, Enkhuizen setting the example; so that, within three months of the capture of Briel, Amsterdam was the only town in Holland in the hands of the Spaniards. In Friesland also the revolt spread far and wide. The states of Holland met, and, acting under advice of Philip of Marnix, lord of St Aldegonde, the prince's deputy, declared that William of Orange was, by Philip's nomination, stadtholder of Holland, Zealand, and Friesland; they also declared their intention to raise money for the costs of war and the relief of Mons, and affirmed again the liberties of the provinces; finally they named the rough and ready William de la Marck captain-general—a man whose prompt and practical daring would supply the qualities which the caution and apparent irresolution and timidity of William of Orange seemed unlikely to provide for the emergency.

...illiam ...Orange ...tlawed.

Capture of Briel.

Revolt ... the provinces.

William of Oran... stadtholder.

Alva's success...

Meanwhile Alva pressed the siege of Mons; French help failed utterly to relieve Louis of Nassau, nor could William of Orange either force his way through the Spanish lines or induce Alva to fight. At this moment came tidings of the massacre of St Bartholomew, and the prince, seeing that all hope of aid from France was utterly at an end, bade his brother make the best terms he could, and withdrew beyond the Rhine and thence into Holland. Mons at once capitulated, and Alva, passing on to Mechlin, pitilessly sacked that wealthy city. Thence he pressed forward to the north; Zutphen was taken, the towns of Guelderland and Friesland submitted, and for a while nothing seemed to stay his career of conquest and revenge. The prince of Orange was powerless; but the despair caused by the cruel destruction of Naarden roused a spirit which even Alva could not tame, and the famous siege of Haarlem, lasting through the winter of 1572 till July 1573, cost 12,000 Spanish troops, and gave the insurgent provinces time to breathe. A great mutiny among Alva's troops still more hindered the work of subjugation. The repulse of Don Frederick of Toledo, Alva's son, from Alkmaar, the capture of Geertruidenberg by the Dutch, and Admiral Dirkson's great victory over Alva's fleet, entirely changed the aspect of affairs, and saved the towns of North Holland. Alva, who had come as far as Amsterdam, returned to Brussels, and thence, obtaining his recall, bade farewell to his government. During the six years it had lasted, his executioners had put to death 18,000 persons, to say nothing of the victims in cities captured by his troops; the Spaniards plundered where they could, and considered the whole wealth of the Netherlands their lawful prey, forfeited by rebellion. But his pitiless severity only served to raise up a stubbornness of civic resistance, against which the tried discipline of the Spanish soldiery, and the consummate skill of their commander, reckoned to be the first general in Europe, were powerless.

Don Louis of Requesens, grand-commander of Castile, was appointed Alva's successor, and after a brief and deceptive lull the war went on. In January 1574, by the fall of Middelburg, the Spaniards lost their last hold on Walcheren and on Zealand, while by the splendid defence of Leyden, unparalleled in the history of heroic endurance, their efforts in another direction were effectually frustrated. After fruitless negotiations with Philip, the estates of Holland, in November 1574, formally offered to William "the Silent," prince of Orange, full authority by land and sea, with the title of governor or regent. Conferences were also held, with a view to peace, at Breda; and on their failure, in summer 1575, Holland and Zealand drew up articles of union, and an ordinance for their joint government under the prince of Orange. By it he received supreme command in war and absolute authority in all matters of defence, the control of all money voted by the estates, the maintenance of the laws as count, in the king's name, the ultimate appointment (after nomination by the estates) of all judicial officers. He undertook to protect Calvinism, and to suppress "all religion at variance with the gospel," while he forbade all inquisition into private opinions. These terms accepted, William became, in spite of their nominal recognition of Philip, the true prince of the two provinces. Still this union, brought about by the prince's personal character and ability, and by the popular faith in him, was distasteful to the larger cities. Already we may note the beginnings of that party division which was afterwards so prominent, and divided Holland between the land-party, popular, quasi-monarchical, Calvinistic, headed by the Orange-Nassau family, and the sea-party, the town-party, headed by the burghers of Amsterdam, Arminian, civic, and aristocratic.

[Margin: William proclaimed governor.]

Meanwhile the grand-commander made a successful attempt on the Zealand coast. His troops took Duiveland, and laid siege to Zierikzee, chief town of Schouwen, and key of the whole coast. The two provinces, unable to relieve the place, were driven to consider their position. So long as they paid any allegiance to Philip of Spain, against whom they were struggling for life, they could never get much help from any other prince, nor were they strong enough to assert their own sovereignty. Three powers lay near them:—the empire, already connected with them by old relations, and by the family connexion of the house of Orange; France, with her restless Valois dukes, ready for any venture, whether in Poland, England, or Holland; and, lastly, England, whose queen knew well that Philip was her foe, and that the Low Countries might effectually hinder his efforts against her. The provinces, though William had suggested it, refused to deal with the emperor, and turned to Elizabeth; she brought them little real help, and they seemed to be on the very brink of ruin when fever carried Requesens off in March 1576.

The breathing space thus gained enabled them to strengthen their union under William; but before the question respecting the position of the duke of Anjou could be settled, the siege of Zierikzee drew to an end. Boisot perished in a too gallant attempt to break the leaguer, and the town yielded. Things looked ill for the patriots, and Zealand would have been at the mercy of the conqueror, had not another great mutiny neutralized the success of the victors; the Spanish and Walloon troops left Zealand and, headed, as usual, by their "eletto," marched into the richer plains of Brabant, seizing Alost, whence they threatened both Brussels and Antwerp. One of the results of the panic they caused in Brabant was the capture of Ghent by William. Brussels was only saved from being pillaged by them by the vigour of the inhabitants, who armed in their own defence. Suffering under a powerless administrative, and smarting from the curse of the foreign soldiery, the southerners now began to wish for freedom and union with the other provinces. The broad liberality of Orange, moderating the Calvinism of the people, enabled the two groups to draw together. In October 1576 a congress of the States General of the provinces met at Ghent; the council of state at Brussels was forcibly dissolved; the frightful "Spanish Fury" at Antwerp struck such terror into all hearts that a treaty was concluded in November 1576 under the title of the "Pacification of Ghent." It was received with great enthusiasm; in it the provinces agreed first to eject the foreigner, then to meet in States General and regulate all matters of religion and defence; it was stipulated that nothing should be done against the Catholic religion; the Spanish king's name was still used; the prince of Orange was recognized only as stadtholder of Holland and Zealand. All the seventeen provinces accepted the Pacification; and for a brief space the "United Provinces" really did exist.

[Margin: Pacification of Ghent.]

Early in January 1577 the "Union of Brussels" was put forth. The document engaged all who joined to help in ejecting the foreign troops, in carrying out the Pacification, in maintaining the Catholic faith, in recognizing Philip's sovereignty, in defending the liberties and constitutions of the provinces. It was eagerly adopted; and even Holland and Zealand made no demur. When the paper, crowded with signatures, was laid before Don John of Austria, who meanwhile had arrived as regent, he also accepted it; and on the 17th February 1577 was signed the "Perpetual Edict," which ratified the Pacification of Ghent. Not till the troops were gone should Don John be received as governor-general. Philip II. ratified the Edict a few weeks later.

[Margin: Union of Brussels.]

[Margin: Perpetual Edict.]

Yet, after all, unity did not ensue from it. The natural divergency between north and south at once appeared; in character, in interests, above all, in religion, they had little in common; and when William of Orange refused to publish the edict in Holland and Zealand he was warmly supported by these provinces. This is perhaps the real point at which Dutch independence begins. Don John entered Brussels in triumph, and, by conciliation and winning manners, had already broken up the union; the whole of the southern provinces withdrew from it at once, and that well-marked difference in political life, which, after so many changes, still distinguishes Belgian from Dutchman, was from that moment made clear. Yet, though Don John had achieved so much, the result, after all, disappointed him; he was surrounded by difficulties, suspicions, and plots; he saw the failure of his larger schemes, and only the partial success of his effort to reduce the Netherlands; he recognized the dangers which the abilities and rivalry of William of Orange were preparing for him. This was soon shown in the seizure of Antwerp citadel by the patriots, and in the destruction of the hated fortifications, so long the sign and efficient cause of their subjection. Other castles, such as that of Ghent, were razed to the ground as soon as the fall of Antwerp citadel was known. Still less was Don John pleased by the election of his rival as ruwaard of Brabant, and by his enthusiastic reception at Brussels. The States General (7th December 1577) declared strongly against Don John's authority.

[Margin: Seizure of Antwerp.]

It was clear war must begin again; and the patriots raised an army nearly 20,000 strong, which was utterly defeated by Don John and Alexander Farnese, at Gembloux near Namur. But their campaign was wasted on isolated movements and town-taking, while William of Orange fell back unmolested to Antwerp. A sudden illness, so sudden as to arouse the common suspicion of poison, carried off the conqueror of Lepanto (1st October 1578), and Alexander of Parma succeeded him in the government.

The struggle had now entirely passed into the southern provinces; Holland and Zealand were left to gather strength; the recovery of Amsterdam (1578) removed the one hindrance to their prosperity. While the south trusted to foreign help, some John Casimir, or duke of Anjou, the north quietly consolidated itself. In January 1579 was proclaimed the famous "Union of Utrecht." The document professed to make no changes; it would but carry out the Pacification of Ghent by a closer junction of Holland and Zealand with Friesland, Guelderland with Zutphen, Utrecht, Overyssel, Groningen; united as one, these provinces should still retain their local uses and privileges. So long as the archduke Matthias, who had been appointed governor-general in 1577, remained, his authority would be respected; on his withdrawal in 1580 the States General named as stadtholder William of Orange, who had already exercised the real authority over the provinces. A considerable number of southern cities, Ghent, Antwerp, Bruges, and others, as well as some of the nobles, also joined this union. Thus did the United Provinces at last come definitely into being.

[U]nion of [U]trecht.

[T]he [U]nited [P]ro[v]inces.

During the next five years Spain devoted her efforts to the southern provinces alone; the union was unmolested. The Walloon provinces were reconciled to Spain; the others, with exception of Holland and Zealand, had accepted the duke of Anjou as their sovereign; Holland and Zealand had proclaimed William of Orange as their chief, though he did not finally accept sovereign power and the title of count till August 1582, by a sort of cross division, the seven northern provinces, meeting at the Hague, had (26th July 1581) made an "Act of Abjuration," and had issued their "Declaration of Independence," the five naming Anjou, the two William, as their sovereign in Philip's stead. Then Holland and Zealand framed an independent constitution, conservative of their ancient liberties, as expressed in the "Great Privilege of the Lady Mary;" they declared themselves a free country, severed alike from Spain and from the empire.

[D]eclaration of [I]ndependence.

But Spain was not yet ready to take up this challenge; and meanwhile she resorted to other weapons. A scandalous proclamation, offering rewards and honours to any ruffian who would serve church and king by murdering William of Orange, was now issued; and, roused by the double inducement, after many unsuccessful attempts, a paltry wretch (10th July 1584) succeeded in assassinating the greatest man of his age, the worthy "Father William" of the Dutch, and the only ruler in the world's history who may fairly be compared with Washington.

[M]urder [o]f William.

[M]aurice.

Fortunately for the Provinces, and for the world's liberties, the spirit of William of Orange survived in his second son Maurice, who now, though he was only seventeen and a student at Leyden, and though he had an older brother living in Spain, was at once, chiefly through the influence of that great statesman John Olden Barneveldt, named governor of the United Provinces, with a council of state, and with Count Hohenlohe, his brother-in-law, as lieutenant-general. He was also, soon after, made stadtholder of Holland and Zealand, while Utrecht was placed under the lord of Villars as stadtholder, Guelderland and Overyssel under the count of Meurs, and Friesland under William of Nassau. Never was any one better fitted for his life's task than was this boy, thus early called to rule in troubled times. For Maurice of Nassau had all the coldness and calculation of his family, all its ambition, all its firmness and tenacity of grasp, while he added thereto a quality wanting in the others, a genius for war, and those gifts which go to make what is commonly called a lucky commander—gifts which may be best described by saying that the lucky captain is he who in war leaves least to luck. For over forty years Maurice was the champion of the Provinces; and, if we except his treatment of Barneveldt, we may say that he comes next after his father as a founder of the Dutch republic.

At the outset his antagonist was that formidable captain, Alexander Farnese, who had by this time nearly subdued all the southern provinces, and whose arms proved successful at Ghent (1584) and at Antwerp (1585). The northern provinces, thinking it necessary to call in foreign aid, appealed to Henry III. of France, but the outburst of the "War of the three Henries," caused by the anxiety of the Guises lest Henry should draw too much towards the heretics, put a stop to all hope of help from that side. Olden Barneveldt, therefore, next crossed over to England with offers to Queen Elizabeth, who, though declining for herself the proffered sovereignty over the Provinces, undertook to appoint a governor-general, and to send over and pay 5000 foot and 1000 horse; in return for which she was to be put in possession of certain cautionary towns. Accordingly, Sir John Norris was at once sent over with the English forces; Sir Philip Sidney was appointed governor of Flushing, and the earl of Leicester was named governor-general by the queen. At first Leicester was welcomed with all the joy that his Calvinistic opinions, and his position as favourite and representative of Elizabeth, could elicit in the breasts of men who had now long been struggling for existence, and who, bereft of their great prince, were yearning for some strong hand to guide them. But it did not last: his high pretensions, and his mistress's haughty tone, joined with his foolish interference with Dutch commerce and with the religious difficulties now beginning to show themselves, soon offended the States General, and neutralized whatever good the active help of England might have promised them. In 1586 Sir Philip Sidney invaded Flanders, and the young stadtholder of Holland gladly served under him. In the same autumn Leicester himself took the field, and marched to meet Parma, who was threatening the provinces from the east. Under the walls of Zutphen Sir Philip Sidney fell; and Leicester, finding his efforts useless, soon raised the siege of that town, and withdrew to the Hague. The rest of his time was spent in bitter quarrels with the estates; Olden Barneveldt and Maurice were united for a time by his marked ill-will towards them both; and so strong did the feeling against him grow, that in 1587 Queen Elizabeth was fain to order his recall. For a while there was great soreness between the countries; the general interest, however, was far stronger than any partial pique, and in the crisis of the Spanish Armada in 1588 the Dutch did very great service to England by resolutely blockading in their ports the transports and army with which Parma had meant to invade the English shores. In the same year Maurice had the satisfaction of seeing the English and Dutch repulse the famous duke from the walls of Bergen-op-Zoom. In 1589, on the other hand, the English garrison of Geertruidenberg betrayed that important place, the doorway out of Brabant into Holland, into Parma's hands, and laid the United Provinces open to attack. In other places also the English forces, not yet withdrawn, were an anxiety and danger to the states. Still, from this moment the fortunes of the Dutch began to rise. No contrast could be more striking than that between the Spanish Netherlands and the United Provinces. In the fertile districts of Hainault and Brabant, where climate and soil are good and transit easy, utter ruin alone was seen: wolves and wild dogs swarmed; the land was overrun with weeds and briars; and even the wealthy cities of the past were almost deserted. In the United Provinces, on the contrary, the wellbeing of the country was steadily increasing: every year its hardy seamen brought back fresh wealth; and thousands of ingenious workers, turning in despair from the hopelessness of their condition in the

Alexander Farnese.

Earl of Leicester.

Spanish Netherlands and United Provinces contrasted.

Spanish Netherlands, brought their skill and industry into the north, which soon became as famous for its manufacturing excellence as for its energy in commerce. It was at this period that, just when the southern cities were languishing and losing ground, the northern burgher life made vigorous growth, and prepared the way for that supremacy of town aristocracy which characterized the history of Holland in the following century.

War against Spain.

The year 1590 opened well for the United Provinces: Utrecht joined its fortunes with those of Holland and Zealand; Guelderland and Overyssel made William Louis of Nassau their stadtholder, so strengthening the power of the family; and Breda was recovered by a daring stratagem. The duke of Parma also, with failing health, was called away to oppose the victorious progress of Henry IV. in northern France. In 1591 Prince Maurice still further strengthened himself by taking Zutphen, Deventer, Hulst, and eventually Nimeguen, which secured for him the complete submission of Guelderland. Parma was unable to oppose him effectually, for his troops were again mutinous; he was also once more called off into France. The reputation of Prince Maurice rose now to its highest point: the greatest captain in Europe seemed unable to cope with him, and the vigorous help of Barneveldt still secured him firm support at home. In 1593 he took Geertruidenberg; and in 1594 Groningen, the only stronghold left to the Spaniards in all the Seven Provinces, was reduced.

Archduke Albert.

The appointment of the cardinal archduke Albert as governor of the Spanish Netherlands did not much change the current of affairs; the Dutch now tried to open up a trade with the East Indies, and made some vigorous explorations in Arctic seas. In 1596 the archduke recovered Hulst, which commanded the northernmost parts of Flanders; the Dutch on the other hand, with the English, sacked Cadiz and destroyed the Spanish fleet; and in the next year Maurice inflicted a defeat on the Spaniards at Turnhout, transferred his sphere of action to the Rhine country, and took town after town, making the provinces secure on the side of Zutphen, Overyssel, and Friesland. The year 1598 gave a new aspect to affairs by the conclusion of the Franco-Spanish war in the treaty of Vervins, and by the death of Philip II. The Dutch, assisted only by the English, and that chiefly by volunteers, were now to bear the whole brunt of the efforts of Spain. In the autumn of 1599 Prince Maurice endeavoured to transfer the war into Germany; and after taking Emmerich in the Cleves country, delivered Bommel from the siege which Mendoza, the Spanish general, was laying to it. But dissatisfaction at home, and the unreadiness of his German allies, forced Maurice to turn his eyes towards Flanders, which he invaded in the summer of 1600. Surprised by the Spaniards in the neighbourhood of Nieuport, Maurice was attacked by the archduke Albert in a most critical position, but, after a long and well-balanced battle, inflicted on him (July 2) a disastrous defeat. Maurice could not, however, take the town, and winter put a stop to the campaign without any great change in the relative position of the belligerents. In 1601 the archduke began the famous siege of Ostend, which lasted three years and two months; the losses on both sides, more especially among the Spanish, were immense. While it continued, the coolness between the States General and Maurice steadily increased; for they thought his cold ambitious nature capable of anything, and saw with fear the paramount influence he had over the army. Their instincts led them to rest on the ships, to prefer peace to war, and commerce to glory. It was during the siege of Ostend that they established the Dutch East India Company in 1602, though its basis had been laid down by a group of Amsterdam traders in 1595.

Battle of Nieuport.

Siege of Ostend.

In 1604 Maurice took Sluis, and Ostend at last fell to Spinola. Thenceforward the main lines of the struggle by land were simple enough: the Spaniards tried to transfer the seat of war into the United Provinces, and were steadily foiled by Maurice. All the while the States General aimed at peace, though the naval war became vigorous as that on land languished. The sea fight off Gibraltar in 1607 utterly ruined the Spanish fleet, and left her commerce powerless. At last, after long negotiations, which served to emphasize the variance between the patriot party, headed by Barneveldt and Grotius, and the war party, which included the official classes, the army, navy, East India Company, the clergy, and the populace in the towns, a truce for twelve years was signed, on the *uti possidetis* ground, between Spain and Holland. In the war the Dutch had added Overyssel and Groningen to the union; they held Sluis, Hulst, and other ports on the Flemish side, in what is called "Dutch Flanders"; they had Bergen-op-Zoom, Breda, and Herzogenbusch on the Brabant frontier, and the forts which commanded the Scheldt and strangled Antwerp for the sake of Amsterdam; lastly, they were become lords of the sea, and the chief traders of the world.

Dutch gains i the wa

Theolo gical conflic

After a brief interference in the affairs of Germany, where the intricate question of the Cleves-Juliers succession was already preparing the way for the Thirty Years' War, Holland settled down into that hot and absorbing theological struggle, which was closely mixed up with political questions, and which stained with a deplorable triumph the last years of the career of Maurice of Nassau. In 1603 Jacob van Hermansen, or, in Latin form, Arminius (see Arminius), had been appointed one of the two professors of theology at Leyden, Francis Gomar being the other. The two men took opposite sides with zeal, Arminius assailing and Gomarus defending the current popular theology. The views of Arminius spread fast among the upper classes, especially in the larger towns, and became the theology of the civic aristocracy; the established opinions were tenaciously supported by the bulk of the clergy, the peasantry, the town populace, the army, and the navy. At their head stood Maurice, ready to use the strength of Calvinistic feeling to secure his own authority, however little he might care for the tenets of his side; at the head of the other party, more philosophical, less in earnest perhaps, was Barneveldt, with the town traders. King James of England as yet supported the Calvinists, and with Archbishop Abbot influenced greatly the proceedings of the famous synod of Dort (1618) in favour of Prince Maurice and the anti-Remonstrants. The results of the synod enabled the prince for his own political purposes to crush the aristocratic party. Barneveldt and Grotius (another leading Remonstrant) were seized, and in spite of all his great services to his country, his venerable age, and his past support of Maurice, the pensionary was brought to an infamous trial and executed at the Hague in 1619. Grotius afterwards escaped from prison and took refuge in France. The silenced Remonstrants, finding that there was no hope of toleration for them, left the country in great numbers, and formed a prosperous settlement in Holstein in 1621, where they founded the town of Frederickstadt on the Eider.

Thirty Years' War.

In 1621 the truce with Spain came to an end, and the Dutch were at once involved in the vortex of the Thirty Years' War, which had now been going on for a couple of years. Spinola, after taking Juliers, attempted Bergen-op-Zoom, hoping thereby to open a passage into Zealand; he was, however, foiled by Maurice. About this time a great coolness sprang up between Holland and England, the beginning of the deadly rivalry which lasted so long.

alry lland gland.

King James was eager to gain his objects without fighting, and to be on friendly terms with Spain; he and Laud were opposed to the Calvinism of the Dutch, and disliked their form of church government; and commercial jealousy was already beginning to arise. Successes and losses were evenly balanced in the war: the Dutch recaptured Juliers and took Cleves, while Spinola, after great losses caused by the gallant defence of the English, in 1625 took Breda. A few days before the town fell Maurice died, leaving the Spaniards in the heart of his territories, and the Dutch vexed with religious and domestic factions.

de- ; ary.

His brother, Frederick Henry of Orange-Nassau, succeeded him as stadtholder of Holland, Zealand, Guelderland, Utrecht, and Overyssel. The war by land became utterly spiritless, though by sea the Dutch still asserted their maritime supremacy. By land the chief operations were the siege and capture by Frederick Henry of Herzogenbusch, Maestricht, and Wesel in 1628; by sea the Dutch interfered, much against the popular feeling, to assist the French court against the Huguenots at La Rochelle. They blockaded Dunkirk, whence Spanish privateers had been wont to harass their commerce; under Piet Heyn of Delftshaven, boldest of their sea-captains, they vexed the Spanish coasts, captured Spanish war ships, carried off their "silver fleet," and finally in 1631 won near Tholen a brilliant victory over a great Spanish fleet commanded by Count John of Nassau, who was endeavouring to make a descent on the Zealand coast.

reli- y suc- sion in use of nge.

In this year the States, feeling that the moderation of the stadtholder was honest and salutary, that his influence alone seemed able to quiet the rage of religious faction, and that his military operations had secured the confidence of the provinces, took the important, and, as it turned out, the unwise step of securing to his infant son the reversion of all his great offices of stadtholder, captain, and admiral-general. The Calvinists were willing to grant so much to the head of their party, and made no objection to the introduction of the principle of hereditary succession; while the Remonstrants, discerning that Frederick Henry, like his brother before him, was personally more favourable to their tenets than to those of their adversaries, accepted the measure in the hope that when permanently established as their prince he would carry out those tolerant views which he was known to hold.

In 1632 he justified their confidence by his masterly siege and capture of Maestricht, in defiance of all the efforts of the Spanish and imperial generals; Namur, Luxembourg, and eastern Brabant were laid under contribution in consequence, and the States defended from danger of attack towards the east. As the war dragged on after the death of Gustavus Adolphus of Sweden, France and Holland drew more together, and in 1635 an alliance and partition treaty was made between them, in which it was proposed that the Spaniards should be driven out of the Netherlands, which should be made an independent state, guaranteed by the allies; that France should receive, as her share, the sea-coast up to Blankenberg, together with Thionville and Namur; and that a corresponding portion should be given to Holland; if this scheme of an independent state proved a failure, then France and Holland should divide the whole district between them. The joint operations consequent on this agreement proved a failure: Frederick Henry had always been opposed to the alliance, and probably did not wish its success; the divergence between him and the States General at this time gave Cardinal Richelieu the opportunity of restoring the Remonstrant party in Holland, and making it French in sympathy, in opposition to the House of Orange—a combination of which Louis XIV. afterwards made great use. In 1637 the stadtholder recovered Breda, though the gain was balanced by the loss of Roermond and other places; and in 1638 the war was favourable to the Spaniards. In 1639, however, a series of great naval triumphs under Tromp and De Witt turned the scale in favour of the Dutch.

iance h ance.

In 1640, on the death of Count Henry of Nassau, stadtholder of Friesland and Groningen, the latter province chose Frederick Henry as its stadtholder, and he thus became chief of six out of the seven United Provinces; in the next year he was able to arrange the marriage of his son William with Mary, eldest daughter of Charles I. of England, a match devised by the queen-mother of France, while a refugee in Holland, in order to increase the ill-will between Richelieu and the stadtholder. Thus began the dynastic relation between the Stewarts and the house of Orange, which led to such great results before the end of the century. The States General were not too well pleased with this alliance, and looked shyly at Henrietta Maria when she came over to Holland to get help for Charles I. in 1642. They were becoming alarmed at the great power and growing ambition of France under Richelieu, while they sympathized to a great extent with the English Puritans.

Connexion with England.

All parties, except the French, being now utterly weary of the war, negotiations for peace, long talked of, long prepared for, began in earnest at Münster and Osnabrück. Before their close Frederick Henry died in 1647, and was succeeded in his dignities and offices by his young son William II., and almost immediately afterwards (January 1648), in spite of the opposition of France and the young prince of Orange, the deputies of the Provinces (with exception of Zealand and Utrecht) signed a separate treaty of peace with Spain, which was confirmed and sworn to in May at Münster. It was a complete surrender of everything for which Spain so long had fought. The United Provinces were recognized as free and independent, and Spain dropped all her claims; the *uti possidetis* basis was adopted in the matter of all conquests; the two contracting parties agreed to respect and keep clear of each other's trading-grounds; each should pay, in the ports of the other, only such tolls as natives of the other paid; the Scheldt was entirely closed by the States, so that Amsterdam might strangle Antwerp—the chief harbour of the free Provinces thus ruining the chief harbour of those still subject to Spain. And so ended the so-called Eighty Years' War.

William II.

Peace with Spain.

No sooner was the peace concluded than bitter disputes arose between Holland, on the one hand, and the prince of Orange, supported by the army and navy and the smaller provinces, on the other. He was tempted into foolish acts: he arrested six of the deputies of Holland; he even tried to surprise and occupy Amsterdam; he favoured the English royalists, now plentiful in the Provinces, while Amsterdam and Holland inclined towards the Commonwealth. Things went so far that William II. had almost destroyed the liberties of the Provinces, and was intent on two schemes,—the resumption of war against Spain, with a partition with France of the Spanish Netherlands, and interference on behalf of Charles II. in England,—when his opportune death by small-pox occurred. A few days afterwards his widow, Mary of England, gave birth to a son, who was destined to be the most distinguished man of his race, William III. of Holland and England.

Holland and William II. at variance.

For a time the death of William II. restored the burgher-party to power, and made Amsterdam the head of the United Provinces. Holland triumphed over Zealand; the house of Orange, friend of the Stewarts, seemed to suffer eclipse with them; and though the royalist mob even at the Hague, set on by a princely rough of the palatine house, made it impossible for the envoys of the English Commonwealth to come to terms with the republic, still the popular monarchical party was in fact powerless in the Provinces for more

Amsterdam now rules.

than twenty years. It was with a view to the security of this aristocratic government that a great assembly of the Provinces was held in 1651, and established that form of rule which Sir William Temple has so well described in his *Observations upon the United Provinces of the Netherlands.*

Constitution of the United Provinces.

There were four chief elements in that federation:—the terms of the Union of Utrecht (1579); the claims and position of the house of Orange; the sovereignty, within its own borders, of each province; and lastly, the liberties and power of the cities. In the last two the lead was taken by Holland: Holland was the chief province, and Amsterdam, its capital, the chief city of the union. And these two parts of the federation were at one also in their resistance to the house of Orange, of which the chief strength lay in Zealand. The union was governed, in theory at least, by the States General of the provinces, which met at the Hague, and consisted of a fluctuating number of deputies (sometimes as many as 800), and was supplemented by a permanent council of state, a kind of cabinet composed of twelve deputies from the provinces, and a chamber of accounts. Besides this body each province had its own estates, and each great city its own senate. Thus Amsterdam was ruled by a senate of thirty-six burghers, who kept order, administered justice, raised local taxes. The office of senator was for life, originally by election of the whole body of freemen, but from the 16th century by cooptation, so that the government of the city became a close oligarchy. The chief towns followed Amsterdam in this direction. The senate elected the deputies of the city to the states of Holland.

The town-governments.

Commercial prosperity.

The commercial prosperity of the Provinces went on advancing throughout the 17th century; each town had its own work. Flushing received the West India trade; Middelburg was entrepôt for French wines; Terveer was the Scottish and Dort the English staple; Leyden manufactured; Haarlem made linen and mixed stuffs, and grew tulips for profit and pastime; Delft was known for beer and hardware; Zaandam built ships; Enkhuizen caught and cured herrings; Friesland had the Greenland trade; and lastly Amsterdam, recognized chief of Dutch cities, had the East India trade, with that of Spain and the Mediterranean: their whole carrying business reached from the Gulf of Bothnia to the farthest Indies. Their seafaring enterprise received an early scientific impulse from the labours of Coignet and G. Mercator. All questions as to the nature and development of wealth were still in their infancy: it was believed that all depended on balances of actual bullion; and the Spaniards were envied because their ships brought over masses of gold and silver. The "balance of trade," the establishment of banks at home and colonies abroad, especially mining colonies, a huge carrying trade, the making of goods to be sold for cash only, the discouragement of all imports, and the support of all monopolies—these things, chief elements of what is called the "isolation theory of trade," guided the politics of the 17th century, gave Holland vast temporary wealth, discouraged her power of production, and eventually have left her impotent among the nations.

The governor and States General.

At first William the Silent had been governor of the Provinces, nominally at least under the king of Spain; and in the reconstruction he secured his own rights, while the sovereign power was transferred to the States General. They took the right of making peace and war, of concluding alliances, of taxing and coining. The governor had all military commands, had power to pardon, and controlled the civil appointments; he represented the dignity of the state, with a court, and guards, and envoys from other lands. Each province had its own stadtholder, an office in name at least derived from the Spanish times; each town had its own pensionary or chief minister. But after the death of William II., the office of stadtholder of Holland was for a time suspended; there was no captain-general or admiral; and the grand pensionary of Holland, first minister of the state, became virtual president of the republic, as we see in the cases of John De Witt and Heinsius.

When the English envoys returned to tell their masters, the Commonwealth, of their failure at the Hague, parliament at once replied by passing the memorable Navigation Act of 1651, which aimed at destroying the carrying-trade of the Provinces. The struggle for the lordship of the seas which ensued, and with which the names of Tromp and Ruyter, Blake, and Monk are so splendidly associated, was waged with equal bravery and nearly equal success on both sides, until 1654, when peace was made by the Amsterdam burgher-party. By the terms of the treaty with Cromwell the Orange-Nassau family was altogether to be excluded from the stadtholderate of Holland, the other Provinces reserving their independence, and the Dutch populace also much disliking the peace. England preserved the honour of her flag, while Holland was seen to be a worthy and equal rival for the command of the sea.

War with Engla[nd].

War with Portu[gal].

Hostilities between the Dutch and Portuguese respecting their rights in Brazil followed, in which, after each side had done much damage to the other, peace was also made; and Holland in 1658 interfered to save the Danes from Charles Gustavus of Sweden. In 1659 a treaty of peace was made between France, England, and the United Provinces, with a view to the settlement of the Dano-Swedish question, which ended in securing a northern peace in 1660, and in keeping the Baltic waters open for Dutch trade. Since the abolition of the stadtholderate after William's death in 1650, the centre of authority had lain in the hands of John de Witt, the sagacious leader of the anti-Orange or Amsterdam burgher-party; and he guided the foreign affairs of the provinces in such a way as to secure the fair development of their commerce on every side.

John Witt.

War with Engla[nd].

The momentous year 1660 was almost as critical for Holland as for any state of Europe. Charles, in England, having re-enacted the Navigation Act, war again broke out in 1665, and the duke of York took the command of the English fleet. At the beginning of June he met the Dutch admiral Opdam, and, after a close-fought battle off Lowestoft, the English were completely victorious. But so bad was the condition of the home Government in England that in the following year the Dutch had by far the stronger fleet at sea, and for a time held their own in the Channel. The four-days' battle (June 1–4) between Prince Rupert and Monk on the one side and Ruyter on the other ended in an uncertain victory for the Dutch; but on July 25th they were decidedly defeated off the North Foreland, and driven back to their own shores with immense loss. The English were now masters of the sea; but both parties needed peace, and negotiations began at Breda. In the course of these Ruyter suddenly sailed up the Thames nearly to Gravesend, and struck terror into the very heart of London, which thus became all the more eager for a settlement. In July 1667 a treaty between England and Holland was signed at Breda; and in the following year Sir William Temple accomplished the triple alliance of England, Holland, and Sweden, against the aggressive views of Louis XIV., a hollow affair, and pernicious in its results to those who made it. It made Louis XIV. determine to take vengeance on the United Provinces and on the De Witts; it led at once to the humiliation of England by the treaty of Dover (1670), to the overthrow of the Amsterdam party, and to the miserable end of the De Witts; and it eventually raised the prince of Orange to supreme authority in the United Provinces.

Triple allianc[e].

ar ıewed th gland.

From 1668 to 1672 Louis XIV. made ready to destroy the Dutch; and so well had his diplomacy served him that they were left without a friend in Europe. In 1672 the storm broke: the English, without a declaration of war, tried unsuccessfully to intercept the Dutch Mediterranean fleet; and France at once set forth to conquer the hated tradesmen of the north. The States were ill-prepared on land, though their fleet was strong and ready; party spirit was exceedingly bitter, and the ruling party, well aware that the prince of Orange was very popular with the land forces, had utterly neglected their army. On May 28, 1672, Ruyter fought a great naval battle in Southwold Bay (Solebay) against the duke of York and Marshal D'Estrées: the French held aloof, pleased to see the Dutch and English destroy each other; the English suffered most, but, as the Dutch withdrew to their own ports, the others claimed the victory. Meanwhile Louis XIV. crossed the Rhine and threatened Amsterdam (see FRANCE). The young prince of Orange alone seemed to rise to the occasion; while others were panic-stricken, sending embassies of submission to the haughty monarch, making preparations for a great flight by sea, William with his miserable army did his best, and aroused so strongly the feelings of the people that Amsterdam, passing from dejection to despair and thence to reckless enthusiasm, rose against the De Witts and foully murdered both in the streets. They had just before proclaimed William stadtholder of Holland with powers unlimited. And thus Louis XIV. destroyed the proud republic, though in so doing he had raised up the most formidable enemy he was destined to encounter. His invasion did not prosper; other nations began to take up the Dutch cause; Germans and Spaniards threatened the embarrassed French army in the Provinces; so that in 1674 France was on the defensive on every side. William of Orange in that year was defeated at Senef, and had to abandon his plan of penetrating into France, and in 1675 the death of Marshal Turenne, and the retirement of the great Condé, turned the tide of war in favour of the Dutch, except on the sea, where the French fleet defeated and destroyed in the Mediterranean (in 1676) the united navies of Holland and Spain. In 1677 negotiations for peace went on, and were hastened by the marriage, at the close of the year, of William of Orange with the Princess Mary, daughter of the duke of York. At last, in 1678, came the great peace of Nimeguen, which secured the independence of the Dutch.

›e of illiam I.

The aggressive policy of Louis XIV., in the years which followed the peace of Nimeguen, enabled William to lay the basis of the famous confederacy which changed the whole front of European politics. Brandenburg, Denmark, and England sided with the French king; while the league of Augsburg (1686), following directly after the revocation of the edict of Nantes, placed William at the head of the resistance to French domination. The league was joined by the emperor, Spain, the United Provinces, Sweden, Bavaria, and other German princes. The accession of James II. to the throne of England made it easy for the stadtholder to keep up close relations with the malcontents in church and state, who regarded him and the Princess Mary as the natural successors to the English throne. On the birth of the prince of Wales the anti-Catholic feeling in England at last grew so strong that William was able to interfere with success; while the diversion of the attention of Louis XIV. from Holland to the Rhine relieved the timid rulers of Amsterdam from all anxiety. The Revolution of 1688 ensued, and England became, under William's strong rule, the chief member of the great coalition against France. In the grand alliance of 1689-90 he clearly sacrificed Dutch to English interests, and carried through his policy in spite of great irritation in Holland and Zealand. His power seemed almost autocratic, and the States impotent. Henceforward their part in history becomes quite secondary compared with that of England, and we may refer for details of the great wars to the articles ENGLAND and FRANCE.

ꞌague Augs-urg.

nglish evolu-on of 688.

Holland at war with France.

In 1690 Waldeck, commanding the Dutch, was defeated by Luxembourg at Fleurus; and the Anglo-Dutch fleet was also severely handled off Beachy Head by the French, who inflicted terrible losses on Dutch commerce. In 1691 the French took Mons; in 1692 the allied ships ruined Tourville's fleet off La Hogue, and recovered the command of the sea. On land the allies fared ill: Louis took Namur, and after a hard-fought battle William was defeated at Steenkirk; in 1693 the Dutch shared in the defeat of Neerwinden, and were not fortunate even on the sea. In 1695 the tide of affairs had turned, and William retook Namur, his greatest triumph after the battle of the Boyne. Negotiations for peace, first attempted in 1694, led to the peace of Ryswick in 1697, in which William was recognized by France as king of England, the Dutch obtaining a favourable commercial treaty, and the right to garrison the Netherland barrier-towns. Holland was still an important factor in the balancing system rendered necessary by the ambition of France. Louis XIV., however, held himself little bound by the peace. In 1701 he elbowed the Dutch troops out of the barrier-towns; he defied England by recognizing James III. on the death of his father; and it was clear to all that another war was imminent, when William III. died in 1702. He had been made hereditary stadtholder in five of the Provinces in 1672; but as he left no children as heirs, the old opposition of Holland to his house again sprang up, and, led by the grand pensionary Heinsius, Amsterdam successfully asserted her independence, and ruled throughout the coming struggle against France with energy and credit.

Peace of Ryswick

The triumvirat against France.

When war was declared in 1702, Marlborough was named commander-in-chief of English and Dutch troops, and thenceforward became the chief man in the famous "triumvirate" of Marlborough, Heinsius, and Prince Eugene. In 1703 the Dutch invaded Flanders, and fought the drawn battle of Eekeren; in 1704 they and the English took Gibraltar; in the same year they took part in the great battle of Blenheim. In 1705 Marlborough led them into the Netherlands; but, hampered by the deputies of the States, he achieved little. In 1706 he won the battle of Ramillies, and swept the French out of the Netherlands; in 1708 came Oudenarde, and after it an unsuccessful attempt of Louis XIV. to detach the Dutch from the alliance; in 1709 the terrible battle of Malplaquet and the capture of Mons. After this great changes followed in England, and Marlborough's power came to an end. Negotiations for peace, often tried before, drew towards success in 1712, and in 1713 the peace of Utrecht was signed. While France received Aire, St Venant, Bethune, and Douay, the Spanish Netherlands were formally handed over to the United Provinces, which in their turn passed them on, after conclusion of a barrier treaty, to Austria; henceforth they are known as the Austrian Netherlands. A favourable commercial treaty was also made between the Dutch and France. The peace of Utrecht made the republic almost as powerful on shore as she had been by sea; at the same time it taught her that the great powers around her would use her resources for war, and abandon her when they wanted peace: she therefore determined henceforth to stand clear of all foreign complications. With 1713 the importance of Holland in European politics comes almost to an end.

Peace of Utrecht.

The ruling party in the States took an active part in securing George I. on the throne of England; and on the death of Louis XIV. in 1715, the old ill-will between France and the provinces died entirely out, so that they were secure in a position of tranquillity; they also brought to a fair conclusion their difficulties with Austria on the subject of the Netherlands barrier. These, however, began again when in 1723 the emperor set on foot the Ostend East India Company, which was at once regarded as an offensive rival by the Amsterdam merchants. For the sake of crushing this competition the States in 1731 consented to guarantee the Pragmatic Sanction of Charles VI. In 1743 they joined England in supporting the claims of Maria Theresa, queen of Hungary, and fell consequently into complications with France, which invaded the barrier country. In 1744 they granted a subsidy in money and put 20,000 men in the field, and became a member of the Quadruple Alliance with Austria, England, and Saxony. In 1745 the Provinces took their part in the rout of Fontenoy, after which Marshal Saxe overran the Austrian Netherlands, while England and Holland were alike paralysed by the Jacobite rising in Scotland. The States lost every barrier-town, and lay defenceless before the French, who in 1747 entered Dutch Flanders, and made an easy conquest. And now the Orange party, supported by English aid, began to lift its head. The Provinces had fallen so low that all men began to wish for a dictator. Accordingly Prince William Charles Henry Friso was proclaimed stadtholder, captain, and admiral-general of Zealand at Terveer, under the title of William IV. The movement thus begun spread like wildfire; all Zealand accepted him with enthusiasm, and Holland was not far behind; even at Amsterdam and the Hague the popular feeling was too strong to be resisted, and the Government had to give way. William IV. became captain and admiral-general of the whole union, and stadtholder of the Seven Provinces; a little later these offices were declared hereditary in both male and female lines.

War with France.

William IV.

Peace of Aix-la-Chapelle.

The peace of Aix-la-Chapelle, in 1748, though it nominally restored things to their old estate, could not efface the mischief and humiliation which the war had caused to Holland. Nor were affairs mended by the death of the stadtholder William IV. in 1751, who, though dull and quiet, did his best to develop the commercial and manufacturing prosperity of the States. His widow, Anne of England, daughter of George II., carried on the government for her son William V. She showed but little aptitude for the post of regent, and the Provinces had great difficulty in standing clear of the European complications of the Seven Years' War. They did so, however, and after her death in 1759 were on better terms with England, which had urged them to take up the cause of Frederick the Great. In 1766 William V. was declared to be of age; irresolute and weak, he was entirely under the command of his old preceptor Louis of Brunswick, and his wife Frederica Wilhelmina, niece of Frederick the Great. His rule is only distinguished for the springing up of several learned societies, and for the stimulus, derived partly from England partly from France, given to scientific inquiries. In other respects the influences of England and France were not propitious to the Provinces. In the American War of Independence William sympathized with the English court against the French and the revolted colonies, while the Dutch people warmly embraced the other side. Hence arose again old maritime disputes. The Provinces quarrelled at home over the relative importance of army and navy, and strengthened neither. So things went on from 1776 to 1780, when the famous "Armed Neutrality," with which the Continental states replied to the demands of England on the seas, drew the Provinces once more into the arena of European politics. After a division of the States, in which four were on one side and three on the other, the United Provinces decided to adopt the Neutrality, and threw in their lot with France and Russia against England. But though war broke out at once, nothing could cure the violence of party spirit—the stadtholder and the court party going with the English, and neutralizing all the warlike efforts of the "patriot" party. In 1781 Dutch commerce was utterly paralysed; the other powers set on the Provinces, and took each its part. Their West India Islands were seized, and it seemed as if they could do nothing in their own defence. At last, however, an indecisive but not inglorious action with Admiral Parker at the Dogger Bank roused the national spirit, and the Orange party lost ground everywhere. In 1782 the Provinces recognized the independence of the United States of America; with generous sympathy the aged commonwealth saluted the rising republic of the West, which was destined to take its share also in the ruin of Dutch trade. In 1783 the States made an inglorious peace with England, in which the English got right of free traffic with the Dutch East India colonies.

William V.

War with England.

The patriot party was so much excited by this long series of blunders and humiliations that the fall of the house of Orange seemed imminent, and the king of Prussia had to interfere on behalf of his kinsfolk. In 1784 the States were in trouble with a new antagonist; the emperor Joseph II. sought to compel them to acquiesce in the reopening of the mouths of the Scheldt, so as to restore some of its ancient prosperity to Antwerp. But as neither party was able to fight, a peace was patched up in 1785, though its terms, as usual, were very humiliating to the States. The resistance against the princess of Orange continued to increase in violence, until in 1787 the Prussians again interfered, occupying Amsterdam, reinstating the stadtholder, who had been driven out, and compelling the states to ally themselves, much against their will, with England and Prussia.

Trouble with Prussia and Austria.

Under their sway the Dutch passively remained, and when the French Revolution came they stood neutral as long as they could between it and the kings; it was not till Dumouriez had overrun all the Austrian Netherlands in 1792, and had determined to secure justice to Antwerp by forcing open the passage of the Scheldt, that they were drawn into the strife. On the death of Louis XVI. in 1793 the national convention at once declared war against both England and the Provinces. Their first campaign against the Dutch under Dumouriez failed: the invaders were arrested before Willemstadt, and ultimately were compelled to retreat. But in the autumn of 1793 Jourdan restored the credit of the French arms in the Austrian Netherlands. In 1794 Pichegru brilliantly completed the conquest of Belgium, and before the end of the year invaded the Provinces. The very severe frost of that winter gave his army easy passage over all the rivers and low-lying lands, which still formed the chief defence of the states; he occupied Amsterdam, and with his hussars crossed the ice and took the Dutch fleet as it lay at the Texel; the stadtholder fled (1795) to England; and the shattered remains of the duke of York's army having reached Bremen returned home in disgrace. The republican party in the Provinces now reorganized the government so as to bring it into close harmony with that of Paris. A new constitution was framed; the ancient system of representative government, the stadtholderate, and the offices of captain and admiral-general were all swept away; a fair and open representation was established; and the Batavian republic came into being in close alliance with France. The French with one hand delivered the Provinces from a worn-out system of government, and with the other seized on a substantial return for their assistance. The new constitution, so excellent

War with France.

The Batavian Republic.

in appearance, soon proved a delusion. One change of government succeeded another: after the States General came a national convention; then in 1798 a constituent assembly with an executive directory; then chambers of representatives; then a return to the earlier system under the names of the eight provincial and one central commissions (1801).

The peace of Amiens gave the country a little rest, and the Dutch got back the Cape of Good Hope and their South American colonies: it was, however, but the brief and deceptive lull between two storms; when war began again England once more swept away all she had restored. In 1805 Bonaparte, with his usual high hand, imposed on them a new constitution, and set Schimmelpenninck over them with the ancient title of grand pensionary. In the next year Napoleon added Holland to the ring of great fiefs with which he surrounded his imperial system, and forced an unwilling brother, Louis, to be king of an unwilling people. Worthy of a better fate, the excellent king of Holland did all in his power to protect his new subjects from the crushing friendship of his brother; but his efforts were in vain, and he withdrew to Vienna. In 1810 Napoleon annexed all Holland to the empire, declaring that it was "in the nature of things nothing but a portion of France." In 1813 the change in the affairs of Europe encouraged the Dutch to join the general revolt, when they established a limited monarchy. The prince of Orange was recalled from England, and entered Amsterdam amidst the utmost enthusiasm. An assembly of notables met and declared him king with the title of William I., king of the Netherlands, in 1814. By the treaty of Paris Belgium was united to Holland, and the seventeen provinces were again forcibly joined together under one prince. It was settled that the house of Orange should have the hereditary sovereignty, with a fairly liberal constitution. To make up to the new king for the loss of his territories in Germany, the grand duchy of Luxembourg, with the exception of the town and fortress of Luxembourg, was handed over to him as his private possession, not as a part of the kingdom; the bishopric of Liége and the duchy of Bouillon also went with it. The episode of the "Hundred Days," though it delayed the conclusion of the very complicated arrangements involved in these transfers, gave the new kingdom an opportunity of distinguishing itself: it was the first point of attack, and met the crisis with vigour. The Dutch troops under William, eldest son of the new king, took considerable part in the short and striking campaign which was closed on June 18, 1815, by the final victory of Waterloo.

The allied powers now founded in Holland and Belgium what they hoped would be a solid and permanent kingdom as a barrier against France. It was felt that Napoleon had shown Europe the importance of this district in connexion with his scheme for European domination. The new kingdom under the house of Orange was therefore the subject of great and anxious consideration at Vienna. The king, an hereditary sovereign, received full executive powers, and the initiative in proposing laws. He had also the power of appointing his own council of state. As a legislative body there were the States-General, divided into two chambers; each province had also its own local states. Freedom of worship and political equality were secured for all.

A highly artificial arrangement like this, however, could not stand long, if Europe came to throw off the trammels of the monarchical reaction, and to give freer course to those liberal tendencies which had survived the drama of the French Revolution. In religious belief, in laws and usages, in language, in interests, the Belgic and Batavian provinces had little in common. Their inhabitants were different races, with instincts and feelings not merely diverse but opposed. The Belgic provinces spoke French or Walloon, the Batavians, Dutch. The Belgians were strict Catholics, while the Dutch were Protestants. The Dutch were chiefly a commercial and seafaring people, with interests in distant lands and colonial possessions; the Belgians were agriculturists, except where their abundance of minerals made them manufacturers. The Dutch connected themselves with Germany and (though often only by way of rivalry) with England; the Belgians drew their chief inspirations from France, and connected themselves with the French in traditions, religion, and commercial interests. Such a diversity could not possibly stand the brunt of any great political movement; especially as the Dutch were oppressive towards their Belgian partners in the kingdom. Accordingly we find that in 1830 the revolution at Paris at once aroused the strongest sympathy at Brussels. The dull obstinacy of William I. had emphasized the divergence, and his narrow and antiquated policy rendered an outburst inevitable.

The revolt at Brussels, which began on the 25th August 1830, spread instantly throughout the whole of Belgium. After a short struggle in November, a conference of France, England, Prussia, Austria, and Russia, sitting in London at the request of William I., proposed an armistice, to which both parties agreed. In the following January the conference attempted to settle the terms of a separation, and proposed that Holland should have Luxembourg and part of the left bank of the Scheldt; this the Dutch accepted, while the provisional Government at Brussels protested against it. The assembly at Brussels constructed a new and liberal constitution, with a broad representative government, liberty of teaching, of the press, of public meeting; and in April 1831 the crown was offered to Leopold of Saxe-Coburg, who, after ascertaining that he would be recognized by England and France, did not hesitate to accept it (see BELGIUM). This appointment caused the utmost irritation at the Hague, and the Dutch suddenly invaded Belgium; the opportune appearance of a French army checked the Dutch advance, and gave diplomacy time to interfere. The citadel of Antwerp, however, was still in Dutch hands, and the allied powers used in vain all their influence to persuade William I. to give it up to the Belgians. War was hereon declared, and France and England blockaded the Dutch ports, while a French army attacked the citadel, and, after a sharp struggle, compelled it to capitulate. The forts of Lillo and Liefkenshoek were left in the hands of the Dutch; on May 21, 1833, there was signed at London by the plenipotentiaries of Holland on one side, and those of England and France on the other, a convention in which William I. engaged not to recommence hostilities against Belgium, and to leave the Scheldt navigation open, till the relation between the two countries should be definitely settled by treaty. The final settlement of outstanding questions, however, was not reached till six years later, when Limburg and the eastern part of Luxembourg were secured to Holland, and heavy tolls were imposed on the navigation of the Scheldt; then the two kingdoms finally parted company on the 19th of April 1839.

In the following year William I. resigned his crown to his son William II., who reigned in peace till his death in 1849, when he was succeeded by his eldest son William III., who still reigns. The wave of revolution which passed over Europe in 1848 had in Holland comparatively little effect: the constitution of 1814 was revised, and the tranquillity of the country secured. In 1853, after the establishment by the papacy of Catholic bishoprics in England and Holland, a considerable excitement arose, which resulted in the accession to power of a moderate, liberal, and entirely Protestant cabinet, and in the main the Protestant-liberal party has guided the country for the last quarter of a century. The Dutch took but a secondary part in the disputes between France and Germany as to Dutch Luxembourg, which by the treaty of London (1867) was declared neutral, and guaranteed to Holland. Recently they have been engaged in a very vexatious and wasteful war with the sultan of Acheen, their neighbour on the island of Sumatra.

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PART III.—LANGUAGE.

Of the Low German tribes the Old Saxons, the Anglo-Saxons, the Franks, and the Frisians played a specially important part both in north-western Europe in general and in the Low Countries in particular; and accordingly it is with these tribes that we have in the first place to do when investigating the origin and development of the Dutch language. A great many dialects formerly existed side by side on Dutch ground, and many of them still live on the lips of the people; but they all belonged to one or other of three well-defined groups—Frisian, Saxon, and Frankish.

In the earliest times about which records have come down to us, the Frisian dialect, in various shades of difference indeed, occupied a very extensive area. It was the language universally spoken in the provinces of Groningen, Friesland, and North Holland. But in Groningen the Frisian has been superseded by the Saxon, and in North Holland by the Low Frankish dialect; and the three leading dialects of the Dutch are now distributed in Holland nearly as follows:—(1) Saxon in Groningen, Drenthe, Overyssel, and the county of Zutphen; (2) Frisian (more or less corrupt in the towns) in Friesland; and (3) Low Frankish in Guelderland (excepting the county of Zutphen), Utrecht, North and South Holland, Zealand, North Brabant, and Limburg.

In Groningen and North Holland the Frisian dialect has left more or less marked traces of its former predominance in the pronunciation, vocabulary, and phraseology of the present spoken language. During a considerable period laws, ordinances, contracts, and similar documents were drawn up in the various provinces in the peculiar dialect of each, and many of these documents, especially in Frisian, have come down to our time. The inhabitants of the northern provinces, however, had neither superiority of culture nor political preponderance enough to secure the assimilation of the adjoining populations. The occupants of the tract in which Low Frankish was spoken were much more favourably situated; and that dialect has in the end ousted the two others, and become the speech, both oral and written, of cultured Dutchmen.

From the documents collected by Müllenhoff and Scherer, and from many others, it is evident that between the 8th and the 12th century the different German dialects served as vehicles of literary composition, and this, it appears, must also have been the case in the Netherlands. It may therefore be safely taken for granted that, among the *libri Teuthonice scripti* referred to in the act given in the year 1202 by the papal legate Guido for the organization of the bishopric of Liége, there were some written in the vernacular, *i.e.*, in Low Frankish, which after the subjugation of the Frisians and Saxons by the Franks was the idiom of the victors. Whatever pains Charlemagne took to raise the dignity of the German language, the practice, prevailing at the time and long afterwards, of using Latin in official documents emanating from the authorities, prevented the predominant form of speech from encroaching to any considerable extent on the other dialects. Still it is in this period that we must seek the first indications of the future victory of the Frankish dialect over the two others. And in course of time the Franks strengthened their political pre-eminence by a superiority of a different character, which, added to the first, went far to secure to the Frankish dialect the prerogative of being the universal vehicle of cultured thought, written and spoken, throughout the Netherlands. The barbarous victors could not resist the humanizing influence of the higher culture resulting from a lengthened intercourse with the Romans. And when, after a considerable lapse of time, the new idiom, thus born from Latin, began to be employed in the composition of literary productions, the influence of these writings soon made itself sensibly felt in the southern Netherlands. The inhabitants of ancient Belgium had always continued in close intercourse with their brethren in France; and the literary productions put forth in France, especially after the crusades, soon began to engage the attention of the opulent citizens of the thriving towns of Flanders and other parts of the southern Netherlands, and were diligently translated by them into their own tongue. Holland, Zealand, and Utrecht in their turn were connected with the southern Netherlands by many close ties. The language spoken in the southern and in the northern Netherlands was the same for all practical purposes; and so it happened that the French literary works and their Flemish reproductions attracted no small share of attention also in the northern Netherlands. The "Dietsch" dialect, in which the oldest and most popular works, such as *Reynard the Fox* and the works of Jacob van Maerlant, dating from the close of the 13th century, were composed, became the model speech for every one who wanted to address a larger public than that of his immediate vicinity. It was in this Dietsch dialect that Melis Stoke, an inmate of the monastery of Egmond, composed his *Rhymed Chronicle* (*c.* 1305).

From Holland and Utrecht the Dietsch dialect readily found its way farther north. What the Franks had tried to achieve in times long past was now undertaken by the counts of Holland and the bishops of Utrecht, viz., the total subjection of the northern provinces to their rule. These efforts on the part of the princes just named again made Frankish the dialect of the dominant, Frisian and Saxon the idiom of the conquered race. In this way Dietsch, *i.e.*, Low Frankish, became the predominant dialect all over the Netherlands.

At a time when laws, mutual contracts, and other official documents issued in Friesland between the Vlie and the Lauwers are still drawn up in pure Old Frisian, the treaty by which the citizens of Stavoren recognize Count Floris for their sovereign lord in 1292 is written in Dutch. The contracts drawn up by Frisians on both sides are nearly always in Frisian, even down to the close of the 15th century, though occasionally Dutch was used. In deeds of sale, contracts, &c., drawn up between 1490 and 1500, we meet with all possible shades and varieties of the Dutch dialect, which is seen to be rapidly gaining ground. Still, this substitution of Dutch for Frisian in documents of this nature by no means proves that Frisian was falling into desuetude among the country population. A good deal of course depended on the persons who were employed to compose the documents above referred to. The historian of Friesland, Gabbema, writing about 1650, bitterly laments the decay of the Frisian tongue; and even foreign writers, such as Conrad Gesner, refer to the fact in a similar way. But in spite of his lamentations Gabbema submits to the pressure of the times and writes his history not in Frisian but in Dutch. Nay, his friend Gysbert Japix, the cultivator *par excellence* of Frisian, the national poet of Friesland, wrote the introduction to his *Friesche Rijmelerije* ("Frisian Rhymes"), and many a manly poem besides, in the same language. They were by no means averse to seeing cultured non-Frisians take cognizance of their literary labours; and to satisfy this ambition, there was no other course open than to employ the language which such eminent men as Marnix, Coornhert, Roemer, Visser, Spiegel, Hooft, Huygens, and Vondel had permanently made the approved vehicle of thought and poetical utterance throughout the Netherlands, more especially after the fall of Antwerp, in 1585, had induced the most highly cultured minds of the southern Netherlands to migrate to Holland. This had been achieved partly by direct endeavours tending to the improvement of the language and the excision of all "foreign dross," partly by the creation of beautiful works of literary art, and solid contributions to history and erudition. For the language and intellectual culture of Holland had now each attained a stage of advancement where neither imperiously demanded new capabilities in the other. What thus happened in Friesland also took place elsewhere, the same or nearly the same causes bringing about the same results throughout the country.

The language of the Dutch has travelled to their transmarine possessions, without engendering a new dialect either in the East or West Indies. But a very different result might be expected if at any time their East Indian possessions should enter upon an independent career. A kind of mongrel dialect would arise, which may be seen foreshadowed in official papers and letters composed by so-called *sinjos*, or "half-breeds," in the island of Java. We may even now point to one such dialect, the speech of the Dutch settlers in the Transvaal and the Orange Territory in South Africa, who have actually begun to raise their clipped Dutch to the dignity of a written language, in which they are now composing works of general literature, and even poems, diligently editing class-books and theological treatises, and printing such newspapers as *Den opregten Afrikaander*.

Flemish or South Dutch, *i.e.*, Belgian Dutch, though very nearly allied to North Dutch or the Dutch of Holland, essentially differs from the latter in many important points of detail. In its vocabulary, its phraseology, and the structure of its sentences, it clearly betrays the influence of the French-speaking part of the nation. In a novel by a very popular Flemish author, A. C. van der Cruyssen, printed in bold type in small octavo, and numbering less than 200 pages, the present writer noted far more than 200 cases in which a North-Dutchman would have chosen quite another turn of expression. The South Dutch dialect, which after the fall of Antwerp had remained almost stationary, but which in our days has become a cultured written language through the diligent efforts of various writers of great talent, bears the evident marks of this recent emergence from a state of utter neglect on the part of cultured men, and to a North-Dutchman has an air of simple-minded artlessness and innocent naiveté.

The complexity of origin of the Dutch language is most noticeable in the case of the vowels. In the consonants the Saxon and the Frankish did not differ greatly, and the Frisian has had a much smaller influence. To the Saxon must be ascribed the dropping of the nasal before *s*, *f*, *th*, as well as before *b* and *v*, in *vyf* (five), *sedert* (sinthe, since), *muiden* (mouth), in proper names, &c. At the same time there are several words in which the *n* is preserved,—most of these being borrowed from the Frankish, as *ander*, *kunde*, *Yselmonde* in Holland (alongside of *Yselmuiden* in Overyssel), and *gans* (for which we have *goeze* in the Overyssel dialect). The *s* in the nom. plur. of the vowel stems is only partially retained: side by side there exist in Middle Dutch plural forms like *honde*, *dorpers*, *kinder*, *kinde*, *kyne*, which have almost all in later Dutch assumed either *s* simply, *s* after the plural form *r*, or *en* (originally the plural form of *n* stems), the *s* and *n* being erroneously regarded as a sign of the plural (see *infra*). On the whole the Frankish influence has been the most potent,—that of the other two tongues being only observable here and there in the terminations, or in a comparatively limited number of words and expressions. The history of the development of the language may be divided into two great periods. In the first, the Middle Dutch, the fuller forms and long vowels of inflexional and derivational suffixes and the final elements of compound words, which are preserved in Gothic and High German, have already become short and unaccented, while at the same time, through the loss of the accent, the final elements have partly lost their significance, and occasionally a notable abbreviation has been effected both in their pronunciation and their orthography. From the Middle Dutch the modern language is distinguished by a greater neglect and confusion of inflexional forms, by the presence of a large number of foreign words introduced about the end of the 15th century, as well as of a multitude of dialect and modern terms, and by the disuse or modified significations of many of the older words.

Of the Middle Dutch we have no remains earlier than the beginning of the 13th century, though Saxon and Frankish linguistic monuments go back to the 8th or 9th. Middle Dutch extends from the 12th century to 1450; then follows a transition period, reaching to 1550, from which date Modern Dutch has prevailed to the present time. In the period last named a subdivision may be made at 1865, the date of the introduction of the new spelling.[1]

In Modern Dutch there is a considerable difference between the latest and the earliest forms. The older language still preserves many words that have now become obsolete, and the style is modelled more closely on that of the classical writers. Towards the end of the 18th century the influence of Van Effen, Stijl, Bilderdijk, and others effected great changes; and while the deflexion largely increased, the Hollandsch dialect began to make itself predominant, especially in regard to the vowels *u* and *y* or *ij* (*î*). Indeed the main difference between Middle and Modern Dutch is due to the fact that the former is under the influence of Dietsch (the Flemish-Zealand dialect), while in the latter Hollandsch has the supremacy.

In the transition period the language was adulterated by a great number of bastard words and bastard forms derived from French, which obtained currency throughout Holland, Zealand, Utrecht, and the southern provinces, from the influence of the court and government of the dukes of Burgundy.

The study of the dialects and grammar of Middle Dutch has not been prosecuted far enough to allow of very detailed statements regarding them. Our principal authorities for the interpretation of the literary remains are the works of De Vries, Verwijs, Verdam, Moltzer, and others. Most of these remains are in Dietsch, as the romances of chivalry, the works of Maerlant, the chronicles and songs; others, as the *St Servaas* of Van Veldeke, are in the language of the south-east (Limburgsch). Of the mediæval language, as it was spoken in Utrecht or in the Saxon provinces[2] (the countship of Zutphen, Overyssel, and Drenthe), the only remains are in charters and similar documents. Since the Saxon, as is indicated by the conjugation of the verb, has exercised no dominant influence, and the Hollandsch on the other hand is closely connected with the Dietsch, we will only quote as an example of the language a single strophe from Maerlant's *Wapene Martyn*, with a metrical translation (hitherto unpublished) from the pen of Nicolas Beets (1880).

God, diet al bi redene doet,	God, die het al met wijsheid doet,
Gaf dit wandel aertsce goet	Gaf dit vergauklijk aardsche goed
Der menscheit gemene,	Den menschen in't gemeen,
Dattere mede ware gevoet,	Op dat zij zouden zijn gevoed,
Ende gecleet, ende gescoet,	Het lijf gekleed, geschoeid de voet
Ende leven soude rene.	En leven rein van zeen.
Nu es gierieheit so verwoet,	Maar zie nu hoe de hebzucht woedt
Dat ele settet sinen moet	Dat iedereen in arren moed
Om al te hebbene allene.	't Al hebben wil alleen!
Hieromme stortmen menscenbloet,	Hierom vergiet men menschenbloed,
Hieromme stichtmen metter spoet	En bouwt met roekeloozen spoed
Borge ende hoge stene	Burchtsloten, zwaar van steen,
Menegen te wene.[3]	Tot smart van menigeen.

The Consonants.—As regards the consonants, Dutch in the main does not differ from the other Low German languages. The explosive *g* and the *th* are wanting. Instead of the former there is a *g* with "fricative" pronunciation, and as in High German the *th* has passed over into *d*.

Nearly all the final consonants in Middle Dutch are sharpened, and the sharp sounds are graphically represented; in Modern Dutch, on the other hand, the historical development of the language being more distinctly kept in view, and the agreement observed with the inflexional forms, the soft consonant is written more frequently than it is sounded; thus we have Middle Dutch *dach*, Modern Dutch *dag*, in analogy with the plural *dagen*.

The gutturals are *g*, *k*, *ch*, and *h*. The aspirate sound of the *g* is of very early date; even in the Old Dutch psalms *g* interchanges with *h* (*weh* side by side with *weg*, just as in Gothic *fakeds* and *faginon*, Anglo-Saxon *borh* and *borges*, Old Saxon *manah* and *manag*). The *gh*, which in Middle Dutch frequently appears before *e* and *i*, served to distinguish the fricative *g* from the French *g*; in later Middle Dutch we find this object lost sight of, and the *gh* also written before *a*, *o*, or *u*. In Maerlant *ghans* and *ghene* both occur. In the 15th century the *gh* was also employed instead of *ch*, when people began to observe the etymological agreement of *ik lach* and *si laghen*, and in this way arose the spelling *ik lagh*. This indicated no change in pronunciation. That in Middle Dutch, however, an explosive pronunciation existed (in some words, more especially after *n*), as well as the aspirated pronunciation, is evident from words like *dinc*, *ginc*; this sound did not hold its ground but passed into the nasalized guttural now written *ding*, *ging*. The explosive force, however, was preserved where the diminutive suffix *je* followed immediately after *ng*, as well as before *lijk* and some other affixes, and it is now expressed by *k* (*koninkje*, *jonkman*). In combination with *s*, *g* became *k* (*speeksel*, *fluks* from *vlug*). So also in intensive verbs like *bukken*, *knikken*, where the *k* arose from an explosive *g* before *j* of the suffix, and was doubled after the short vowels. In non-intensives, as *liggen*, *zeggen*, where the *g* was aspirated, that letter was doubled in the same way from *gj*. The Dutch *g* is besides sometimes derived from the common German *g* (*gans*, *dag*); sometimes it is the Old German *h* at the end of a word, between vowels, or after liquids (*hoog*, *zuig*). Sometimes it is a survival of the compound *gw*, and exists along with a form in *w*, as *spugen*, *spuwen*. *G* arose out of *j* in *kruisigen* and other verbs in *-igen*, just as in Anglo-Saxon. In the beginning of some words in Middle Dutch *g* passed into *j*, as *jonst* for *gonst*, while Modern Dutch again has *gunst*. The passage of *g* into *j*, and *i* after *a* or *e*, and before a vowel, is found both in Middle Dutch and Modern Dutch: *segel* becomes *zeil*, *gezegd gezeid*. In some words the explosive *g* has passed into *k*; in others, and indeed the majority, the *k*, both in the body of the word and as an initial and a final letter, is the common Low German *k*. After short vowels the *k* of the compound *kj* was doubled, and the *j* dropped off after producing "umlaut" (*dekken*, *wekken*). An original *k* remained as an initial letter before *n* or *r* in *kring*, *knijpen*, &c., alongside of which we have *ring*, *nijpen*, &c., in which the *k* passed into *h* and then disappeared. The *k* also remains undisplaced in the diminutive *ken* (*Taal- en Letterbode*, ii. 105). Before *t*, *k* became *ch* in *zucht* (*ziek*), *wacht* (*waken*).

In Middle Dutch *c* and *k* are interchanged without distinction of sound. *C* is used before vowels except *e* and *i*, and before *l*, *n*, and *r*, and at the end of a word (*cop*, *cleen*, *cranc*). After *n* sometimes *ck* is also employed (*ganc* and *ganck*). In later Middle Dutch the *ck* is more frequent; in other cases *k* is common (*kint*, *kerke*). Frequently we find *k* as well as *c*,—never, however, *c* before *e* or *i*, except in French words, where *c* had the sound of *s* (*citroen*). Sometimes *ch* (as in *cheins*, *chessen*) occurs as well as *c* (*ceins*, *cessen*), where *ch* represents the palatal sound of the *s*, which in the more modern language is rather represented by *sj* (*korsjet* and *corset*, *sjokken* and *sokken*, &c.). The doubling of the *k* was indicated by *ck* (*decken*), while *qu* was the ordinary for *kw* (*bequame*, *quedelen*, *quene*), in Modern Dutch *dekken*, *bekwaam*.

In the beginning of words *h* has lost its original aspirate sound and become a mere breathing, and consequently it has often dropped off both before other consonants and between vowels: thus *hring* becomes *ring* (as early as in the Old Frankish psalms), *slahan* becomes *slaan*, *vliehen* in Middle Dutch *vlien*. In some of these words a *d* has been afterwards inserted out of a supposed analogy with weak verbs, as *e.g.*, with *belien*, *belîde*; where Modern Dutch has *vlieden*, *geschieden*, Middle Dutch had *vlien*, *gescien*; even in Middle Dutch, indeed, *geschiede* (Modern Dutch *geschiedde*) was an alternative form with *geschach*. In the dialects *h* is frequently prefixed improperly (*harm* for *arm*, &c.). At the end of words the *h* occasionally kept its fricative sound (*hooch*, *geschach*, *tooch*), as the *ch* shows. In the verbs *tiegen* (*tiuhan*) and *tijgen* (*tîhan*), which sounded *tien* and *tijen* in Middle Dutch, the *g* has been afterwards introduced into the present stem, probably through the similarity of the sound of the *h* (*ch*) in *tooch* with the *ch* sound which *g* acquires as a final consonant, and through the *g* of the plural preterite *togen*. *Ch* did not remain in the preterite of all verbs in Middle Dutch: *vlien* has *vloe* as well as *vlooch*; alongside of this, however, there is an infinitive *vlieghen*, also with a preterite *vlooch*. From the compound *hw* the *h* soon dropped off in the Middle Dutch (*walrisch*, *wie*, *waar*), not, however, where the *w* was vocalized (compare *hui* with *wei*, *hoe* with *woe* in the Saxon; in this last case *woe* passes further into *boe*). Before *t*, *h* retains its aspirate sound, as in *vlucht* (*ch* pronounced as the German *ch* without *i*); and *g* also before *t* takes the sharp sound of *ch*, although this is not represented by the spelling in substantives in *-te*, as *gebergte*, adjectives in *-lijk*, as *genoeglijk*, and in the conjugation *hij ligt*. The *ch* in *sch* (pronounced as *s*: *vleesch*, pron. *vlees*), derived from the Middle Dutch *sc* (*sk*), is a mere orthographical convention; as an initial consonant *sch* is now pronounced *sg* (*schip*), but in the Saxon dialects and in Frisian the old sound is preserved: *skip*, *skool* (*schola*). *Sculan* has already in Middle Dutch changed the *sc* into *s*, and in Modern Dutch it appears as *z* (*zullen*). *Ch* before *t*, except where it stands for *g*, is derived from an *f* (compare *gehucht*, *kocht*, *sticht*, alongside of which we have words in which the *f* has been retained, as *stift* and *bruiloft*, Middle Dutch *brulochte*). Before *s* the guttural is assimilated or syncopated: examples are *bus* (High German *büchse*), *vos* (*fox*), *zes*, *deesem* (*deegsem*).

There is in Dutch a *d* which corresponds to the English *th* and

[1] For information regarding the results furnished by an investigation of the proper names, see Professor H. Kern in *Taal- en Letterbode*, part iii. p. 275.
[2] See Sloet, *Oorkondenboek van Gelre en Zutphen: Taalkundige Bijdragen*, i.
[3] *Van Jacob ende van Martine*, ed. E. Verwijs (Bibliotheek van Middelnederl. Letterkunde, 27).

the High German *d*; it is formed by the tongue and the upper row of teeth; the *d*, on the other hand, which is like the English *d* and the High German *t* is formed by the tongue and the roof of the mouth (or the gums above the teeth).[1] In the Old Frankish psalms *ðferde* and *ðferthi* still exist side by side, but even then the distinction was probably not a great one; in Middle Dutch *th* has become *d*, or the *th* is retained as a mere orthographical convention. While in the psalms a distinction is still preserved between *th* and *d* as a final letter, inasmuch as *d* passes into *t*, but *th*, or *d* derived from *th*, remains, *d* at the end of words always changes in Middle Dutch into *t* or into *dt*. Where, however, the *d* had remained before vowels in the conjugations of the verbs or the inflexions of the nouns, the *d* was in several words afterwards restored, although the sharp sound was preserved. In other instances the sharp sound of the nominative affected the oblique cases, and all forms acquired the sharp sound which then remained in Modern Dutch (*gezant*, *gezanten*; *rit*, *ritten*; *verwant*, *verwanten*); and the same change took place especially in indeclinable words, as *want*, *met*.

In Middle Dutch a *tenuis* or spirant before *d* changes it into *t*; but whether it be owing to difference of dialect or to inaccuracies of orthography, many instances may be pointed out where this does not occur; thus we find *nochtan*, *ontaen* (for *onttaen*), but along with these also *nochdanne*, *ontdaen*. In Modern Dutch this is not the case, but a number of forms are due to the same principle, especially in compounds of prepositions with the article (*metten*, *metter*), while in the conjugation of weak verbs also the suffix *de* turns into *te* after sharp consonants (*legde*, *lachte*, Middle Dutch *loech*). On account of the sharpening of the *d* as a final letter, no *d* is ever found before the suffix *-nis*, and *t* even occurs before an afterwards inserted *e*, as in *beeltenis* (the same is the case with *f*, *b*, *v*, as *vergiffenis* for *vergifnis*).

After *o*, *oe*, or *ui* the *d* passes into *j*, though in Middle Dutch instances seldom occur (Middle Dutch *ruden*, Modern Dutch *ruien*; Middle Dutch *roden*, Modern Dutch *uitroeien*); sometimes it drops out (*kwede*, *kwee*). The spoken language goes much farther than the written in this use of *j* for *d*; thus *dooje*, *goeje* are written *doode*, *goede*. In like manner the spoken language has changed *d* into *w* after *au* or *ou* derived from *al* or *ol*; thus we find the pronunciation *ouwe*, *gouwen*, *kouw*, with the spelling *oude*, *gouden*, *koude*. In the adjectives *ouwelijk* and *kouwelijk* the *w* has become established. Except after vowels in verbs where *h* has dropped out, whenever there is no preceding consonant, and an *r* follows either immediately or after an *e*, *d* is inserted after *l*, *n*, *r* (*kelder*, *zwaarder*, *helder*, *diender*, *donder*), an insertion which is less common in Middle Dutch (*helre*, *solre*, *donre*; also, however, *dondre*). At the end also of words we often have a paragogic *d* after *n* where the Middle Dutch kept the *n* as the final letter (thus *iemand*, *arend*; Middle Dutch *ieman*, *aren*); after sharp consonants *t* is added, as *gedrocht*, *burcht*, *borst* (High German *bursche*), and also in *mijnent*, &c.

D is frequently syncopated as a penultimate consonant before *s*: *thans* for *thands*, *volgens* for *volgends*. *Asem*, *wasem*, perhaps, have not dropped the *d* (*th*) before *s*, but have changed *th* into *s*. While the final *t* has partly grown out of *d*, it is partly also the common Low German and English *t* (*tal*, *laten*, *haat*). Between *s* and *r* in words derived from the Romance tongues a *t* is inserted owing to the common German dislike to *sr* (*stroop* from *sirop*); after *n*, and also before the suffix *-lijk*, the introduction of *t*, which was frequent in the 16th century, is less and less heard, and on this point the written speech is far before the spoken (*wezenlijk*, *eigenlijk* are frequently pronounced *wezentlijk*, *eigentlijk*; *ordentelijk* alongside of *ordelijk* at an early date has acquired the *t*, and afterwards an inserted *e*, at the same time modifying its signification). In the dialects (Limburg, Brabant, Utrecht) the final *t* after consonants and vowels is frequently dropped: *hij heef* (*heeft*), *nie* (*niet*). The compound *ts* serves in words borrowed from the French to represent the Dutch pronunciation of the French sound *ç* (*fatsoen*, Fr. *façon*). While the present language, both in orthography and pronunciation, makes a distinction between *s* (as in the English *sound*) and *z* (as in the English *hazel*), the Middle Dutch had only *s* (though in the later MSS. *z* begins to appear), and Frisian is still in the same position. Before a vowel or *w*, *s* has for the most part passed into *z*, except in those words in which it is followed either by a long or short vowel succeeded by *s*, or by a short vowel before *s* or *k*; or *z* was sharpened into *s* by a *t* from the preposition *te*: *zoel*, *zwak*, *zitten*; *sissen*, *suizen*, *sokken*, *samen* (from *tsamen* for *te zamen*). In foreign words the *s* usually remains (*saluut*, *soldij*). Contrary to the pronunciation, *z* is written in *zestig* and *zeventig* (pronounced *sestig*, *seventig*, and in dialects *tsestig*, *tseventig*).[2] The *z* in the middle of a word, after a syllable which originally had no accent, has passed into *r*: *generen*, *bevrooren*; at the same time we have the forms *genezen* (to heal), *bevrozen*, and in the Middle Dutch *vroos* along with *vroor*, and *kozen* with *koren*. In many cases the meaning has been modified.

Prothesis of *s* occurs in *smoel* for *moel*. Such forms as *slink* and *link*, *snebbe* and *nebbe*, *zwenken* and *wanken*, go back to older forms, and are thus probably doublets of much older date than the breaking off of the German languages from each other.

As in English so in Dutch *b* is the undisplaced German medial. At the beginning and in the body of a word it has the same sound; at the end it is pronounced as *p* (see p. 86). In Middle Dutch for the most part *b* was followed by a vowel (Middle Dutch *webbe*, Modern Dutch *web*); this vowel fell away in Modern Dutch, but the *b* remained in the written language. Wherever the *b* represents *bj* it is doubled, just as after a short vowel (*krab*, *krabben*). So, too, frequentatives have *bb* (*krabbelen*, *kibbelen*, with which compare Modern Dutch *kijven*, Middle Lower German *kibben*; *stribbelen* side by side with *streven*; compare also *hebben* and *heeft*, Old Frankish *libban*, Dutch *leven*). After *ă* or *ŏ* + *m*, *b* fell away both as a middle letter and as a final consonant; but this is not as yet general in Middle Dutch; alongside of *crom*, *omme*, we find *cromp*, *ombe*, while in Modern Dutch we always have *lam*, *krom*, *dom*, *om*. In substantives ending in *m* with a preceding long vowel, wherever the diminutive particle *je* is appended, a *p* is inserted (*kruim*, *kruimpje*; *bloem*, *bloempje*); but this does not take place after an imperfect vowel where an *e* is inserted (*kam*, *kammetje*). As in English the *p* has not been displaced, and it has the same sound (*paard*, *post*, *pink*, *lap*).

For the English *f* as an initial letter (*cf.* Sweet, *Hist. of English Sounds*, p. 78), Modern Dutch as well as Middle Dutch has *f* and *v*. In the body of a word the *f* passes into *v* (= *v* in English *lover*), or is doubled after short vowels (*leef*, *leven*; *plof*, *ploffen*). At the end and also before consonants after vowels, *v* becomes *f* (*hoofd*, Middle Dutch *hoved*; *af*, Middle Dutch *ave* and *af*). Verbs in *-elen* have *f* before *e* (*schuifelen* from *schuiven*).

F (*v*) is the common German *f*, and accordingly interchanges with *th*, as in *ofte* (Got. *aiththau*) = English *or*; but *of* (Got. *iba*) = English *if*; *veel* (*filu*). Before vowels and *l*, *f* is sometimes preserved in pure German words, while in others of the same sort *v* appears (*frisch*, *versch*; *flink*, *vlak*; *fel*, *vechten*); so also in the Old Dutch psalms we find *vater* along with *fader*, while in Middle Dutch likewise a similar variation prevails. Usually the precedence of a sharp consonant in Middle Dutch causes the *v* to become *f* (*mesfal*, *ontfaen*; *cf.* *val* and *vaen*; but also *mesval*, &c.).

The combination *ft* has in Dutch passed into *cht*, but it appears in the dialects, and was more frequent in Middle Dutch (*verkocht*, *hecht*, *sticht*, *achter*; *verkoft*, *heft*, *stift*, *after*). On the other hand in the psalms and the *Glossæ Lipsianæ*, and also in dialectic charters, we find occasionally *ft* for *ht*: *druften* (*druhtin*), *sufte* (stem *sûk*), *eendraftig* (for *eendrachtig*).

The liquids are unchanged, except *m* and *n* in inflexional terminations. In certain other cases *l* interchanges with *n*: for example, *slak*, High German *schnecke*; *Schevelingen* (17th century), *Scheveningen*, &c. By the *l* sound a preceding *a* or *e* is turned into *o*, as *overtollig* (*tal*); in some instances *ol* changes into *ou*, *e.g.*, *goud*, *oud*, *zout*; if the *o* before *e* passes into *u* (see under *o*), then the solution does not take place (*gulden*; Middle Dutch *hulten*, Modern Dutch *houten*; *menigvuldig*). In Middle Dutch we have *ul*, *ol*, and *ou* side by side. *M* remains with stem vowels, in the suffix *-ma* (even where it becomes *n* in High German), as *bloem*, *bezem* (High German *besen*), and in *hem*, dat. sing. 3d pers. pron. In other cases it passes into *n* in inflexional terminations; *den* (High German *dem*), *geven* (1st pers. plu. pres.); *mb* becomes *mm*, and consequently *m*. In *maar*, *m* represents *nw* (*nware* for *ne ware*). In *drempel*, *m* is inserted.

The *r* is of very various character. In the first place we have the dental *r*, agreeing with the Italian *r* in *ragazzo*—for example, *raad*, *rust*, *hart*; and secondly we have the guttural *r*, only heard in words which had *hr* in Old German (*ring*, *ros*, *reuzel*). As the former is a difficult sound for many Dutchmen, especially for those of the Saxon district, the guttural *r* is used instead of it. In the Saxon districts we find, besides, a very strong consonant called by Sievers the "cerebral" *r* (*e.g.*, *hard*, *worst*, *marsch*). Although it is not distinctly audible, a practised observer can hear it, just as in the English *letter*, *hard*.[3] The *r* derived from *z* belongs to the first class. Through the influence of the *r*, short vowels are lengthened in Middle Dutch (*aerch*, *aerbeid*, for *arg*, *arbeid*). Transposition of the *r*, both before and after the vowel, is frequent in Middle Dutch and in Modern Dutch: *godsvrucht*, *nooddruft*, *dertig*, *barnen*, *kersten* (*krist*). Before *r*, *n* was elided in Middle Dutch (*mire* for *minre*, &c.); before *m* it was assimilated (*onmate*, *ommate*), and before *b* it passed into *m* (*omberaden*); but in Modern Dutch this change does not take place.

In some words beginning with a vowel, *n* has been prefixed through the influence of the declined article, the possessive pronoun, or the preposition *in*: thus *naarstig*, Middle Dutch *naernst*, grew out of *in ernst*; *navonds* from *avond*; *noom* (17th century) out of *min oom* (Modern Dutch, however, has *oom*). As regards the preterites *dacht* and *bracht* along with *denken* and *brengen*, which appear in Middle Dutch, no certainty has been attained. The *n* in this case

[1] Compare on this point Kern in the *Taalkundige Bijdragen*, i. 175.

[2] This dialect *t* has probably come from the Old Saxon *ant-* (*hund*), which stood before *zeventig*, *tachtig*, *negentig* (dialect *tnegentig*). From these words the sharpening of the initial consonant has spread to the other numerals: *veertig* and *vijftig* are pronounced *feertig* and *fijftig*.

[3] Kern, *Taalk. Bijdr.*, i. 21

may have dropped out, as in the other German languages, while before *ch* the *â* was shortened to *a*, which like *a* in other cases before *ch* passed into *o* (hence, in the spoken language, *brocht*, *docht* exist side by side with *bracht*, *dacht*), or the suffix may be appended to the non-nasalized stem. That each Germanic language may in these cases have gone its own way is evident from the Anglo-Saxon, where such a form as *gipohta* indicates an older form *gipanhta*.

Vowels.—As early as the Middle Dutch period, the final vowels of the inflexions, *i* and *u* as well as *e*, had for the most part lost their sound. The *i* which gave rise to the umlaut was in great measure elided in some words before the umlaut period, in others later. The number of words in which no umlaut occurs is increased; in some words it is absent, even while *i* is retained or has passed into *e*; this depends on the greater or less sensitiveness of the dialect for the umlaut:—*laat*, comparat. *later*; *beter*; Middle Dutch *hoved*, Modern Dutch *hoofd*; *teugel*; Middle Dutch *hoge*, Modern Dutch *verheugd*, *heug*; *bleu[de]*, *bloode*; *edel*, *adel*. Analogy has also played a great part in the modification of formations (*vast*, *vaster*, along with *vesting*, *vesten*; *macht*, *machtig*, along with *amechtig*; *hand*, *handen*, *handig*, along with *behendig*).

A has in open syllables the sound of English *a* in *father*, in closed syllables that of the English *a* in *as*; when there is a perfect sound in closed syllables the spelling is *aa* (*jaar*), in open syllables *a* (*maken*); in *bad*, *nat*, *a*=*ă*. An original short *a* and a long *a* in open syllables are even in Middle Dutch pronounced alike, and may be rhymed with each other (*dagen*, *lagen*, a rhyme which was not permitted in Middle High German). In the Saxon dialects *â* was expressed by *ao* (some words came in this way into Dutch with *oo* for *ao*, as *moot*, a slice of fish), and *a* or *â* in the Frisio-Saxon districts passes into *è* before *r*, as *jèr* (*jaar*). Middle Dutch preserved *a* in several words where in Modern Dutch it passes into *e* before *r* (*arg*, *erg*; *sarc*, *zerk*; *warf*, *werf*); in others, as *aarde*, *staart*, *zwaard*, the Middle Dutch had *e* and *a* (*erde*, *stert*, *swert*, *swart*, *start*; Modern Dutch *zwaard*, *staart*). In foreign words, likewise, *e* before *r* has become *a*; *paars*, *perse*; *lantaarn*, *lanterne* (in the dialects *e* is still frequently retained). In Middle Dutch *a* before *l* sometimes, but not usually, becomes *o* (*overtallich* side by side with *drievoldich*); the passage of *a* into *o* before *ch* also occurs (*ambocht*, *brocht*, &c.).

In the preterite singular of the first conjugation of strong verbs the *a* is always retained in Middle Dutch, and has not passed, as in Modern Dutch, into *o* through the influence of the plural (Middle Dutch *ic vant*, *bant*, *wi vonden*, *bonden*, Modern Dutch *ik vond*, *bond*, &c.). It is also retained before *l* and *r*, *e.g.*, *barg*, *starf* (though side by side with these we have *berg*, *sterf*), where Modern Dutch has *borg*, *stierf*, *hielp*, &c. In *ic sel*, *hi sel*, the *e* came from the plural *wi selen*, whereas the present form is again *ik zal*. A similar influence of analogy is observable in the *o* for *a* in the verbs *scheren*, *zweren*, and *wegen*, which now have *schoor*, *schoren*, *zwoor*, and *woog*; Middle Dutch *scar*, *scâren*, *wach*, &c., in which the *a* has been displaced by the *o* of the preterite participle. In the conjugation of the verbs Middle Dutch has *e* where Modern Dutch has *a* (*geslegen*, *dregen*, Modern Dutch *dragen*). In *geheven* alone *e* has been kept. In the 3d pers. sing. forms like *ontfeet*, *geet*, *steet*, occur in Middle Dutch, along with *ontfaet*, *gaet*, *staet* (Modern Dutch *ontvangt*, *gaat*, *staat*). In participles of verbs in the Germanic *-jan*, Middle Dutch has in some cases the original form without the umlaut, where Modern Dutch, through the analogy with the present, has the umlaut: Middle Dutch *becant*, *genant*, *gesant*; Modern Dutch *bekend*, *gezonden*. This last arose through confusion with the participle of the verb *sinden*, which had become obsolete, *gezant* continuing to exist as a substantive.

In substantives and adjectives we find *e* (derived from *a* through *i*) along with the unchanged *a* (*gretig*, *graag*, from *gradig*; *hekel*, *akelig*; *edel*, *adel*).

The sound of the *e* derived from *a* does not differ from that of an original *e*, or of an *e* derived from *i*, as they appear in open syllables (*vele*, *steden*, pronounced as *a* in English *name*). If the *e* derived from *a* or *i* or the original *e* occurs in closed syllables, it has a short sound, as in English *men*, *end*, Modern Dutch *stem*; while before *r* it is pronounced almost as the *e* in the High German *Herr*. The *e* in closed syllables with a full sound (as English *a*; Sweet, *ei*) is spelled *ee*: *veel*, *week* (*e* from *i*), *beek*. The sharp, clear *ee* which comes from *ai* before *r* and *w*, followed or not by *i* or *j*, is indicated by the same letters in both open and closed syllables: *eer*, *sneeuw*, *zee*. Before other consonants followed by *i* or *j* we always find *ei*: *verbreiden*, *heil*, *leiden*, *-heid*, Middle Dutch *-hede*, (hence in Modern Dutch plural *-heden*). If no *i* or *j* followed, then *ai* became *ee* (*leed*, *breed*). While in the Saxon dialect of Guelderland and Overyssel *ai* is always *ee* except when *i* or *j* follows, an *ei* often occurs in the western dialects, which has not arisen through the umlaut; in some places it is even pronounced as *ai* where the written form has *ee*: *Yselstein* (proper name), *gemein*, &c.; Modern Dutch *steen*, *gemeen*.

Sometimes the *ei* has come from *ag* or *eg* through vocalization of the *g* to *j* (*meid*, *maged*; *zeil*, *segel*); sometimes it is from the French *ai*, *ei*, *é*, *ée* (*fontein*, *hakkenei*, *balein*, &c.). In individual cases *ei* stands where the Middle Dutch has *e* before *n*: *deinzen*, Middle Dutch *denzen*; *peinzen*, Middle Dutch *penzen* and *peizen*; sometimes it is the result of an *i* following: *heinde* (*hende*, *handi*).

Since the umlaut has not been equally effective in all dialects, being even wanting where *i* has passed into *e* or dropped out, we find words with *ee* side by side with words with *ei*. Thus, Middle Dutch has *reene*, *kleene*, where Modern Dutch, through the influence of another dialect, has *rein*, *klein*. In Modern Dutch *ee* frequently exists side by side with *ei* (*verbreeden*, *verbreiden*; *heelen*, *heil*); in this case there is usually a differentiation of meaning. The dialect of North Holland turns *ee* into *ie* (*biest*, *stien*, *bien*, for the Dutch *beest*, *steen*, *been*); and this explains some words with *ie* in the spoken language: for example, *tientje* (*twig*), *driegen* (*dreigen*)—17th century.

The letter *o* represents three sounds:—(1) the short sharp *o* and (2) the short soft *o*, the former like the *o* in English *not* and French *soldat* (Dutch *bod*, *belofte*, *tocht*, *kolf*), the latter like the French *o* in *ballon* (Dutch *vod*, *ploffen*, *ochtend*, *rol*; Middle Dutch has frequently *u*, as *uchtend*); and (3) the full *o* as in French *noter* (Dutch *kolen*, *sloten*, *verloren*). The sharp clear *oo* has almost the same sound as the full *o*; in some dialects (among others the Saxon) it is pronounced as double *oo*, in others (Flemish and Hollandsch) somewhat like *au*. In Middle Dutch, the lengthening of the vowels was frequently indicated by *e* (before *r* sometimes by *i*, as in *oir*); hence *ae* for *â*, *oe* for *ô*. Where *oe* occurs in the modern language, it has the sound of *u* (pronounced like the *u* in High German, and answering to the Gothic *ô*, Old High German *uo* from *ua*), which in Middle Dutch was frequently represented by *ou* (*au*; Sweet, p. 6), still so pronounced in West Flemish and the Groningen dialects,[1] though before labials and gutturals it was expressed by *ue* and *oe* (*boue*, *souken*, and also *guet*, *vuerin*, but usually *goet*, *socken*, *boec*). The Saxon dialects still preserve in these cases an *ô* sound which agrees with the Middle Dutch *oe* (*bôk*, *môder*); in two words—*romer* (*roemer*, however, is also used) and *spook*—*o* has passed from these dialects into Dutch. As the *u* (Old German *û*), which in the modern tongues has passed into *ui* except before *r* and *w*, retains the *u* sound in the Saxon districts, some words have come into Dutch from these dialects, being written with *oe* from the similar sound of *oe* (from *ô*) and *ua* (*snoet*, *boer*, *soezen*, alongside of which are Frankish words, *snuit*, *suizen*, &c.). Except in the Saxon dialects, which are more sensitive to the umlaut, the modification of *oe* by *i* seldom occurs (Modern Dutch *groen*, *zoet*, *zoeken*, but Saxon *gryn*, *zyt*, *zyken*,—*cf.* Sweet, *History of English Sounds*, p. 6). In the Groningen dialect, *öi* in *zöiken* is umlaut of *ou* (*oe*=*ou*; *mouder*, Modern Dutch, *moeder*). Forms in Modern Dutch as *reukeloos*, *beuk*, *geneugte* alongside of *roekeloos*, *boek*, *genoegen*, show the *oe* changed before *i* in *eu*, when *oe* was still pronounced *ô*; they have thus not umlaut of *oe* but of *ô*.

In French words which are completely naturalized long *o* becomes *oe* (*façon*=*fatsoen*).

In Middle Dutch, *o* in some cases occurs instead of *oe* (*u*) in open syllables (*gode*, *moder*). This *o* for *oe* rhymes with *o*; rhymes like *gode* (*goede*) and *gode* (Goth. *Gups*), *stoect* (*stookt*) and *soect* (*zoekt*), are repeatedly introduced. Thus, too, *oe*=*ô* from *au* and *oe*=Goth. *ô* and *û* rhyme with each other.

The Modern Dutch *oo* from *au* is represented by *oo* both in open and in closed syllables. The full clear *o* from the German *o* or *u* is expressed in closed syllables by *oo*, in open syllables by *o*: *kool*, *kolen* (English *coal*), *stroom*, *stroomen*. The umlaut of the soft and sharp *o* (*eu*=*ö* in High German *schön*) is rare in Middle Dutch: Modern Dutch *vleugel*, Middle Dutch *vlogel*; *keuken*, *kokene*; *verheugen*, *hogen*. Side by side with some cases where the umlaut occurs the form without the umlaut is also retained in Modern Dutch (*leugen*, *logen*), sometimes with a difference in the meaning (*spreuk*, *sprook*; *heusch*, *hoofsch*). In the dialects the area of the umlaut is wider.

Oe before *m* and *oe* and *oo* before *ch*, especially in monosyllables, have changed into *ŏ*: *bloem*, *blom*; *zoeken*, *zocht*; *roepen*, *rocht* (whence *berucht* and *gerucht*); *koopen*, *kocht*. As in *rocht*, *gerucht*, the short soft *o* from the Middle Dutch has in many words passed into *u* (Middle Dutch *connen*, *gonnen*, *joffer* (*jonevere*); Modern Dutch *kunnen*, *gunnen*, *juffer*); sometimes both forms have continued in use: *snorken*, *snurken*; *plonderen*, *plunderen*; *veelvoudig* (*veelvoldig*), *menigvuldig*. In like manner, the forms *u* and *o* from *ŭ* exist side by side (*droppel*, *druppel*; *gort*, *grut*), as also *u* from *e* before *l* (*spul*, *spel*).

The *û* had still the Old German pronunciation in the Old Frankish psalms, and this was probably the case also in the oldest Middle Dutch. In Maerlant's style, however, it had already acquired the sound of the French *u* in *nature*: thus, Maerlant rhymes *nature*, *cure*; *gure*, *pure*; *sure*, *creature*. In the dialects we still hear the old sound *û* and not *y* (Sweet, p. 6), *e.g.*, Guelders dialect *zur*, Dutch *zyr*. Under the influence of the Hollandsch in the 16th and 17th centuries, the *û* has passed over through *öi* into *ui*

[1] See De Bo, *Westvlaamsch Idioticon*, 1804.

(pronounced nearly as the High German *eu*, English *oy*), except before *r* and *w*, where the *û* keeps the sound *ü*. Middle Dutch *oi* also passed into *ui* (*sloier, sluier*), just as *wi* after consonants: *hui* (*hwei*), *duit* (*thweit*). From the common German *û* thus arose the Middle Dutch *u* in *duve, dusent, mues*, and in the verbs *sugen, supen, luken*, corresponding to the Modern Dutch *ui* in *duizend, duif, muis, zuigen, zuipen, luiken* (in which the High German has *au*, Old High German *û*). The words in which the Saxon has the umlaut have in Middle Dutch likewise *u*, but in Modern Dutch *ui*: Middle Dutch *budel, surer, lusteren*; Modern Dutch *buidel, zuiver, luisteren*; Saxon *büdel, zürer, lüsteren*, &c. In Modern Dutch *moel, snoet, knoest*, &c., have *oe* along with forms in *ui* (*muil, snuit, knuist*). In the Saxon dialect, *oe* (*u*) and *ü* occur in some cases in the oblique cases (*knoest*, pl. *knüste*). The same thing takes place in the strong verbs, which in Anglo-Saxon have *û*, in Old High German *io* (Modern Dutch *buigen*, Anglo-Saxon *bûgan*, Old High German *biogan*); the Saxon dialects have here sometimes *ü* (*bügen, slüten*), sometimes *oe* (*kroepen, schoeren*). Old German *iu* passes before the suffix *a* into *eo, io*, and finally in Middle Dutch and Modern Dutch into *ie* (*dier, bieden, kiezen*). Before *r* Middle Dutch has the *û* frequently along with *ie* (*onghiere, ongehure*); Modern Dutch *duur* along with *dierbaar* (Belgian *duurbaar*), *vuur* (from *viwar*) along with *vier*. Sometimes *ie* changes into *e*: *deemoedig*, (*diemoedig, dienen*), *dre* as well as *drie, heden* and Modern Dutch *huiden* (Cosijn, *Noord en Zuid*, i. 219). In some cases *ui* comes from the degradation of *ai* or *i*, especially in words borrowed from the French (*fruiten*, Fr. *frite*, Lat. *frictare*; *fornuis*, Fr. *fornaise*, Middle Dutch *fornays*).

If an original *eu* is followed by *j, i*, or *u*, then *eu* becomes *iu*, Middle Dutch *u*, Modern Dutch *ui*: *beduden, dutsch, luden*, Modern Dutch *beduiden, duitsch, luiden*, along with which, however, exist the forms *dietsch* (derived from *diet*), *lieden, bedieden*, which must be ascribed to the influence of the Flemish and Zealand dialects. To this influence must also be assigned the *ie* before *r* and *l* in strong verbs of the first class which originally had *a* (*stierf, hielp*, &c.), while the reduplicative verbs in the preterite have *ie*, just as in Middle German and Modern German it is produced through contraction, according to analogy, and passes before double consonants into *ī* (*sliep, ving*).

Ie further indicates a lengthened *i* and *ī* in syllables on which the chief accent falls (*fabriek, fabrieken*), while *i* is used for short *i* and in unaccented syllables, or, it may be, for short *i* in closed syllables (*fabrikant, sikkel, midden, binden*). The long *i* is indicated by *ie*, where *ij* (which was originally the sign of *ī*, and in Middle Dutch and the dialects is still so pronounced) passes over into *ai* and *ei* through dialect influence, but retains the written form *ij*: *sijsje* (Eng. *siskin*), *partij, pijn, ijs*, &c. In some words in which the original *i* sound has been preserved, *ī* is also expressed by *ie* (*gerief, wierook, kiem*, &c.).

The sounds in Dutch which are the most difficult for foreigners to pronounce are the aspirated *g*, the *ch* after vowels, the *sch* before vowels, and *r*. This last letter is pronounced by the Germans either as *w* or as *f*, and they also usually confound *b* and *p* as initial consonants. Of the vowels, the most difficult is the *ui*, which is almost never pronounced with perfect accuracy by a foreigner. The *ij* and *ei* are generally sounded too closely like *ai*.

Grammar.—In Middle Dutch the different noun-stems are divided into two principal classes:—(1) a combination of the various vowel stems, which have more or less lost their individual characters, though here and there, in particular expressions and dialects, the difference of the stems makes itself apparent; and (2) a consonantal declension, that of the *n* stems—the other consonantal stems having been assimilated partly to the *n* stems and partly to the vowel stems. Gradually, however, the two classes begin to be confused with each other; thus in the vowel stems *s* completely ousts the *e* as a sign of the nominative plural, and consequently acquires a plural significance as well as *en*, so that (with some exceptions, like *graaf, hertog*, &c., and adjectives employed as substantives) *s* and *en* are in Modern Dutch used indifferently as plural terminations, the selection mainly depending on the nature of the foregoing consonant. In the words already mentioned—*graaf, heer, vorst*, &c., and in compounds like *gravenkroon, hanenkam*, the genitive termination *en* is preserved. The *s* of the genitive is employed in feminines whenever the qualified word stands after it, as *moederskind*; with this exception, the *s*, especially in the spoken speech, is almost entirely superseded by the periphrasis *van den*; *des heeren* becomes *van den heer*, the two forms having the same meaning, which is not the case in High German.

Neuters have in the plural the same inflexion as masculines; but they more frequently than these have the plural termination *-er*,—corrupted, however, to *-ers* or *-eren* (*kind, kinders* or *kinderen*), no plural termination in *-er* alone being now recognized. Some words, which in the singular had a parallel form with another termination, have the plural according only to one form: *stad* and *stede*, for example, have the plural *steden*. In some cases (as *schip*, plur. *schepen*; *smid*, plur. *smeden*) the plural form has not yet been explained. In the dialects, especially in the Saxon, the older forms, more particularly of the plural, are still in force; and there is still a certain difference between the several stems: *boom*, pl. *beume* (*bōme*); *gast, geste*.

The old genitive and dative forms are only retained in individual expressions, as *den lande, des huizes*, &c.; in all other cases the genitive and dative are expressed by the prepositions *van* or *aan*. The accusative is like the nominative, while in the neuter the dative also without *aan* is like the accusative. From the similarity of the dative and accusative masculine and neuter of the article great similarity has arisen in the government of the prepositions; it is only in a few expressions (*metterdaad, van goeden huize*) that the original cases have been maintained; in all other instances *voor, van, door, met*, &c., govern the accusative. In Middle Dutch this confusion had not advanced so far. The dropping of the *n* at the end after vowels—a special peculiarity of Hollandsch—has given rise to great neglect of the genders in the spoken language; and this confusion has even made itself felt in the literary style, though it is kept in check by the Saxon dialects, which are strongly conservative in this respect.

The singular of the second personal pronoun *du* (still used in Middle Dutch) has been displaced by the plural *gij*, which was originally used out of politeness; and *U* derived from *Uwe Edelheid* is now employed as the honorific. As dative and accusative of *gij, jou* is familiar in the spoken language (Eng. *you*, Goth. *jus*). The third person has, as in English, for the masculine *hij* (*hī*), thus diverging from the High German; the neuter is *het*. The form in use for the neuter article also sounds *het*; this *het* is due to the fact that the abbreviation *'t* for the pronoun *het* and for the article *dat* was the same,—a coincidence which led to an erroneous identification. In Middle Dutch the reflexive pronoun was *hem*; Modern Dutch (agreeing in this with the Old Frankish psalms) has *zich*.

Though the strong verbs and the various classes of weak verbs are always kept separate, many verbs have become through association of ideas almost unrecognizable. Strong verbs have become wholly or partially weak: *bannen, bande, gebannen*; *spannen, spande, gespannen*; *helen, heelde, verholen* and *verheeld*, *beseffen, besefte, beseft* (Middle Dutch *besief, beseven*); weak verbs have become strong: *jagen* (Middle Dutch *jaagde*), *joeg* and *jaagde, gejaagd*; *schenden, schond, geschonden*; *zenden* (see above); *prijzen* and *wijzen* pass through the *ij* (the weak) into the strong *ī* class (Middle Dutch, *prisde, wīsde*; Modern Dutch, *prees, wees, geprezen, gewezen*. In *belijden, beluidde*, Middle Dutch *beliën, belide*, the *d* of the preterite found its way into the present also and into the infinitive; and the *beliden*, Modern Dutch *belijden*, thus formed passed into the *ī* class of strong verbs. The *a* of *ward*, the preterite of *werden*, has passed into *werd*, and the plural has through analogy become *werden*, the present being *ik word* and the infinitive *worden*. The first class of strong verbs has before *n* + a consonant *i* in the stem of the present (*binden*) or else *e* (*helpen*), this *e* remaining throughout the conjugation of the present (*hij helpt*, not, as in High German, *hilft*). In the preterite the *a* has changed into *o* through the influence of the plural, as has already been mentioned under *o*. The conjunctive or optative is frequently neglected even in Middle Dutch; in the living language it is sometimes used after certain verbs and conjunctions (*op dat* and *ten einde*), but in expressing a wish it is sometimes periphrased by *mogen* or *laten*, and it is very frequently displaced by the indicative. The High German construction of the verb with *zich* to express a passive idea is contrary to the genius of Dutch, which employs the periphrastic passive form *het wordt daar gevonden* instead of *es findet sich da* (Fr. *il se trouve là*). The formation of the future likewise differs from that of the High German, the auxiliary being not *werden* but *zullen* (Eng. *shall*): *ik zal het doen* = both *I shall do it* and *I will do it*.

Much of the vocabulary of Middle Dutch has now become obsolete. Some words have altogether disappeared:—*dorper, dorperlike* (Modern Dutch, *gemeen*), *graen* (*knevel*), *grein* (*kern*, excellent person), *ontstaen* (*afwachten*), *ors* (*paard*), *oorbaer* (*nut*). Others have changed their meaning:—*cousc*, "breeches," now "hose"; *clene*, "few," now "small"; *onnoozel*, "innocent," now "half-witted"; *slecht*, "simple," now "wicked"; *beproeven*, "to prove," now "to attempt"; *crane*, "weak," now "sick."

Many new native words have grown up in connexion with trade, industry, art, and science; many foreign words have also been introduced, such as those taken from the French with the suffixes *eeren, iek, ief*; and many words from the dialects have received rights of citizenship.

For a fuller survey of the history of Dutch, the reader is referred to W. Dwight Whitney's *Language and its Study*, and the excellent translation of it by J. B. Vinckers, *Taal en Taalstudie, volgens de 3de uitgave voor Nederlanders bewerkt*. The grammar of the current speech may be studied in the *Spraakkunsten* of Kern, P. J. Cosijn, Van Helten. For the explanation of Middle Dutch words and forms, see the papers of De Vries, Verwijs, and Verdam in the *Taalgids*, the *Taal- en Letterbode*, and the *Taalkundige Bijdragen*; De Vries, *Middelnederlandsche Taalzuivering*; the editions of the *Spieghel Historiael* by Maerlant, of De Rose, William van Hillegaerdsberg, Seghelyn; and the *Bibliotheek van Middelnederlandsche Letterkunde*, by H. E. Moltzer. For explanation and history of words of the current language see the *Woordenboek der Ned. Taal*, by De Vries, Te Winkel, &c. The old Saxon and Frankish forms are treated by Kern in *Taal- en Letterbode*, Cosijn in the *Oud Frank. Psalmen*, Gallée in *Altsächsische Laut- und Flexionslehre* (1st part). A good survey of the orthography is given in De Vries and Te Winkel's *Grondbeginselen der Nederlandsche Spelling* and *Woordenlijst voor de Spelling der Nederlandsche Taal*. (J. B. V.—J. H. G.)

PART IV.—LITERATURE

As has been shown above, the language now known as Dutch or Flemish did not begin to take distinct shape till about the end of the 11th century. From a few existing fragments—two incantations from the 8th century, a version of the Psalms from the 9th century, and several charters—a supposed Old Dutch language has been recognized; but Dutch literature actually commences in the 13th century, as Middle Dutch, the creation of the first national movement in Brabant, Flanders, Holland, and Zealand. From the wreck of Frankish anarchy no genuine folk-tales of Dutch antiquity have come down to us, and scarcely any echoes of German myth. On the other hand, the sagas of Charlemagne and Arthur appear immediately in Middle Dutch forms. These were evidently introduced by wandering minstrels and jongleurs, and translated to gratify the curiosity of the noble women. It is rarely that the name of such a translator has reached us, but we happen to know that the fragments we possess of the French romance of *William of Orange* were written in Dutch by a certain Klaas van Haarlem, between 1191 and 1217. The *Chanson de Roland* was translated about the same time, and considerably later *Parthenopeus de Blois.* The Flemish minstrel Diederic van Assenede completed his version of *Floris et Blanchefleur* about 1250. The Arthurian legends appear to have been brought to Flanders by some Flemish colonists in Wales, on their return to their mother-country. About 1250 a Brabantine minstrel translated Walter Map's *Lancelot du Lac* at the command of his liege, Lodewijk van Velthem. The *Gauvain* was translated by Penninc and Vostaert before 1260, while the first original Dutch writer, the famous Jakob van Maerlant, occupied himself about 1260 with several romances dealing with Merlin and the Holy Grail. The earliest existing fragments of the epic of *Reynard the Fox* were written in Latin by Flemish priests, and about 1250 a very important version in Dutch was made by Willem the Minstrel, of whom it is unfortunate that we know no more, save that he was the translator of a lost romance, *Madoc.* In his existing work the author follows Pierre de Saint-Cloud, but not slavishly; and he is the first really admirable writer that we meet with in Dutch literature. It is not necessary to dwell at any length on the monkish legends and the hymns to the Virgin Mary which were abundantly produced during the 13th century, and which, though destitute of all literary merit, were of use as exercises in the infancy of the language. The first lyrical writer of Holland was John I., duke of Brabant, who practised the *minnelied* with success, but whose songs are only known to us through a Swabian version of a few of them. In 1544 the earliest collection of Dutch folk-songs saw the light, and in this volume one or two romances of the 14th century are preserved, of which *Het Daghet in den Oosten* is the best known. Almost the earliest fragment of Dutch popular poetry, but of later time, is an historical ballad describing the murder of Count Floris V. in 1296. A very curious collection of mystical mediæval hymns by Sister Hadewych, a nun of Brabant, was first printed in 1877.

Willem the Minstrel.

John I., duke of Brabant.

Hitherto, as we have seen, the Middle Dutch language had placed itself at the service of the aristocratic and monastic orders, flattering the traditions of chivalry and of religion, but scarcely finding anything to say to the bulk of the population. With the close of the 13th century a change came over the face of Dutch literature. The Flemish towns began to prosper and to assert their commercial supremacy over the North Sea. Under such mild rulers as William II. and Floris V., Dort, Amsterdam, and other cities contrived to win such privileges as amounted almost to political independence, and with this liberty there arose a new sort of literary expression. The founder and creator of this original Dutch literature was Jakob van Maerlant, born near Bruges between 1225 and 1250. His youth was spent in Holland, and probably in connexion with the court, but in 1261 he returned to Flanders, where he died about thirty years later. Maerlant commenced, as his predecessors had done, by translating the courtly romances of the French, but when he returned to Flanders he began to take his true position as an original didactic poet. His *Flowers of Nature*, written about 1263, forms an epoch in Dutch literature; it is a collection of moral and satirical addresses to all classes of society. With his *Rijmbijbel* (Rhyming Bible) he nearly brought down on his too secular head, in 1270, the chastisement of the bishop of Utrecht, and thus early in Dutch history foreshadowed the courage and free-thought of the Reformation. It was not until 1284 that he commenced his masterpiece, *De Spieghel Historiael* (The Mirror of History), at the command of Count Floris V. After writing a great many important works, lyrical and didactic, Maerlant died at Damme, about 1291. Of his disciples, the most considerable in South Holland was Jan van Boendale (1280–1365). He was a politician of considerable influence, and his works are historical and moral in character. In him the last trace of the old chivalric and romantic element has disappeared. He completed his famous rhyme chronicle, the *Brabantsche Yeesten*, in 1315; it contains the history of Brabant down to the times of the author himself. For English readers it is disappointing that Boendale's other great historical work, an account of Edward III. and his expedition to Flanders in 1338, has survived only in some fragments. The remainder of Boendale's works are didactic poems, pursuing still further the moral thread first taken up by Maerlant, and founded on mediæval scholastic literature. In Ypres the school of Maerlant was represented by Jan de Weert, a surgeon, who died in 1362, and who was the author of two remarkable works of moral satire and exhortation. In North Holland a greater talent than that of Weert or of Boendale was exhibited by Melis Stoke, a monk of Egmond, who wrote the history of the state of Holland to the year 1305; this work, the *Rijmkronik*, was printed in 1591, and for its exactitude and minute detail has proved of inestimable service to later historians.

Maerlant. Boendale. Weert. Stoke.

With the middle of the 14th century the chivalric spirit came once more into fashion. A certain revival of the forms of feudal life made its appearance under William III. and his successors. Knightly romances came once more into vogue, but the new-born didactic poetry contended vigorously against the supremacy of what was lyrical and epical. It will be seen that from the very first the literary spirit in Holland began to assert itself in a homely and utilitarian spirit. Jan van Heelu, a Brabanter, was the author of an epic poem on the battle of Woeronc (1288), and to him has been attributed the still finer romance of the *War of Grimbergen.* Still more thoroughly aristocratic in feeling was Hein van Aken, a priest of Louvain, who lived about 1255–1330, and who combined to a very curious extent the romantic and didactic elements. As early as 1280 he had completed his translation of the *Roman de la Rose*, which he must have commenced in the lifetime of Jean de Meung. More remarkable than any of his translated works, however, is his original romance *Heinric en Margriete*, upon which he was at work for thirty-seven years. During the Bavarian period (1349–1433) very

Heelu. Aken.

little original writing of much value was produced in Holland. Buodewijn van der Loren wrote one excellent piece on the Maid of Ghent, in 1389. Augustijnken van Dordt was a peripatetic minstrel of North Holland, who composed for the sheriff Aelbrecht and for the count of Blois from 1350 to 1370. Such of his verses as have been handed down to us are allegorical and moral. Willem van Hildegaersberch (1350–1408) was another northern poet, of a more strictly political cast. Many of his writings exist still unpublished, and are very rough in style and wanting in form. Towards the end of the 15th century an erotic poet of considerable power arose in the person of the lord of Waddinxsveen and Hubrechtsambacht, Dirk Potter. During a stay of three years in Rome, from 1409 to 1412, this eminent diplomatist made himself acquainted with the writings of Boccaccio, and commenced a vast poem on the course of love, *Der Minnen Loep*, which is a wonderful mixture of classical and Biblical instances of amorous adventure, set in a framework of didactic philosophy. In Dirk Potter the last traces of the chivalric element died out of Dutch literature, and left poetry entirely in the hands of the school of Maerlant.

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It is now time to consider the growth of prose literature in the Low Countries. The oldest pieces of Dutch prose now in existence are charters of the towns of Flanders and Zealand, dated 1249, 1251, and 1254. A prose translation of the Old Testament was made about 1300, and there exists a *Life of Jesus* of about the same date. Of the mystical preachers whose religious writings have reached us, the Brussels friar, Jan van Ruysbroec (1294–1381), is the most important. But the most interesting relics of mediæval Dutch prose, as far as the formation of the language is concerned, are the popular romances in which the romantic stories of the *trouvères* and minstrels were translated for the benefit of the unlettered public into simple language. As in most European nations, the religious drama takes a prominent place in every survey of mediæval literature in Holland. Unfortunately the text of all the earliest mysteries, the language of which would have an extraordinary interest for us, has been lost. We possess records of dramas having been played at various places—*Our Lord's Resurrection*, at the Hague, in 1400; *Our Lady the Virgin*, at Arnheim, in 1452; and *The Three Kings*, at Delft, in 1498. The earliest existing fragment, however, is part of a *Limburg-Maestricht Passover Play* of about 1360. The latest Dutch miracle play was the *Mystery of the Holy Sacrament*, composed by a certain Smeken, at Breda, and performed on St John's Day, 1500. This play was printed in 1867. With these purely theological dramas there were acted mundane farces, performed outside the churches, by semi-religious companies; these curious moralities were known as "Abelespelen" and "Sotternieën." In these pieces we discover the first traces of that genius for low comedy which was afterwards to take perfect form in the dramas of Brederôo and the paintings of Teniers.

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The theatrical companies just alluded to, "Gesellen van den Spele," formed the germ out of which developed the famous "Chambers of Rhetoric" which united within themselves all the literary movements that occupied the Low Countries during the 15th and 16th centuries. The poets of Holland had already discovered in late mediæval times the value of guilds in promoting the arts and industrial handicrafts. The term "colléges de rhétorique" is supposed to have been introduced about 1440 by the courtiers of the Burgundian dynasty, but the institutions themselves existed at least from 1400. These literary guilds lasted for two centuries, and during the greater part of that time preserved a completely mediæval character, even when the influences of the Renaissance and the Reformation obliged them to modify in some degree their outward forms. They were in almost all cases absolutely middle class in tone, and opposed to aristocratic ideas and tendencies in thought. Of these remarkable bodies the earliest were almost entirely engaged in preparing mysteries and miracle-plays for the populace. Each chamber, and in process of time every town in the Low Countries, possessed one, and took as its title some fanciful or heraldic sign. The earliest of all, "The Alpha and Omega," at Ypres, was founded about 1398; that of the "Violet," at Antwerp, followed in 1400; the "Book," at Brussels, in 1401; the "Berberry," at Courtrai, in 1427; the "Holy Ghost," at Bruges, in 1428; the "Floweret Jesse," at Middelburg, in 1430; the "Oak Tree," at Vlaardingen, in 1433; and the "Marigold," at Gouda, in 1437. The most celebrated of all the chambers, that of the "Eglantine" at Amsterdam, with its motto *In Liefde Bloeyende* (Blossoming in Love), was not instituted until 1496. Among the most influential chambers not above mentioned should be included the "Fountain" at Dort, the "Corn Flower" at the Hague, the "White Columbine" at Leyden, the "Blue Columbine" at Rotterdam, the "Red Rose" at Schiedam, the "Thistle" at Zierikzee, "Jesus with the Balsam" at Ghent, and the "Garland of Mary" at Brussels. And not in these important places only, but in almost every little town, the rhetoricians exerted their influence, mainly in what we may call a social direction. Their wealth was in most cases considerable, and it very soon became evident that no festival or procession could take place in a town unless the "Kamer" patronized it. Towards the end of the 15th century the Ghent chamber of "Jesus with the Balsam" began to exercise a sovereign power over the other Flemish chambers, which was emulated later on in Holland by the "Eglantine" at Amsterdam. But this official recognition proved of no consequence in literature, and it was not in Ghent, but in Antwerp, that intellectual life first began to stir. In Holland the burghers only formed the chambers, while in Flanders the representatives of the noble families were honorary members, and assisted with their money at the arrangement of ecclesiastical or political pageants. Their pompous *landjuweelen*, or tournaments of rhetoric, at which rich prizes were contended for, were the great occasions upon which the members of the chambers distinguished themselves. Between 1426 and 1620 at least 66 of these festivals were held. There was a specially splendid *landjuweel* at Antwerp in 1496, in which 28 chambers took part, but the gayest of all was that celebrated at Antwerp on the 3d of August 1561. To this the "Book" at Brussels sent 340 members, all on horseback, and clad in crimson mantles. The town of Antwerp gave a ton of gold to be given in prizes, which were shared among 1893 rhetoricians. This was the zenith of the splendour of the "Kamers van Rhetorica," and after this time they soon fell into disfavour. We can trace the progress of literary composition under the chambers, although none of their official productions have descended to us. Their dramatic pieces were certainly of a didactic cast, with a strong farcical flavour, and continued the tradition of Maerlant and his school. They very rarely dealt with historical or even Biblical personages, but entirely with allegorical and moral abstractions, until the age of humanism introduced upon the stage the names without much of the spirit of mythology. Of the pure farces of the rhetorical chambers we can speak with still more confidence, for some of them have come down to us, and among the authors famed for their skill in this sort of writing are named Cornelis Everaert of Bruges and Laurens Janssen of Haarlem. The material of these farces is extremely raw, consisting of rough jests at the expense of priests and foolish husbands, silly old men and their light wives. Laurens Janssen is also deserving of remembrance for a satire against the clergy, written in 1583. The chambers also encouraged the composition of songs, but with very little success; they produced no lyrical genius more considerable than Matthijs de Casteleyn (1488–1550), the founder of the Flemish chamber of "Pax Vobiscum" at Oudenarde, a personage whose influence as a fashioner of language would have been more healthy if his astounding metrical feats and harlequin *tours-de-force* had not been performed in a dialect debased with all the worst bastard phrases of the Burgundian period.

In the middle of the 16th century a group of rhetoricians in Brabant and Flanders attempted to put a little new life into the stereotyped forms of the preceding age by introducing in original composition the new-found branches of Latin and Greek poetry. The leader of these men was Jean Baptista Houwaert (1533–1599), a personage of considerable political influence in his generation. He considered himself a devout disciple of Matthijs de Casteleyn, but his great characteristic was his unbounded love of classical and mythological fancy. His didactic poems are composed in a wonderfully rococo style, and swarm with misplaced Latinities. In his bastard Burgundian tongue he boasted of having "poëtelijck geïnventeert ende rhetorijckelijck ghecomponeert" for the Brussels chamber such dramas as *Æneas and Dido*, *Mars and Venus*, *Narcissus and Echo*, or *Leander and Hero*. But of all his writings *Pegasides Pleyn*, or the Palace of Maidens, is the most remarkable; this is a didactic poem in sixteen books, dedicated to a discussion of the variety of earthly love. Houwaert's contemporaries nicknamed him "the Homer of Brabant;" later criticism has preferred to see in him an important link in that chain of homely didactic Dutch which ends in Cats. His writings are composed in a Burgundian so base that they hardly belong to Flemish literature at all. Into the same miserable dialect Cornelis van Ghistele of Antwerp translated, between 1555 and 1583, parts of Terence, Virgil, Horace, and Ovid, while the painter Karel van Mander (1547–1609) put a French version of the *Iliad* and of the *Eclogues* of Virgil into an equally ill-fitting Flemish dress. In no country of Europe did the humanism of the 16th century at first affect the national literature so slightly or to so little purpose.

Houwaert.

Psalms and hymns.

The stir and revival of intellectual life that arrived with the Reformation found its first expression in the composition of Psalms. The earliest printed collection appeared at Antwerp in 1540, under the title of *Souter-Liedekens*, and was dedicated to a Dutch nobleman, Willem van Zuylen van Nieuvelt, by whose name it is usually known. This collection, however, was made before the Reformation in Holland really set in. For the Protestant congregations Jan Utenhove printed a volume of Psalms in London in 1566; Lucas de Heere, and immediately after him, with much greater success, Petrus Datheen (1531–1590), translated the hymns of Clément Marot. For printing this last volume, in 1567, Herman Schinkel of Delft was burned to death in 1568. Datheen was not a rhetorician, but a person of humble origin, who wrote in the vulgar tongue, and his hymns spread far and wide among the people. Until 1773 they were in constant use in the state church of Holland. But the great events of the period of reformation are not marked by psalms only in Dutch literature. Two collections of hymns and lyrical pieces, printed in 1562 and 1569, perpetuate the fervour and despair of the martyrs of the Mennonite Church. Similar utterances of the persecuted Protestants were published at Haarlem and Leeuwarden, at Ghent and at Bruges. Very different in tone were the battle-songs of liberty and triumph sung a generation later by the victorious Reformers or "Geuzen." The famous song-book of 1588, the *Geusen Lieden Boecxken*, was full of ardent and heroic sentiment, expressed often in marvellously brilliant phrases. In this collection appeared for the first time such classical snatches of Dutch song as the Ballad of Heiligerlee, the Ballad of Egmond and Horn, and the song of the Storm of Leyden. The political ballads, with their ridicule of the Spanish leaders, form a section of the *Boecxken* which has proved of inestimable value to historians. All these lyrics, however, whether of victory or of martyrdom, are still very rough in form and language.

Battle-songs.

Anna Bijns.

The first writer who used the Dutch tongue with grace and precision of style was a woman and a professed opponent of Lutheranism and reformed thought. Modern Dutch literature practically begins with Anna Bijns. Against the crowd of rhetoricians and psalm-makers of the early part of the 16th century she stands out in relief as the one poet of real genius. The language, oscillating before her time between French and German, formless, corrupt, and invertebrate, took shape and comeliness, which none of the male pedants could give it, from the impassioned hands of a woman. Anna Bijns, who is believed to have been born at Antwerp in 1494, was a schoolmistress at that city in her middle life, and in old age she still "instructed youth in the Catholic religion." Hendrik Peppinck, a Franciscan, who edited her third volume of poems when she was an old woman in 1567, speaks of her as "a maiden small of descent, but great of understanding, and godly of life." Her first known volume bears the date 1528, and displays her as already deeply versed in the mysteries of religion. We gather from all this that she was a lay nun, and she certainly occupied a position of great honour and influence at Antwerp. She was named "the Sappho of Brabant" and the "Princess of all Rhetoricians." She bent the powerful weapon of her verse against the faith and character of Luther. In her volume of 1528 the Lutherans are scarcely mentioned; in that of 1540 every page is occupied with invectives against them; while the third volume of 1567 is the voice of one from whom her age has passed. All the poems of Anna Bijns which we possess are called *refereinen* or refrains. Her mastery over verse-form was extremely remarkable, and these refrains are really modified chants-royal. The writings of Anna Bijns offer many points of interest to the philologist. In her the period of Middle Dutch closes, and the modern Dutch begins. In a few grammatical peculiarities—such as the formation of the genitive by some verbs which now govern the accusative, and the use of *ghe* before the infinitive—her language still belongs to Middle Dutch; but these exceptions are rare, and she really initiated that modern speech which Filips van Marnix adopted and made classical in the next generation.

Marnix.

In Filips van Marnix, lord of St Aldegonde (1538–1598), a much greater personage came forward in the ranks of liberty and reform. He began life as a disciple of Calvin and Beza in the schools of Geneva. It was as a defender of the Dutch iconoclasts that he first appeared in print, with his tract on *The Images thrown down in Holland in August* 1566. He soon became one of the leading spirits in the war of Dutch independence, the intimate friend of the prince of Orange, and the author of the glorious *Wilhelmuslied*. It was in the autumn of 1568 that Marnix composed this, the national hymn of Dutch liberty and Protestantism. In 1569 he completed a no less important and celebrated prose work, the *Biencorf* or Beehive of the Romish Church. In this satire he was inspired in a great measure by Rabelais, of whom he was an intelligent disciple. It is written in prose that may be said to mark an epoch in the language and literature of Holland. Overwhelmed with the press of public business, Marnix wrote little more until in 1580 he published his *Psalms of David newly translated out of the Hebrew Tongue*. He occupied the last years of his life in preparing a Dutch version of the Bible, translated direct from the original. At his death only Genesis was found completely revised; but in 1619 the synod of Dort placed the unfinished work in the hands of four divines, who completed it.

Coornhert. In Dirck Volckertsen Coornhert (1522–1590) Holland for the first time produced a writer at once eager to compose in his native tongue and to employ the weapons of humanism. Coornhert was a typical burgher of North Holland, equally interested in the progress of national emancipation and in the development of national literature. He was a native of Amsterdam, but he did not take part in the labours of the old chamber of the Eglantine, but quite early in life proceeded to Haarlem, of which place he remained a citizen until his death. He practised the art of etching, and spent all his spare time in the pursuit of classical learning. He was nearly forty years of age before he made any practical use of his attainments. In 1561 he printed his translation of the *De Officiis* of Cicero, and in 1562 of the *De Beneficiis* of Seneca. In these volumes he opposed with no less zeal than Marnix had done the bastard forms still employed in prose by the rhetoricians of Flanders and Brabant. During the next decade he occupied himself chiefly with plays and poems, conceived and expressed with far less freedom than his prose, and more in the approved conventional fashion of the rhetoricians; he collected his poems in 1575. The next ten years he occupied in polemical writing, from the evangelical point of view, against the Calvinists. In 1585 he translated Boetius, and then gave his full attention to his original masterpiece, the *Zedekunst*, or Art of Ethics, a philosophical treatise in prose, in which he studied to adapt the Dutch tongue to the grace and simplicity of Montaigne's French. His humanism unites the Bible, Plutarch, and Marcus Aurelius in one grand system of ethics, and is expressed in a style remarkable for brightness and purity. He died in 1590; his works, in three enormous folio volumes, were first collected in 1630.

Amsterdam the centre of letters. Towards the end of the period of transition, Amsterdam became the centre of all literary enterprise in Holland. In 1585 two of the most important chambers of rhetoric in Flanders, the "White Lavender" and the "Fig-Tree," took flight from the south, and settled themselves in Amsterdam by the side of the "Eglantine." The last-named institution had already observed the new tendency of the age, and was prepared to encourage intellectual reform of every kind, and its influence spread through Holland and Zealand. In Flanders, meanwhile, crushed under the yoke of Parma, literature and native thought absolutely expired. From this time forward, and until the emancipation of the southern provinces, the domain of our inquiry is confined to the district north of the Scheldt.

In the chamber of the Eglantine at Amsterdam two men took a very prominent place, more by their intelligence and modern spirit than by their original genius. Hendrick

Spieghel. Laurenssen Spieghel (1549-1612) was a humanist of a type more advanced and less polemical than Coornhert. He wrote a charming poem in praise of dancing; but his chief contributions to literature were his *Twespraeck van de Nederduytsche Letterkunst*, a philological exhortation. in the manner of Joachim du Bellay's famous tract, urging the Dutch nation to purify and enrich its tongue at the fountains of antiquity, and a didactic epic, entitled *Hertspieghel*, which has been greatly praised, but which is now much more antiquated in style and more difficult to enjoy than Coornhert's prose of a similar tendency. That Spieghel was a Catholic prevented him perhaps from exercising as much public influence as he exercised privately among his younger friends. The same may be said of the man who, in 1614, first collected Spieghel's writings, and

Roemer Visscher. published them in a volume with his own verses. Roemer Pieterssen Visscher (1545-1620) proceeded a step further than Spieghel in the cultivation of polite letters. He was deeply tinged with a spirit of classical learning that was much more genuine and nearer to the true antique than any that had previously been known in Holland. His own disciples called him the Dutch Martial, but he was at best little more than an amateur in poetry, although an amateur whose function it was to perceive and encourage the genius of professional writers. Roemer Visscher stands at the threshold of the new Renaissance literature, himself practising the faded arts of the rhetoricians, but pointing by his counsel and his conversation to the naturalism of the great period.

The Renaissance. It was in the salon at Amsterdam which the beautiful daughters of Roemer Visscher formed around their father and themselves that the new school began to take form. The republic of the United Provinces, with Amsterdam at its head, had suddenly risen to the first rank among the nations of Europe, and it was under the influence of so much new emotion and brilliant ambition that the country no less suddenly asserted itself in a great school of painting and poetry. The intellect of the whole Low Countries was concentrated in Holland and Zealand, while the six great universities, Leyden, Groningen, Utrecht, Amsterdam, Harderwijk, and Franeker, were enriched by a flock of learned exiles from Flanders and Brabant. It had occurred, however, to Roemer Visscher only that the path of literary honour lay, not along the utilitarian road cut out by Maerlant and Boendale, but in the study of beauty and antiquity. In this he was curiously aided by the school of ripe and enthusiastic scholars who began to flourish at Leyden, such as Drusius, Vossius, and Hugo Grotius, who themselves wrote little in Dutch, but who chastened the style of the rising generation by insisting on a pure and liberal Latinity. Out of that generation arose the greatest names in the literature of Holland,—Vondel, Hooft, Cats, Huygens,—in whose hands the language, so long left barbarous and neglected, took at once its highest finish and melody. By the side of this serious and æsthetic growth there is to be noticed a quickening of the broad and farcical humour which had been characteristic of the Dutch nation from its commencement. For fifty years, and these the most glorious in the annals of Holland, these two streams of influence, one towards beauty and melody, the other towards lively comedy, ran side by side, often in the same channel, and producing a rich harvest of great works. It was in the house of the daughters of Roemer Visscher that the tragedies of Vondel and the comedies of Brederôo, the farces of Coster and the odes of Huygens, alike found their first admirers and their best critics.

Roemer Visscher's daughters. Of the famous daughters of Roemer, two cultivated literature with marked success. Anna (1584–1651) was the author of a descriptive and didactic poem, *De Roemster van den Aemstel* (The Glory of the Aemstel), and of various miscellaneous writings; Tesselschade (1594–1649) wrote some lyrics which still place her at the head of the female poets of Holland, and she translated the great poem of Tasso. They were women of universal accomplishment, graceful manners, and singular beauty; and their company attracted to the house of Roemer Visscher all the most gifted youths of the time, several of whom were suitors, but in vain, for the hand of Anna or of Tesselschade.

Hooft. Of this Amsterdam school, the first to emerge into public notice was Pieter Cornelissen Hooft (1581–1647). He belonged to a patrician family, and became a member at a very early age of the chamber of the Eglantine. When he was only eighteen he produced, before this body, his tragedy of *Achilles and Polyxena* (1598), which displayed a precocious ease in the use of rhetorical artifices of style. His intellectual character, however, was formed by a journey into Italy which he took in 1598, where he steeped himself for three years in the best Italian literature, both prose and verse. He returned to Holland in 1601, with his head full of schemes for the creation of a Dutch school of belles lettres. In 1605 he produced his pastoral drama of *Granida*, in which he proved himself a pupil of Guarini. During the remainder of his life he dedicated himself chiefly to history and tragedy. In the latter field he produced *Baeto* and *Geraad van Velsen*; in history he published in 1626 his *Life of Henry the Great*, while from 1628 to 1642 he was engaged upon his master-work, the *History of Holland*. Hooft desired to be a severe purist in style, and to a great extent he succeeded, but, like most of the writers of his age, he permitted himself too many Latinisms. In his poetry, especially in the lyrical and pastoral verse of his youth, he is full of Italian reminiscences both of style and matter; in his noble prose work he has set himself to be a disciple of Tacitus. Mr Motley has spoken of Hooft as one of the greatest historians, not merely of Holland, but of Europe. His influence in purifying the language of his country, and in enlarging its sphere of experience, can hardly be overrated.

Brederôo. Very different from the long and prosperous career of Hooft was the brief, painful life of the greatest comic dramatist that Holland has produced. Gerbrand Adriaanssen Brederôo (1585-1618) was the son of an Amsterdam shoemaker. He knew no Latin; he had no taste for humanism; he was a simple growth of the rich humour of the people. His life was embittered by a hopeless love for Tesselschade, to whom he dedicated his dramas, and whose beauty he celebrated in a whole cycle of love songs. His ideas on the subject of drama were at first a mere development of the mediæval "Abelespelen." He commenced by dramatizing the romance of *Roderick and Alphonsus*, in 1611, and *Griane* in 1612, but in the latter year he struck out a new and more characteristic path in his *Farce of the Cow*. From this time until his death he continued to pour out comedies, farces, and romantic dramas, in all of which he displayed a coarse, rough genius not unlike that of Ben Jonson, whose immediate contemporary he was. His last and best piece was *Jerolimo, the Spanish Brabanter*, a satire upon the exiles from the south who filled the halls of the Amsterdam chambers of rhetoric with their pompous speeches and preposterous Burgundian phraseology. Brederôo was closely allied in genius to the dramatists of the Shakespearian age, but he founded no school, and stands almost as a solitary figure in the literature of Holland.

Coster. The only individual at all clearly connected with Brederôo in talent was Dr Samuel Coster, whose dates of birth and death are unknown. He is chiefly remembered for having been the first to take advantage of the growing dissension in the body of the old chamber of the Eglantine to form a new institution. In 1617 Coster founded what he called the "First Dutch Academy." This was in fact a theatre, where, for the first time, dramas could be publicly acted under the patronage of no chamber of rhetoric. Coster himself had come before the world in 1612 with his farce of *Teuwis the Boor*, and he continued this order of composition in direct emulation of Brederôo, but with less talent. In 1615 he began a series of "blood-and-thunder" tragedies with his horrible *Itys*, and he continued this coarse style of tragic writing for several years. He survived at least until after 1648 as a supreme authority in Amsterdam upon all dramatic matters.

Vondel. The greatest of all Dutch writers, Joost van der Vondel (1587-1679), was born at Cologne on the 17th of November 1587. In 1612 he brought out his first work, *Het Pascha*, a tragedy or tragi-comedy on the exodus of the children of Israel, written, like all his succeeding dramas, on the recognized Dutch plan, in alexandrines, in five acts, and with choral interludes between the acts. There is comparatively little promise in *Het Pascha*. It was much inferior dramatically to the plays just being produced by Brederôo, and metrically to the clear and eloquent tragedies and pastorals of Hooft; but it secured the young poet a position inferior only to theirs. Yet for a number of years he made no attempt to emphasize the impression he had produced on the public, but contented himself during the years that are the most fertile in a poet's life with translating and imitating portions of Du Bartas's popular epic. The short and brilliant life of Brederôo, his immediate contemporary and greatest rival, burned itself out in a succession of dramatic victories, and it was not until two years after the death of that great poet that Vondel appeared before the public with a second tragedy, the *Jerusalem laid Desolate*. Five years later, in 1625, he published what seemed an innocent study from the antique, his tragedy of *Palamedes, or Murdered Innocence*. All Amsterdam discovered, with smothered delight, that under the name of the hero was thinly concealed the figure of Barneveldt, whose execution in 1618 had been a triumph of the hated Calvinists. Thus, at the age of forty-one, the obscure Vondel became in a week the most famous writer in Holland. For the next twelve years, and till the accession of Prince Frederick Hendrick, Vondel had to maintain a hand-to-hand combat with the "Saints of Dort." This was the period of his most resolute and stinging satires; Cats took up the cudgels on behalf of the counter-Remonstrants, and there raged a war of pamphlets in verse. A purely fortuitous circumstance led to the next great triumph in Vondel's slowly developing career. The Dutch Academy, founded in 1617 almost wholly as a dramatic guild, had become so inadequately provided with stage accommodation that in 1638, having coalesced with the two chambers of the "Eglantine" and the "White Lavender," it ventured on the erection of a large public theatre, the first in Amsterdam. Vondel, as the greatest poet of the day, was invited to write a piece for the first night; on the 3d of January 1638 the theatre was opened with the performance of a new tragedy out of early Dutch history, the famous *Gysbreght van Aemstel*. The next ten years were rich in dramatic work from Vondel's hand; he supplied the theatre with heroic Scriptural pieces, of which the general reader will obtain the best idea if we point to the *Athalie* of Racine. In 1654, having already attained an age at which poetical production is usually discontinued by the most energetic of poets, he brought out the most exalted and sublime of all his works, the tragedy of *Lucifer*. Very late in life, through no fault of his own, financial ruin fell on the aged poet, and from 1658 to 1668—that is, from his seventieth to his eightieth year—this venerable and illustrious person, the main literary glory of Holland through her whole history, was forced to earn his bread as a common clerk in a bank, miserably paid, and accused of wasting his masters' time by the writing of verses. The city released him at last from this wretched bondage by a pension, and the wonderful old man went on writing odes and tragedies almost to his ninetieth year. He died at last in 1679, of no disease, having outlived all his contemporaries and almost all his friends, but calm, sane, and good-humoured to the last, serenely conscious of the legacy he left to a not too grateful country. Vondel is the typical example of Dutch intelligence and imagination at their highest development. Not merely is he to Holland all that Camoens is to Portugal and Michiewicz to Poland, but he stands on a level with these men in the positive value of his writings.

Starter. Lyrical art was represented on its more spontaneous side by the songs and ballads of Jan Janssen Starter (b. 1594), an Englishman by birth, who was brought to Amsterdam in his thirteenth year. Very early in life he was made a member of the "Eglantine," and he worked beside

Brederôo for two years; but in 1614 he wandered away to Leeuwarden, in Friesland, where he founded a literary guild, and brought out, in 1618, his tragi-comedies of *Timbre de Cardone* and *Daraida*. But his great contribution to literature was his exquisite collection of lyrics, entitled the *Friesche Lusthof*, or Frisian Pleasance. He returned to Amsterdam, but after 1625 we hear no more of him, and he is believed to have died as a soldier in Germany. The songs of Starter are in close relation to the lyrics of the English Elizabethans, and have the same exquisite simplicity and audacity of style.

While the genius of Holland clustered around the circle of Amsterdam, a school of scarcely less brilliance arose in Middelburg, the capital of Zealand. The ruling spirit of this school was the famous Jakob Cats (1577–1660). In this voluminous writer, to whom modern criticism almost denies the name of poet, the genuine Dutch habit of thought, the utilitarian and didactic spirit which we have already observed in Houwaert and in Boendale, reached its zenith of fluency and popularity. Cats was a man of large property and high position in the state, and his ideas never rose above the horizon of wealth and easy domestic satisfaction. Between 1609 and 1621, that is, during early middle life, he produced the most important of his writings, his pastoral of *Galathea*, and his didactic poems, the *Maechdenplicht* and the *Sinne- en Minne-Beelden*. In 1624 he removed from Middelburg to Dort, where he soon after published his tedious ethical work called *Houwelick*, or Marriage; and this was followed from time to time by one after another of his monotonous moral pieces. Cats is an exceedingly dull and prosaic writer, whose alexandrines roll smoothly on without any power of riveting the attention or delighting the fancy. Yet his popularity with the middle classes in Holland has always been immense, and his influence extremely hurtful to the growth of all branches of literary art. Among the disciples of Cats, Jakob Westerbaen (1599–1670) was the most successful. The Jesuit Adriaen Poirters (1606–1675) closely followed Cats in his remarkable *Masquer of the World*. A poet of Amsterdam, Jan Hermansz Krul, preferred to follow the southern fashion, and wrote didactic pieces in the Catsian manner.

A poet of dignified imagination and versatile form was Sir Constantijn Huygens (1596–1687), the diplomatist. Though born and educated at the Hague, he threw in his lot with the great school of Amsterdam, and became the intimate friend and companion of Vondel, Hooft, and the daughters of Roemer Visscher. His famous poem in praise of the Hague, *Batava Tempe*, appeared in 1621, and was, from a technical point of view, the most accomplished and elegant poem till that time produced in Holland. His collected poems, *Otiorum Libri Sex*, were printed in 1625. *Oogentroost*, or Eye Consolation, was the fantastic title of a remarkable poem dedicated in 1647 to his blind friend, Lucretia van Trello. He printed in 1654 a topographical piece describing his own mansion, *Hofwijck*. Huygens represents the direction in which it would have been desirable that Dutch literature, now completely founded by Hooft and Vondel, should forthwith proceed, while Cats represents the tame and mundane spirit which was actually adopted by the nation. Huygens had little of the sweetness of Hooft or of the sublimity of Vondel, but his genius was eminently bright and vivacious, and he was a consummate artist in metrical form. The Dutch language has never proved so light and supple in any hands as in his, and he attempted no class of writing, whether in prose or verse, that he did not adorn by his delicate taste and sound judgment. A blind admiration for our own John Donne, whose poems he translated, was the greatest fault of Huygens, who, in spite of his conceits, remains one of the most pleasing of Dutch writers. In addition to all this he comes down to us with the personal recommendation of having been "one of the most lovable men that ever lived."

Three Dutchmen of the 17th century distinguished themselves very prominently in the movement of learning and philosophic thought, but the illustrious names of Hugo Grotius (1583–1645) and of Baruch Spinoza (1632–1677) can scarcely be said to belong to Dutch literature. Balthasar Bekker (1634–1698), on the contrary, a Reformed preacher of Amsterdam, was a disciple of Descartes, who deserves to be remembered as the greatest philosophical writer who has used the Dutch language. His masterpiece, *Betoverde Wereld*, or the World Bewitched, appeared in 1691–1693. Bekker is popularly remembered most honourably by his determined attacks upon the system of a penal code for witchcraft.

From 1600 to 1650 was the blossoming time in Dutch literature. During this period the names of greatest genius were first made known to the public, and the vigour and grace of literary expression reached their highest development. It happened, however, that three men of particularly commanding talent survived to an extreme old age, and under the shadow of Vondel, Cats, and Huygens there sprang up a new generation which sustained the great tradition until about 1680, when the final decline set in. Jan Vos (d. 1667) gained one illustrious success with his tragedy of *Aaron and Titus* in 1641, and lost still more in the same year by his obscene farce of *Oene*. His second tragedy of *Medea*, in 1665, and his collected poems in 1662, supported his position as the foremost pupil of Vondel. Geeraerdt Brandt (1626–1685) deserves remembrance less as a tragic dramatist than as a consummate biographer, whose lives of Vondel and of De Ruyter are among the masterpieces of Dutch prose. Johan Antonides van der Goes (1647–1684) followed Vos as a skilful imitator of Vondel's tragical manner. His Chinese tragedies, *Trazil* (1665) and *Zungchin* (1666), scarcely gave promise of the brilliant force and fancy of his *Ijstroom*, a poem in praise of Amsterdam, 1671. He died suddenly, in early life, leaving unfinished an epic poem on the life of St Paul. Reyer Anslo (1626–1669) marks the decline of taste and vigour; his once famous descriptive epic, *The Plague at Naples*, is singularly tame and rococo in style. Joachim Oudaen (1628–1692) wrote in his youth two promising tragedies, *Johanna Gray* (1648) and *Konradyn* (1649). The Amsterdam section of the school of Cats produced Jeremias de Decker (1609–1646) and Joannes Vollenhove (1631–1708), voluminous writers of didactic verse. The engraver Jan Luiken (1649–1708) published in 1671 a very remarkable volume of poems. In lyrical poetry Starter had a single disciple, Daniel Jonctijs (1600–1652), who published a volume of love songs in 1639 under the affected and untranslatable title of *Rooselijns oochjens ontleed*. None of these poets, except in some slight degree Luiken, set before themselves any more ambitious task than to repeat with skill the effects of their predecessors.

Meanwhile the romantic and voluminous romances of the French school of Scudéry and Honoré d'Urfé had invaded Holland and become fashionable. Johan van Heemskerk (1597–1656), a councillor of the Hague, set himself to reproduce this product in native form, and published in 1637 his *Batavian Arcadia*, the first original Dutch romance, in which a party of romantic youths journey from the Hague to Katwijk, and undergo all sorts of romantic adventures. This book was excessively popular, and was imitated by Hendrik Zoeteboom in his *Zaanlandsche Arcadia* (1658), and by Lambertus Bos in his *Dordtsche Arcadia* (1662). A far more spirited and original romance is the *Mirandor* of Nikolaes Heinsius, the younger (b. 1655), a book which resembles *Gil Blas*, and precedes it by forty years. It was written when the author was only twenty years of age, and gave promise of very great talent in the future; but unfortunately Heinsius committed a murder only two years afterwards, and, escaping to Paris, was never heard of again.

Gallican dramatists. The drama fell into Gallicized hands at the death of Vondel and his immediate disciples. Lodewijck Meijer translated Corneille, and brought out his plays on the stage at Amsterdam, where he was manager of the national theatre or Schouwburg after Jan Vos. In connexion with Andries Pels, author of the tragedy of *Dido's Death*, Meijer constructed a dramatic club, entitled "Nil Volentibus Arduum," the great object of which was to inflict the French taste upon the public. Pels furthermore came forward as the censor of letters and satirist of barbarism in *Horace's Art of Poetry expounded*, in 1677, and in his *Use and Misuse of the Stage*, in 1681. Willem van Focquenbroch (1640–1679) was the most voluminous comic writer of this period. The close of the century saw the rise of two thoroughly Gallican dramatists, Johan van Paffenrode and Pieter Bernagie, who may not unfairly be compared respectively to our own Farquhar and Shadwell. Thomas Asselijn (1630–1695) was a writer of more considerable talent and more homely instincts. He attempted to resist the dictatorship of Pels, and to follow the national tradition of Brederôo. He is the creator of the characteristic Dutch type, the comic lover, Jan Klaaszen, whom he presented on the stage in a series of ridiculous situations. Abraham Alewijn, author of *Jan Los* (1721), possessed a coarse vein of dramatic humour; he lived in Java, and his plays were produced in Batavia. Finally Pieter Langendijk claims notice among the dramatists of this period, although he lived from 1683 to 1756, and properly belongs to the next century. With him the tradition of native comedy expired.

Decline of poetry. The Augustan period of poetry in Holland was even more blank and dull than in the other countries of Northern Europe. Of the names preserved in the history of literature there are but very few that call for repetition here. Arnold Hoogvliet (1687–1763) wrote a passable poem in honour of the town of Vlaardingen, and a terrible Biblical epic, in the manner of Blackmore, on the history of Abraham. Hubert Cornelissen Poot (1689–1733) showed an unusual love of nature and freshness of observation in his descriptive pieces. Sybrand Feitama (1694–1758), who translated Voltaire's *Henriade*, and wrote much dreary verse of the same class himself, is less worthy of notice than Dirk Smits (1702–1752), the mild and elegiac singer of Rotterdam. Tragic drama was more or less capably represented by Lucretia Wilhelmina van Merken (1722–1789), wife of the very dreary dramatist Nicholaas Simon van Winter (1718–1795).

Van Effen. In the midst of this complete dissolution of poetical style, a writer arose who revived an interest in literature, and gave to Dutch prose the classical grace of the 18th century. Justus van Effen (1684–1735) was born at Utrecht, fell into poverty early in life, and was thrown very much among the company of French émigrés, in connexion with whom he began literary life in 1713 by editing a French journal. Coming to London just when the *Tatler* and *Spectator* were in their first vogue, Van Effen studied Addison deeply, translated Swift and Defoe into French, and finally determined to transfer the beauties of English prose into his native language. It was not, however, until 1731, after having wasted the greater part of his life in writing French, that he began to publish his *Hollandsche Spectator*, which his death in 1735 soon brought to a close. Still, what he composed during the last four years of his life, in all its freshness, manliness, and versatility, constitutes the most valuable legacy to Dutch literature that the middle of the 18th century left behind it.

The brothers Van Haren. The supremacy of the poetical clubs in every town produced a very weakening and Della-Cruscan effect upon literature, from which the first revolt was made by the famous brothers Van Haren, so honourably known as diplomatists in the history of the Netherlands. Willem van Haren (1710–1768) wrote verses from his earliest youth, while Onno Zwier van Haren (1713–1779), strangely enough, did not begin to do so until he had passed middle life. They were friends of Voltaire, and they were both ambitious of success in epic writing, as understood in France at that period. Willem published in 1741 his *Gevallen van Friso*, an historical epos, and a long series of odes and solemn lyrical pieces. Onno, in a somewhat lighter strain, wrote *Piet and Agnietje, or Pandora's Box*, and a long series of tragedies in the manner of Voltaire. The Baroness Juliana Cornelia de Lannoy (1738–1782) was a writer of considerable talent, also of the school of Voltaire; her poems were highly esteemed by Bilderdijk, and she has a neatness of touch and clearness of penetration that give vivacity to her studies of social life. Jakobus Bellamy (1757–1786) was the son of a Swiss baker at Flushing; his pompous odes struck the final note of the false taste and Gallic pedantry that had deformed Dutch literature now for a century, and were for a short time excessively admired.

Baroness de Lannoy.

Bellamy.

The ladies Wolff and Dekken. The year 1777 has been mentioned as the turning-point in the history of letters in the Netherlands. It was in that year that Betjen Wolff (1738–1804), a widow lady in Amsterdam, persuaded her friend Aagjen Deken (1741–1804), a poor but extremely intelligent governess, to throw up her situation and live with her. For nearly thirty years these women continued together, writing in combination, and when the elder friend died on the 5th of November 1804, her companion survived her only nine days. Madame Wolff had appeared as a poetess so early as 1762, and again in 1769 and 1772, but her talent in verse was by no means very remarkable. But when the friends, in the third year of their association, published their *Letters on Divers Subjects*, it was plainly seen that in prose their talent was very remarkable indeed. Since the appearance of Heinsius's *Mirandor* more than a century had passed without any fresh start in novel-writing being made in Holland. In 1782 the ladies Wolff and Deken, inspired partly by contemporary English writers, and partly by Goethe, published their first novel, *Sara Burgerhart*. In spite of the close and obvious following of Richardson, this was a masterly production, and it was enthusiastically received. Another novel, *Willem Leevend*, followed in 1785, and *Cornelia Wildschut* in 1792. The ladies were residing in France at the breaking-out of the Revolution, and they escaped the guillotine with difficulty. After this they wrote no more, having secured for themselves by their three unrivalled romances a place among the foremost writers of their country.

The last years of the 18th century were marked in Holland by a general revival of intellectual force. The romantic movement in Germany made itself deeply felt in all branches of Dutch literature, and German lyricism took the place hitherto held by French classicism. Pieter Nieuwland (1764–1794) was a feeble forerunner of the revival, but his short life and indifferent powers gave him no chance of directing the transition that he saw to be inevitable. The real precursor and creator of a new epoch in letters was the famous Willem Bilderdijk (1756–1831). This remarkable man, whose force of character was even greater than his genius, impressed his personality on his generation so indelibly that to think of a Dutchman of the beginning of the present century is to think of Bilderdijk. He was born at Amsterdam on the 7th of September 1756, and through an accident in early childhood was obliged to rest almost constantly, thus attaining habits of long and

Nieuwland.

Bilderdijk.

concentrated study. His parents were zealous in the cause of the house of Orange, and the youth grew up violently monarchical and Calvinistic, as Da Costa says, "anti-revolutionary, anti-Barneveldtian, anti-Loevesteinish, anti-liberal." In poetry his taste was strictly national and didactic; he began as a disciple of Cats, nor could he to the end of his life tolerate what he called "the puerilities of Shakespeare." His early love-songs, collected in 1781 and 1785, gave little promise of talent, but in his epic of *Elias* in 1786, he showed himself superior to all the Dutch poets since Huygens in mastery of form. For twenty years he lived a busy, eventful life, writing great quantities of verse, and then commenced his most productive period with his didactic poem of *The Disease of the Learned*, in 1807; in 1808 he imitated Pope's *Essay on Man*, and published *Floris V.*, and in 1809 commenced the work which he designed to be his master-piece, the epic of *De Ondergang der eerste Wereld* (The Destruction of the First World), which he never finished, and which appeared as a fragment in 1820. His long and fretful life ceased on the 18th of December 1831. To the foreign student Bilderdijk is a singularly uninviting and unpleasing figure. He unites in himself all the unlovely and provincial features which deform the worst of his countrymen. He was violent, ignorant, and dull; his view of art was confined to its declamatory and least beautiful side, and perhaps no writer of equal talent has shown so complete an absence of taste and tact. Ten Brink has summed up the character of Bilderdijk's writings in an excellent passage:—"As an artist," he says, "he can perhaps be best described in short as the cleverest versemaker of the 18th century. His admirable erudition, his power over language, more extended and more colossal than that of any of his predecessors, enabled him to write pithy and thoroughly original verses, although the general tone of his thought and expression never rose above the ceremonious, stagy, and theatrical character of the 18th century." But in spite of his outrageous faults, and partly because these faults were the exaggeration of a marked national failing, Bilderdijk has enjoyed almost to the present day an unbroken and unbounded popularity in Holland. Fortunately, however, within the last few years a sounder spirit has arisen in criticism, and the prestige of Bilderdijk is no longer preserved so religiously.

Bilderdijk's scorn for the dramas of Shakespeare was almost rivalled by that he felt for the new German poetry. Notwithstanding his opposition, however, the romantic fervour found its way into Holland, and first of all in the persons of Hieronymus van Alphen (1746–1803) and Pieter Leonard van de Kastiele (1748–1810), who amused themselves by composing funeral poems of the school of Gessner and Blair. Van Alphen at one time was extolled as a writer of verses for children, but neither in this nor in the elegiac line did he possess nearly so much talent as Rhijnvis Feith (1753–1824), burgomaster of Zwolle, the very type of a prosperous and sentimental Dutchman. In his *Julia* (1783), a prose romance, Feith proved himself as completely the disciple of Goethe in *Werther* as Wolff and Deken had been of Richardson in their *Sara Burgerhart*. In Johannes Kinker (1764–1845) a comic poet arose who, at the instigation of Bilderdijk, dedicated himself to the ridicule of Feith's sentimentalities. The same office was performed with more dignity and less vivacity by Baron W. E. van Perponcher (1741–1819), but Feith continued to hold the popular ear, and achieved an immense success with his poem *The Grave*, in 1792. He then produced tragedies for a while, and in 1803 published *Antiquity*, a didactic epic. But his popularity waned before his death, and he was troubled by the mirth of such witty scoffers as Arend Fokke Simons (1755–1812), the disciple of Klopstock, and as P. de Wacker van Zon (1758–1818), who, in a series of very readable novels issued under the pseudonym of Bruno Daalberg, sharply ridiculed the sentimental and funereal school.

Feith.

Under the Batavian republic an historian of great genius arose in the person of Johannes Henricus van der Palm (1763–1840), whose brilliant and patriotic *Gedenkschrift van Nederlands Herstelling* (1816) has somewhat obscured his great fame as a politician and an Orientalist. The work commenced by Van der Palm in prose was continued in verse by Cornelis Loots (1765–1834) and Jan Frederik Helmers (1767–1813). Loots, in his *Batavians of the Time of Cæsar* (1805), read his countrymen a lesson in patriotism, which Helmers far exceeded in originality and force by his *Dutch Nation* in 1812. Neither of these poets, however, had sufficient art to render their pieces classical, or, indeed, enough to protect them during their lifetime from the sneers of Bilderdijk. Other political writers, whose lyrical energies were stimulated by the struggle with France, were Maurits Cornelis van Hall (1768–1858), Samuel Iperuszoon Wiselius (1769–1845), and Jan ten Brink (1771–1839), the second of whom immortalized himself and won the favour of Bilderdijk by ridiculing the pretensions of such frivolous tragedians as Shakespeare and Schiller.

Van der Palm. Loots. Helmers.

The healthy and national spirit in which the ladies Wolff and Deken had written was adopted with great spirit by a novelist in the next generation, Adriaan Loosjes (1761–1818), a bookseller at Haarlem. His romantic stories of mediæval life, especially his *Charlotte van Bourbon*, are curiously like shadows cast forward by the Waverley Novels, but he has little of Sir Walter Scott's historical truth of vision. His production was incessant and his popularity great for many years, but he was conscious all through that he was at best but a disciple of the authoresses of *Sara Burgerhart*. Another disciple whose name should not be passed over is Maria Jacoba de Neufville (1775–1856), author of *Little Duties*, an excellent story somewhat in the manner of Mrs Opie.

Loosjes.

A remarkable poet whose romantic genius strove to combine the power of Bilderdijk with the sweetness of Feith is Hendrik Tollens (1780–1856), whose verses have shown more vitality than those of most of his contemporaries. He struck out the admirable notion of celebrating the great deeds of Dutch history in a series of lyrical romances, many of which possess a lasting charm. Besides his folk-songs and popular ballads, he succeeded in a long descriptive poem, *A Winter in Nova Zembla*, 1819. He lacks the full accomplishment of a literary artist, but his inspiration was natural and abundant, and he thoroughly deserved the popularity with which his patriotic ballads were rewarded. Willem Messchert (1790–1844), a friend and follower of Tollens, pushed the domestic and familiar tone of the latter to a still further point, especially in his genre poem of the *Golden Wedding*, 1825. Both these writers were natives and residents of Rotterdam, which also claims the honour of being the birthplace of Adrianus Bogaers (1795–1870), the most considerable poetical figure of the time. Without the force and profusion of Bilderdijk, Bogaers has more truth to nature, more sweetness of imagination, and a more genuine gift of poetry than that clamorous writer, and is slowly taking a higher position in Dutch literature as Bilderdijk comes to take a lower one. Bogaers printed his famous poem *Jochebed* in 1835, but it had then been in existence more than thirteen years, so that it belongs to the second period of imaginative revival in Europe, and connects the name of its author with those of Byron and Heine. Still more beautiful was his *Voyage of Heemskerk to Gibraltar* (1836), in which he rose to the highest level of his genius. In 1846 he privately printed his *Romances and Ballads*. Bogaers had a great objection to publicity,

Tollens. Messchert. Bogaers.

and his reputation was long delayed by the secrecy with which he circulated his writings among a few intimate friends. A poet of considerable talent, whose powers were awakened by personal intercourse with Bogaers and Tollens, was Antoni Christiaan Winand Staring (1767–1840), who first at the age of fifty-three came before the world with a volume of *Poems*, but who continued to write till past his seventieth year. His amorous and humorous lyrics recall the best period of Dutch song, and are worthy to be named beside those of Starter and Vondel.

Since 1830 Holland has taken a more prominent position in European thought than she could claim since the end of the 17th century. In scientific and religious literature her men of letters have shown themselves cognizant of the newest shades of opinion, and have freely ventilated their ideas. The language has resisted the pressure of German from the outside, and from within has broken through its long stagnation and enriched itself, as a medium for literary expression, with a multitude of fresh and colloquial forms. At the same time, no very great genius has arisen in Holland in any branch of literature, and all that a foreign critic can do in such space as is here at his command is to chronicle the names of a few of the most prominent writers of the past and present generations. The vast labours of Jakobus van Lennep (1802–68) consist of innumerable translations, historical novels, and national romances, which have gained for him the title of the leader of the Dutch romantic school. Reinier Cornelis Bakhuizen van den Brink (1810–65) was the chief critic of the romantic movement, and Everhard Johannes Potgieter (1808–75) its mystical philosopher and esoteric lyrical poet. The genius and influence of Potgieter were very considerable, but they were exceeded by the gifts of Nicolaes Beets, author of the famous *Camera Obscura* (1836), a masterpiece of humour and character. Johannes Pieter Hasebroek, who has been called the Dutch Charles Lamb, wrote in 1840 an admirable collection of essays entitled *Truth and Dreams*. A poet of unusual power and promise was lost in the early death of Pieter Augustus de Genestet (1830–1861). Criticism has been represented by W. J. A. Jonckbloet, C. Busken Huet, and Jan ten Brink. With Isaac de Costa (1798–1860), W. J. van Zeggelen, and J. J. L. Ten Kate, the domestic tendency of Cats and Bilderdijk has overpowered the influence of romanticism. An independent writer of great power and charm both in prose and verse is C. Vosmaer, author of a life of Rembrandt, and of a translation of the *Iliad* into Dutch hexameters. E. Douwes Dekker, in his novel of *Max Havelaar*, and Marcellus Emants, in his poem of *Lilith*, have displayed talents of a very modern and cosmopolitan order, but it yet remains to be seen whether they have sufficient power to sustain their promise.

Revival of Flemish literature.

Flemish literature has again come into being since the independence of Belgium, and has produced two writers of very remarkable talent, the popular poet Karel Ledeganck (1805–47), and the still more popular novelist Hendrik Conscience. But the general use of the French language, although Flemish exercises are encouraged by the Government, has prevented any considerable cultivation of Flemish by modern writers of ambition.

Authorities.—Dr W. J. A. Jonckbloet, *Geschiedenis der Nederlandsche Letterkunde*, 2d ed., 1873; Dr J. ten Brink, *Kleine Geschiedenis der Nederlandschen Letteren*, Haarlem, 1877; Dr J. van Vloten, *Schets van de Geschiedenis der Nederlandschen Letteren*, 1879. (E. W. G.)

HOLLAND, or Holland and West Friesland, was the second province of the republic of the United Netherlands, and consisted of the old countship of Holland, with the addition of the lordship of Voorne. In 1801, after the erection of the Batavian republic, very nearly the same area was included in the "department" of Holland; but when in June 1806 Holland became the name of the new kingdom, it ceased to be applied to any of the administrative divisions. On the establishment of the kingdom of the Netherlands in 1814 the province of Holland was restored, with its ancient limits only slightly modified. A few further alterations were made in 1815, 1819, and 1820. It was the only province that had two governors, one for the north and another for the south, and the provincial states met alternately at the Hague and at Haarlem. In 1840 this bipartite arrangement was carried to its logical conclusion by the erection of two distinct provinces called respectively North and South Holland.

1. North Holland (*Noordholland*), the fourth province of the kingdom of the Netherlands, lies between the German Ocean and the Zuyder Zee, and on the land side is bounded by the provinces of South Holland and Utrecht. The area—which in 1855 was increased by the commune of Haarlemmermeer, and in 1864 was diminished by the larger part of Leimuiden—is estimated at 744,554 acres, exclusive of the newly won lands of the Y. The amount of available ground has been augmented by the draining not only of the Haarlemmermeer but also of more than a score of lesser lakes. In 1840 the population was returned at 443,334, in 1850 at 477,079, in 1860 at 521,125, and in 1875 at 620,890. In 1870, when the total was 577,436, there were 382,607 Protestants, 157,971 Roman Catholics, 2723 Old Catholics, and 32,953 Jews. Amsterdam is the largest city, with a population in 1876 of 296,200; and next in order as communes follow Haarlem, 34,797; Helder, 22,030; Haarlemmermeer, 13,171; Zaandam, 12,772; Alkmaar, 12,245; Nieuweramstel, 11,502; Hoorn, 9763; Hilversum, 7805; Texel, 6383; Enkhuizen, 5560; and Edam, 5361. There are besides 36 communes with more than 2000 inhabitants.

2. South Holland (*Zuidholland*) is the third province of the kingdom of the Netherlands. On the W. it is bounded by the German Ocean, on the N. by North Holland, on the E. by Utrecht and Guelderland, on the S.E. by North Brabant, and on the S. by Zealand. The area is estimated at 823,851 acres. In 1850 the population was returned at 564,000, in 1860 at 617,699, and in 1876 at 748,162. In 1870, when the total was 688,254, there were 508,132 Protestants, 166,219 Roman Catholics, and 12,152 Jews. The largest city is Rotterdam, with a population in 1876 of 136,230; and next in order as communes follow the Hague, 101,095; Leyden, 41,298; Dort, 26,576; Delft, 24,511; Schiedam, 21,880; Gouda, 17,070; Kralingen, 10,313; Delfshaven, 10,042; and Gorinchem, 9301. There are besides 74 communes with more than 2000 inhabitants.

HOLLAND, Sir Henry (1788–1873), physician and author, was born at Knutsford, Cheshire, on the 27th October 1788. He could claim relationship to three persons who have attained eminence in careers entirely different both from one another and from his own: his maternal grandmother was the sister of Josiah Wedgwood, whose grandson was Charles Darwin; and his paternal aunt was the mother of Mrs Gaskell. After spending some years at a private school at Knutsford, he was sent to a school at Newcastle-on-Tyne, whence after four years he was transferred to Dr Estlin's school near Bristol. There he at once took the position of head boy, in succession to John Cam Hobhouse, afterwards Lord Broughton, an honour which required to be maintained by physical prowess. On leaving school he became articled clerk to a mercantile firm in Liverpool, but, as the privilege was reserved to him of passing two sessions at Glasgow university, he at the close of his second session sought relief from his articles, and in 1806 began the study of medicine in the university of Edinburgh, where he graduated in 1811. After several years spent in foreign travel, he began practice in 1816 as a physician in London,—according to his own statement, "with a fair augury of success speedily and completely fulfilled." This "success," he adds, "was materially aided by visits for four successive years to Spa, at the close of that which is called the London season." It must also, however, be in a great degree attributed to his happy temperament and his gifts as a conversationalist—qualities the influence of which, in the majority of cases belonging to his class of practice, is often of more importance than direct medical treatment. In 1816 he was elected a fellow of the Royal Society, and in 1828 a fellow of the Royal College of Physicians. He became physician in ordinary to Prince Albert in 1840, and was appointed in 1852 physician in ordinary to the Queen. In April 1853 he was created a baronet. He was also a D.C.L. of Oxford and a member of the principal learned societies of Europe. He was twice married, his second wife being a daughter of Sydney Smith, a lady of considerable literary talent, who published a biography of her father. Sir Henry Holland at an early period of his practice resolved to devote to his professional duties no more of his time than was necessary to secure an income of £5000 a-year, and also to spend two months of every year solely in foreign travel. By the former resolution he secured leisure for a wide acquaintance with general literature, and for a more than superficial cultivation of several branches of science; and the latter enabled him, besides visiting, "and most of them repeatedly, every country of Europe," to make extensive tours in the other three continents, journeying often to places little frequented by European travellers. As, moreover, he procured an introduction to nearly all the eminent personages in his line of travel, and knew many of them in his capacity of physician, his acquaintance with "men and cities" was of a species without a parallel. The *London Medical Record*, in noticing his death, which took place on his eighty-fifth birthday, October 27, 1873, remarked that it "had occurred under circumstances highly characteristic of his remarkable career." On his return from a journey in Russia he was present, on Friday, October 24th, at the trial of Marshal Bazaine in Paris, dining with some of the judges in the evening. He reached London on the Saturday, took ill the following day, and died quietly on the Monday afternoon.

Sir Henry Holland was the author of *General View of the Agriculture of Cheshire*, 1807; *Travels in the Ionian Isles, Albania, Thessaly, and Greece*, 1812-13, 2d ed., 1819; *Medical Notes and Reflections*, 1839; *Chapters on Mental Physiology*, 1852; *Essays on Scientific and other Subjects contributed to the Edinburgh and Quarterly Reviews*, 1862; and *Recollections of Past Life*, 1872, which is less interesting than it might have been, owing to the reticence of the author in regard to personal details and characteristics.

HOLLAND, PHILEMON (1551-1636), usually styled, in the words of Thomas Fuller, "the translator-general of his age," was born in 1551 at Chelmsford, in Essex, the son of a clergyman, John Holland, who had been obliged to take refuge abroad during the Marian persecution. Having become a fellow of Trinity College, Cambridge, and passed M.A. at Oxford in 1587, he further took the degree of M.D. at Cambridge in 1591. In 1612 he was sworn freeman of the city of Coventry, and in 1617, dressed in a suit which cost £11, 1s. 11d., he had the honour of reading, as the recorder's deputy, an oration to King James I. In 1628 he was appointed head master of the free school of Coventry, but, owing probably to advancing old age, he held office only for eleven months. His latter days were oppressed by poverty, partly relieved by the generosity of the common council of Coventry, which in 1632 assigned him £3, 6s. 8d. for three years, "if he should live so long." He died February 9, 1636, survived by only one of his seven sons. The fame of Philemon Holland is due solely to his activity as a translator; Livy, Pliny's *Natural History*, Plutarch's *Morals*, Suetonius, Ammianus Marcellinus, and Xenophon's *Cyropædia* successively employed him; and he also published an English version of Camden's *Britannia*. Pope's allusion to his voluminousness is well known—

"De Lyra there his dreadful front extends,
And here the groaning shelves Philemon bends."

Henry Holland, his surviving son, became a London bookseller, and is known to bibliographers for his *Baziliωlogia; a Booke of Kings, beeing the true and liuely Effigies of all our English Kings from the Conquest* (London, 1618), and his *Herωologia Anglica, hoc est clariss. et doctiss. aliquot Anglorum viuæ Effigies, Vitæ et Elogia* (1620).

See Colvile's *Worthies of Warwickshire* (Warwick, 1869), and Lowndes's *Bibliographical Manual*.

HOLLAND, HENRY RICHARD VASSALL FOX, THIRD BARON (1773-1840), nephew of Charles James Fox and only son of Stephen Fox, second Lord Holland, was born at Winterslow House, Wiltshire, 21st November 1773. Of his ancestry an account is given in the article FOX (CHARLES JAMES). Not long after his birth he was with difficulty saved from the flames which destroyed the splendid family mansion in which he was born. When little more than a year old he succeeded, through the death of his father, to the peerage. On the death of his mother in his fifth year, the care of his early education nominally devolved upon her brother, the earl of Upper Ossory, but the character of his early training and studies was determined chiefly by his uncle Charles James Fox, of whom he wrote—"He seemed to take pleasure in awakening my ambition, and directing it both by conversation and correspondence, and yet more by talking to me of my studies and inspiring me with a love of poetry both ancient and modern." After spending eight or nine years at Eton, where he had as contemporaries J. Hookham Frere, Mr Canning, and Frederick Howard, fifth earl of Carlisle, he in 1790 entered Christ Church College, Oxford. Though the years of his early manhood were occupied more in amusement than in study, he acquired at school and the university a taste for classical literature which he more fully cultivated in after life. Before taking his seat in the House of Lords, he made two tours on the Continent,—in 1791, while still a student at Oxford, visiting Paris about the time when Louis XVI. accepted the revolutionary constitution; and in 1793 making a prolonged stay in Spain, where he began the study of its language and literature. Thence he went in 1795 to Italy; and at Florence he formed the acquaintance of Lady Webster, wife of Sir Godfrey Webster, whom after her divorce from her husband —who received £6000 damages in the action against Lord Holland—he married in 1797. After the marriage he assumed his wife's family name of Vassall, but its use was discontinued by his son, the fourth and last Lord Holland.

Lord Holland's early inheritance of a peerage must be regarded rather as a misfortune than an advantage, for it debarred him from a career in the House of Commons which might have proved as brilliant as that of his uncle Charles Fox, and raised him to an assembly, not only more listless and much less numerous, but where at the time he entered it the Whig party, of whose principles the influence of his uncle had induced him to become a strenuous supporter, could muster only a minority of six or seven in a house of eighty or ninety. He began his political career by a motion against the Assessed Tax Bill, and though his speech had, as was to be expected, no influence on the division, it proved that he had inherited the oratorical abilities of his family, and pointed him out as the leader of his uncle's supporters in the Upper House. As his disapproval of most of the proceedings of the House of Lords was recorded by protests, his copiousness in this species of composition has perhaps never been equalled. These protests were afterwards collected and published by D. C. Moylan under the title *The Opinions of Lord Holland as recorded in the Journals of the House of Lords, from* 1797 *to* 1841 (London, 1841), and, besides constituting, as they necessarily do, a full though condensed account of his political views and opinions, form one of the most authentic and original records of the course of Whig policy during the years to which they refer. After the peace of Amiens in 1802 Lord Holland proceeded to Paris, whence he went to Spain, staying in that country until the declaration of war in January 1805, when he returned to England. Of this second visit to Spain he doubtless took advantage for the purpose of acquiring a more complete mastery of the Spanish language and literature, and the fruit of this was seen by the publication in 1807 of *The Life and Writings of Lope Felix de Vega Carpio*, and in 1808 of *Three Comedies from the Spanish*. When the ministry of "All the Talents" came into office in 1806, Lord Holland was made a privy councillor, and was appointed along with Lord Auckland to negotiate with the American plenipotentiaries that treaty the refusal of whose ratification by Mr Jefferson resulted in the subsequent war with America. On the death of Mr Fox, 15th October following, Lord Holland received the privy seal, holding office till the dismissal of the ministry in 1807. When the Spaniards rebelled against the French yoke in 1808, Lord Holland's interest in the country induced him to pay it a third visit. He landed at Corunna almost simultaneously with the division of the British army under Sir David Baird, and did not return to England till the close of 1809. During the long period when the Whigs were excluded from power Lord Holland continued to afford them his strenuous and steady support. He did not join the Canning ministry of 1827, but when the Whigs were recalled in 1830 he became chancellor of the duchy of Lancaster, an office which, with the exception of two short intervals when his party were temporarily excluded from power, he continued to hold till his death at Holland House, 22d October 1840.

Although Lord Holland for the greater period of his life had to lead the forlorn hope of his party in the House of Lords, his influence on the politics of his country was of an importance far beyond what was manifest at the time, and without his persistent support in parliament and his aid in maintaining his party's courage and discipline, the triumph of many of the measures he advocated would in all probability not have been so speedy and complete. Few have been more closely identified with all the great political changes of the first half of the present century, more especially the extension of the suffrage, the abrogation of Catholic disabilities, the abolition of the Test and Corporation Acts, the repeal of the corn laws, and the repression of the slave trade. A sympathizer with the French Revolution, he differed from his party in his admiration and esteem for Napoleon, against whose imprisonment he protested as an outrageous violation both of good faith and of what was due to fallen greatness. The character of Lord Holland's oratory very closely resembled that of his uncle Charles Fox, and was inferior to it only perhaps because his natural indolence was not counteracted by the stimulus of a popular assembly encouraging him to a more careful study of the art of eloquence, and affording him more adequate opportunities for its display. He excelled principally in close reasoning rendered clear and easy of apprehension by copious illustration, and—as was to be expected from the fact that he trusted little to previous preparation—was more happy in reply than in original statement. The effect of the best passages of his speeches was often marred by a more aggravated form of that tendency to hesitation which was one of the principal oratorical defects of Fox, the rush of ideas seeming to be too rapid to permit him to select with ease from his copious vocabulary the word most appropriate for his purpose. According to Lord Brougham—"The same delicate sense of humour which distinguished Mr Fox he also showed, and much of the exquisite Attic wit which formed so large and so effective a portion of that great orator's argumentation, never uselessly introduced, always adapted nicely to the occasion, always aiding and as it were directing the reasoning." The language both of his spoken and written style was graceful, pure, flowing, and vigorous, and entirely devoid of extravagance, singularity, or affectation. In addition to his poetical translations, he was the author of fugitive verses of some elegance. Two of his works were published posthumously by his son Henry Edward, fourth Lord Holland —*Foreign Reminiscences* (1850), and *Memoirs of the Whig Party during my Time* (2 vols. 1852-54).

It is, however, as the restorer of Holland House, and as the host of the brilliant company which he there assembled, that Lord Holland in all probability will be chiefly remembered by posterity. Though his temper was quick and excitable, his amiable disposition rendered his manners in private uniformly cordial and engaging. His conversation, easy, unconstrained, and of great variety both as to manner and matter, was enlivened by a peculiarly genial wit, and a never-failing supply of racy anecdote to which his powers of mimicry gave additional point and zest. The width of his sympathies and his manifold acquirements enabled him to enjoy the society of persons of every species of intellectual eminence. Holland House, which owes its name to Henry Rich, first earl of Holland,—who was no relation of the Fox family,—and which had been afterwards the home of Addison and of other tenants of various kinds of distinction, was restored by Lord Holland in a manner worthy of the company of European statesmen, artists, and men of letters, of which it became the common meeting-place. Much of the attraction of these brilliant gatherings was due to the management and personal influence of Lady Holland, who had the peculiar gift of making herself both feared and fascinating at the same time. Of her the Princess Liechtenstein writes—"Beautiful, clever, and well-informed, she exercised a natural authority over those around her. But a habit of contradiction—which, it is fair to add, she did not mind being reciprocated upon herself—occasionally lent animation, not to say animosity, to the arguments in which she engaged. It is easy for some natures to say a disagreeable thing, but it is not always easy to carry a disagreeable thing off cleverly. This Lady Holland could do."

See Macaulay's *Essays*; Brougham's *Statesmen of the Time of George III. and IV.*; Hayward's *Essays*; Sir Henry Holland's *Recollections*; and *Holland House*, by Princess Marie Liechtenstein, 2 vols., 1874.

HOLLAR, WENZEL or WENCESLAUS (1607-1677), a celebrated etcher, was born at Prague on July 13, 1607, and died in Westminster, being buried at St Margaret's church on March 28, 1677. His family was ruined by the capture of Prague in the Thirty Years' War, and young Hollar, who had been destined for the law, determined to become an artist. The earliest of his works that have come down to us are dated 1625 and 1626; they are small plates, and one of them is a copy of a Virgin and Child by Dürer, whose influence upon Hollar's work was always great. In 1627 he was at Frankfort, working under Matthew Merian, an etcher and engraver; thence he passed to Strasburg and thence, in 1633, to Cologne. It was there that he attracted the notice of the famous amateur Thomas, earl of Arundel, then on an embassy to the imperial court; and with him Hollar travelled to Vienna and Prague, and finally came in 1637 to England, destined to be his home for many years. Though he lived in the household of Lord Arundel, he seems to have worked not exclusively for him, but to have begun that slavery to the publishers which was afterwards the normal condition of his life. In his first year in England he made for Stent, the printseller, the magnificent View of Greenwich, nearly a yard long, and received thirty shillings for the plate,—perhaps a twentieth part of what would now be paid for a single good impression. Afterwards we hear of his fixing the price of his work at fourpence an hour, and measuring his time by a sandglass. The civil war had its effect on his fortunes, but none on his industry. Lord Arundel left England in 1642, and Hollar passed into the service of the duke of York, taking with him a wife and two children. With other royalist artists, notably Inigo Jones and Faithorne, he stood the long and eventful siege of Basing House; and as we have some hundred plates from his hand dated during the years 1643 and 1644 he must have turned his enforced leisure to good purpose. Taken prisoner, he escaped or was released, and joined Lord Arundel at Antwerp, and there he remained eight years, the prime of his working life, when he produced his finest plates of every kind, his noblest views, his miraculous "muffs" and "shells," and the superb portrait of the duke of York. In 1652 he returned to London, and lived for a time with Faithorne the engraver near Temple Bar. During the following years were published many books which he illustrated:—Ogilby's *Virgil* and *Homer*, Stapylton's *Juvenal*, and Dugdale's *Warwickshire*, *St Paul's*, and *Monasticon* (part i.). The booksellers continued to impose on the simple-minded foreigner, pretending to decline his work that he might still further reduce the wretched price he charged them. Nor did the Restoration improve his position. The court did nothing for him, and in the great plague he lost his young son, who, we are told, might have rivalled his father as an artist. After the great fire he produced some of his famous "Views of London"; and it may have been the success of these plates which induced the king to send him, in 1668, to Tangier, to draw the town and forts. During his return to England occurred the desperate and successful engagement fought by his ship the "Mary Rose," under Captain Kempthorne, against seven Algerine men-of-war,—a brilliant affair which Hollar etched for Ogilby's *Africa*. He lived eight years after his return, still working for the booksellers, and retaining to the end his wonderful powers; witness the large plate of Edinburgh (dated 1670), one of the greatest of his works. He died in extreme poverty, his last recorded words being a request to the bailiffs that they would not carry away the bed on which he was dying.

Hollar has been called by a recent critic "the most accurate delineator and the most ingenious illustrator of his time, and as to technic the most able etcher." His variety was boundless; his plates number some 2740, and include views, portraits, ships, religious subjects, heraldic subjects, landscapes, and still life in a hundred different forms. No one that ever lived has been able to represent fur, or shells, or a butterfly's wing, as he has done. His architectural drawings, such as those of Antwerp and Strasburg cathedrals, and his views of towns, are mathematically exact, but they are pictures as well. He could reproduce the decorative works of other artists quite faultlessly, as in the famous chalice after Mantegna's drawing. His *Theatrum Mulierum* and similar collections reproduce for us with literal truth the outward aspects of the people of his day; and his portraits, a branch of art in which he has been unfairly disparaged, are of extraordinary refinement and power. His genius is wholly unlike that of his great contemporary Rembrandt; it aims rather at the delicate rendering of details than at the truth of character and the mystery of light and shade. But in his own way Hollar is as perfect as Rembrandt.

Almost complete collections of Hollar's works exist in the British Museum and in the library at Windsor Castle. Two admirable catalogues of his plates have been made, one in 1745 (2d ed., 1759), by George Vertue, and one in 1853 by Parthey. The latter, published at Berlin, is a model of German thoroughness and accuracy, and leaves very little to be added by future research.

HOLLY, *Ilex*, L., a genus of trees and shrubs of the natural order *Ilicineæ* or *Aquifoliaceæ*, containing some one hundred and fifty species, of which several occur in the temperate northern hemisphere, North-West America excepted, by far the larger number in tropical Asia and America, and very few in Africa and Australia. In Europe, where *I. Aquifolium* is the sole surviving species, the genus was richly represented during the Miocene period by forms at first South American and Asiatic, and later North American in type (Schimper, *Paléont. Végét.*, iii. 204, 1874). The leaves are generally coriaceous and evergreen, and are alternate and stalked; the flowers are commonly diœcious, are in axillary cymes, fascicles, or umbellules, and have a persistent four- to five-lobed or parted calyx, a white, rotate four- or rarely five- or six-cleft corolla, with the four or five stamens adherent to its base in the male, sometimes hypogynous in the female flowers, and a two- to twelve-celled ovary; and the fruit is a globose, very seldom ovoid, and usually red drupe, containing two to sixteen one-seeded stones.

The Common Holly, or Hulver (apparently the κήλαστρος of Theophrastus;[1] Ang.-Sax., *holen* or *holegn*; Mid. Eng., *holyn* or *holin*, whence *holm* and *holmtree*;[2] Welsh, *celyn*; Germ., *Stechpalme*, *Hülse*, *Hulst*; Old Fr., *houx*; and Fr., *houlx*),[3] *I. Aquifolium*, L., is an evergreen shrub or low tree, having smooth, ash coloured bark, and wavy, pointed, smooth, and glossy leaves, 2 to 3 inches long, with a spinous margin, raised and cartilaginous below, or, as commonly on the upper branches of the older trees, entire—a peculiarity alluded to by Southey in his poem *The Holly Tree*. The flowers, which appear in May, are ordinarily diœcious, as in all the best of the cultivated varieties in nurseries (*Gard. Chron.*, 1877, i. 149). Darwin (*Diff. Forms of Flow.*, p. 297, 1877) says of the holly: "During several years I have examined many plants, but have never found one that was really hermaphrodite." Shirley Hibberd, however (*Gard. Chron.*, 1877, ii. 777), mentions the occurrence of "flowers bearing globose anthers well furnished with pollen, and also perfect ovaries." In his opinion, *I. Aquifolium* changes its sex from male to female with age. In the female flowers the stamens are destitute of pollen, though but slightly or not at all shorter than in the male flowers; the latter are

[1] *Hist. Plant.*, i. 9. 3, iii. 3. 1, and 4. 6, *et passim*. On the *aquifolium* or *aquifolia* of Latin authors, commonly regarded as the holly, see A. de Grandsagne, *Hist. Nat. de Pline*, bk. xvi., "Notes," pp. 199, 206.

[2] The term "holm," as indicative of a prevalence of holly, is stated to have entered into the names of several places in Britain. From its superficial resemblance to the holly, the tree *Quercus Ilex*, L., the evergreen oak, received the appellation of "holm-oak."

[3] Skeat (*Etymolog. Dict.*, 1879) with reference to the word holly remarks: "The form of the base KUL (=Teutonic HUL) is probably connected with Lat. *culmen*, a peak, *culmus*, a stalk; perhaps because the leaves are 'pointed.'" Grimm (*Deut. Wört-rb.*, Bd. iv.) suggests that the term *Hulst*, as the O.H.G. *Hulis*, applied to the butcher's broom, or knee-holly, in the earliest times used for hedges, may have reference to the holly as a protecting (*hüllender*) plant.

more numerous than the female, and have a smaller ovary, and a larger corolla, to which the filaments adhere for a greater length. The corolla in male plants falls off entire, whereas in fruit-bearers it is broken into separate segments by the swelling of the young ovary (M'Nab). The holly occurs in Britain, north east Scotland excepted, and in western and southern Europe, from as high as 62° N. lat. in Norway to Turkey and the Caucasus, and in western Asia. It is found generally in forest glades or in hedges, and does not flourish under the shade of other trees. In England it is usually small, probably on account of its destruction for timber, but it may attain to 60 or 70 feet in height, and Loudon mentions one tree at Claremont, in Surrey, of 80 feet. Some of the trees on Bleak Hill, Shropshire, are asserted to be 14 feet in girth at some distance from the ground (*N. and Q.*, 5th ser., xii. 508). The holly is abundant in France, especially in Britanny. It will grow in almost any soil not absolutely wet, but flourishes best in rather dry than moist sandy loam. Beckmann (*Hist. of Invent.*, i. 193, 1846) says that the plant which first induced J. di Castro to search for alum in Italy was the holly, which is there still considered to indicate that its habitat is aluminiferous. The holly is propagated by means of the seeds, which do not normally germinate until their second year (see ARBORICULTURE, vol. ii. p. 322), by whip-grafting and budding, and by cuttings of the matured summer shoots, which, placed in sandy soil and kept under cover of a hand-glass in sheltered situations, generally strike root in spring. Transplantation should be performed in damp weather in September and October, or, according to some writers, in spring or on mild days in winter, and care should be taken that the roots are not dried by exposure to the air. It is rarely injured by frosts in Britain, where its foliage and bright red berries in winter render it a valuable ornamental tree. The yield of berries has been noticed to be less when a warm spring, following on a wet winter season, has promoted excess of growth. There are numerous varieties of the holly. Some trees have yellow, and others white or even black fruit. In the fruitless variety *laurifolia*, "the most floriferous of all hollies" (Hibberd), the flowers are highly fragrant; the form known as *femina* is, on the other hand, remarkable for the number of its berries. The leaves in the unarmed varieties *aureo-marginata* and *albo-marginata* are of great beauty, and in *ferox* they are studded with sharp prickles. The holly is of importance as a hedge-plant (see ARBORICULTURE, vol. ii. p. 319), and is patient of clipping, which is best performed by the knife. Evelyn's holly hedge at Say's Court, Deptford, was 400 feet long, 9 feet high, and 5 feet in breadth. To form fences, for which Evelyn recommends the employment of seedlings from woods, the plants should be 9 to 12 inches in height, with plenty of small fibrous roots, and require to be set 1 to 1½ feet apart, in well-manured and weeded ground, and thoroughly watered.

The wood of the holly is even-grained and hard, especially when from the heartwood of large trees, and almost as white as ivory, except near the centre of old trunks, where it is brownish. It is employed in inlaying and turning, and, since it stains well, in the place of ebony, as for tea-pot handles. For engraving it is inferior to box. When dry it weighs about 47½ lb per cubic foot. From the bark of the holly bird-lime is manufactured. From the leaves are obtainable a colouring matter named *ilixanthin*, *ilicic acid*, and a bitter principle, *ilicin*, which has been variously described by different analytical chemists. The leaves have been used in rheumatism, and were at one time, on account of their taste, supposed to be of value in intermittent fever. A. Lonicerus (*Kreuterb.*, Th. 1, p. xxxviii., Frankf., 1582, fol.) speaks of their decoction as a remedy for pain in the side. They are eaten by sheep and deer, and in parts of France serve as a winter fodder for cattle. The berries provoke in man violent emesis and catharsis, but are eaten with immunity by thrushes and other birds. The larvæ of the moths *Sphinx ligustri*, L., and *Phoxopteryx nævana*, Hb., have been met with on holly. The leaves are mined by the larva of a fly, *Phytomyza ilicis*, and both on them and the tops of the young twigs occurs the plant-louse *Aphis ilicis*, Kalt. (Kaltenbach, *Pflanzenfeinde*, p. 427, 1874). The custom of employing holly and other plants for decorative purposes at Christmas is one of considerable antiquity, and has been regarded as a survival of the usages of the Roman Saturnalia, or of an old Teutonic practice of hanging the interior of dwellings with evergreens as a refuge for sylvan spirits from the inclemency of winter. A Border proverb defines an habitual story-teller as one that "lees never but when the hollen is green." Several popular superstitions exist with respect to holly. In the county of Rutland it is deemed unlucky to introduce it into a house before Christmas Eve. In some English rural districts the prickly and non-prickly kinds are distinguished as "he" and "she" holly; and in Derbyshire the tradition obtains that according as the holly brought at Christmas into a house is smooth or rough, the wife or the husband will be master. Holly that has adorned churches at that season are in Worcestershire and Herefordshire much esteemed and cherished, the possession of a small branch with berries being supposed to bring a lucky year; and Lonicerus (*op. cit.*) mentions a notion in his time vulgarly prevalent in Germany that consecrated twigs of the plant hung over a door are a protection against thunder.

Among the North American species of *Ilex* are *I. opaca*, Ait., which resembles the European tree, and the Inkberry, *I.* (*Prinos*) *glabra*, L., and the American Black Alder, or Winterberry, *I.* (*Prinos*) *verticillata*, L. Hooker (*Fl. of Brit. India*, i. 598,606) enumerates twenty-four Indian species of Ilex. The Japanese *I. crenata*, Thb., and *I. latifolia*, Thb., a remarkably hardy plant, and the North American *I. Dahoon*, Walt., are among the species cultivated in Britain. The leaves of several species of *Ilex* are used by dyers. The member of the genus most important economically is *I. paraguayensis*, St.-Hil., the prepared leaves of which constitute Paraguay tea, or MATÉ (*q.v.*). Knee Holly is the species *Ruscus aculeatus*, L.; Sea Holly, *Eryngium maritimum*, L.; and the Mountain Holly of America, *Nemopanthes canadensis*, D. C.

See, besides the above mentioned works, T. Forster, *The Perennial Calendar*, p 726, 1824; Loudon, *Arboretum*, ii. 506, 1844; De Candolle, *Géog. Botan.*, i. 1855; Lindley, *Med. and Œconom. Bot.*, p. 190, 2d ed., 1856; N. Paterson, *The Manse Garden*, pp. 17 *seq.*, 1860; Syme, *Sowerby's Eng. Bot.*, ii 219, 1864; Darwin, *Origin of Species*, p. 107, 5th ed., 1869, and *Anim. and Pl.*, i. 384, ii. 19, 230; Stillé and Maisch, *The National Dispensatory*, p. 754, 2d ed., 1879; J. Britten and R. Holland, *Dict of Eng. Plant Names*, pt. ii. pp. 253, 263–4, Eng. Dialect Soc., 1880; *Notes and Queries*, 2d ser., i. 335, 398, 443, 502, iii. 344, 4th ser., viii. 506, x. 486, 492, xii. 467, 5th ser, xi. 206, ix. 67; and *The Garden*, xiii., xiv, 1878. (F. H. B.)

HOLLYHOCK (from M.E. *holi*—doubtless because brought from the Holy Land, where it is indigenous (Wedg.)—and A.-S. *hoc*, a mallow), *Althæa rosea*, L., a perennial plant of the natural order *Malvaceæ* and tribe *Malveæ*, a native of the East, has been cultivated in Great Britain for about three centuries. The ordinary hollyhock is single-blossomed, but the florists' varieties have all double flowers, of white, yellow, rose, purple, violet, and other tints, some being almost black. The plant is in its prime about August, but by careful management examples may be obtained in blossom from July to as late as November. Hollyhocks are propagated from seed, or by division of the root, or by planting out in rich sandy soil, in a close frame, with a gentle bottom heat, single eyes from wood-shoots, or cuttings from outgrowths of the old stock or of the lateral offsets of the spike. The seed may be sown in October under cover, the plants obtained being potted in November, and kept under glass till the following April, or, if it be late-gathered, in May or June, in the open ground, whence, if required, the plants are best removed in October or April. Seedlings may also be raised in February or March, by the aid of a gentle heat, in a light and rich moist soil; they should not be watered till they have made their second leaves, and when large enough for handling should be pricked off in a cold frame; they are subsequently transferred to the flower-bed. Hollyhocks thrive best in a well-trenched and manured sandy loam. The spikes as they grow must be staked; and water and, for the finest blossoms, liquid manure should be liberally supplied to the roots. Plants for exhibition require pruning of side growths; and it is recommended, when the flowering is over, and the stalks have been cut off 4 to 6 inches above the soil, to earth up the crowns with sand. Some of the finest double-flowered kinds of hollyhock will not bloom well in Scotland. The plant is susceptible of great modification under cultivation. The forms now grown are due to the careful selection and crossing of varieties, first by Mr Charles Baron, a shoemaker at Saffron-Walden, and afterwards by Mr Paul of Cheshunt, Messrs R. B. Bircham, W. Chater, Downie & Laird, John Laing, Anthony Parsons, and other well-known floriculturists. It is found that the most diverse varieties may be raised with certainty from plants growing near together. Darwin from the seed of 11 out of 18 varieties procured 62 plants, all perfectly true to their kind, and from the seed of the remaining 7 varieties 49 plants, half true and half false. Mr Masters of Canterbury, he relates, saved seed from a great bed of 24 named varieties planted in closely adjoining rows, each of which faithfully reproduced itself, with only sometimes a shade of difference in tint. Since the abundant pollen of the hollyhock becomes ripe, and is for the most part shed, before the stigma of the flower affording it is ready for its reception, the preservation of the individuality of different varieties flourishing side by side, in spite of the frequent visits of bees (unless, as suggested by Mr Turner of Slough, those insects be debarred access to the pollen and stigmas by the doubleness of the flowers), would appear to be due to the prepotency of the pollen of each variety on its own stigma over that of all other plants. The hollyhock is very liable to the attacks of slugs, and to a disease occasioned by a fungus, *Puccinia malvacearum*, which, originally from South America, attained notoriety in the Australian colonies, and finally, reaching Europe, threatened the extermination of the hollyhock, the soft parts of the leaves of which it destroys, leaving the venation only remaining. It has been found especially hurtful to the plant in dry seasons. Wild mallows, upon which also it is parasitic, do not appear to be very injuriously affected by it. As means of getting rid of this pest the following expedients have been resorted to:—the application of a weak aqueous solution of Condy's fluid, which in killing it turns its natural light grey colour to a rusty black, or of a strong solution of soft soap with sulphur ("Gishurst compound"); the destruction of the plants, and their replacement by healthy stocks; and, as practised by Mr Chater, cultivation in highly-manured trenches, with all possible exposure to the open air, and mulching during summer.

See Darwin, *Var. of Anim. and Plants under Domest.*, ii. 107, 310; *Treas. of Bot.*, 2d ed., 1874; M. C. Cooke and M. J. Berkeley, *Fungi: their Nature, Influence, and Uses*, p. 230, 1875; *Florist*, 1875; *Floral World*, 1877 and 1879; *Gardener's Chron.*, 1877, i. 114, and 1878, i. 766, and ii. 478; and, for fig. of pollen of hollyhock, BOTANY, vol. iv. p. 139.

HOLMAN, JAMES (*c.* 1787–1857), the "Blind Traveller," was born about 1787. He entered the British navy in 1798 as first-class volunteer, and was appointed lieutenant in April 1807. In 1810 he was invalided by an illness which resulted in the total and hopeless deprivation of sight. In consideration of his helpless circumstances he was in 1812 appointed one of the royal knights of Windsor, but the dulness and seclusion of such a life harmonized so ill with his active habits and his keen interest in the outside world that he requested leave of absence that he might go abroad. This being granted, he in 1819, 1820, and 1821 journeyed through France, Italy, Switzerland, the parts of Germany bordering on the Rhine, Belgium, and the Netherlands. In 1822 he published a narrative of his journey. His enjoyment in his travels was derived from the love of locomotion and the attendant exercise, the varieties of company and of topics of conversation, and the information and descriptions he obtained from eye-witnesses, which constantly supplied him with new materials on which to exercise his imagination. He again set out in 1822 with the design of making the circuit of the world, but after travelling through Russia into Siberia, he was arrested when he had managed to penetrate 1000 miles beyond Smolensk, and after being conducted to the frontiers of Poland, returned home by Austria, Saxony, Prussia, and Hanover. The pretext for arresting him was the suspicion of his being a spy, but the probability is that the authorities wished to prevent him from persevering in what they must have regarded as, to one in his helpless condition, a foolish and hazardous adventure. An account of his journey was published in 1825. Shortly afterwards he again set out to accomplish by a somewhat different method the design which had been frustrated by the Russian authorities; and an account of his remarkable achievement was published in four volumes in 1834–35, under the title of *A Voyage round the World, including Travels in Africa, Asia, Australasia, America, &c., from* 1827 *to* 1832. His last journeys were through Spain, Portugal, Wallachia, Moldavia, Montenegro, Syria, and Turkey; and he was engaged in preparing his journals of this tour for the press when he died at London, 29th July 1857. The works of Holman, besides the interest attaching to them from his incidental references to the peculiarities of his circumstances arising from his physical defect, and to his methods of triumphing over his difficulties, occupy a unique place in literature as products of very extraordinary energy and perseverance, while, on account of the variety of their information and their frequently graphic descriptions, they are of considerable value as books of travel.

HOLSTEIN. See SCHLESWIG-HOLSTEIN.

HOLT, SIR JOHN (1642–1710), lord chief-justice of the Court of King's Bench in the reigns of William III. and Anne, was born at Thame, Oxfordshire, December 30, 1642. His father, Sir Thomas Holt, possessed a small patrimonial estate, but in order to supplement his income had adopted the profession of law, in which he was not very successful, although he became sergeant in 1677, and afterwards for his political services to the "Tories" was rewarded with knighthood. After attending for some years the free school of the town of Abingdon, of which his father was recorder, young Holt in his sixteenth year entered Oriel College, Oxford. He is said to have spent a very dissipated youth, and even to have been in the habit of taking purses on the highway, but after entering Gray's Inn about 1660 he completely renounced his old habits and applied himself with exemplary diligence to the study of law. He was called to the bar in 1663, and, although his youth hindered his immediate success, when once he had an opportunity of manifesting his talent he speedily acquired a lucrative practice. An ardent supporter of civil and religious liberty, he distinguished himself in the state trials which were then so common by the able and courageous manner in which he supported the pleas of the defendants. In February 1666 he was appointed recorder of London, and on the 22d of April he was made king's sergeant and received the honour of knighthood. His giving a decision adverse to the pretensions of the king to exercise martial law in time of peace led to his dismissal from the office of recorder, but he was continued in the office of king's sergeant in order to prevent him from becoming counsel for accused persons. Having been one of the judges who acted as assessors to the peers in the Convention parliament, he took a leading part in arranging the constitutional change by which William III. was called to the throne, and after his accession he was appointed lord chief-justice of the king's bench. His merits as a judge are the more apparent and the more remarkable when contrasted with the qualities displayed by his unworthy predecessors in office. In judicial fairness, legal knowledge and ability, clearness of statement, and unbending integrity he has had few if any superiors on the English bench. Over the civil rights of his countrymen he exercised a jealous watchfulness, more especially when presiding at the trial of state prosecutions, and he was especially careful that all accused persons should be treated with fairness and respect. He is, however, best known for the firmness with which he upheld his own prerogatives in opposition to the authority of the Houses of Parliament. On several occasions his physical as well as his moral courage was tried by extreme tests. Having been requested to supply a number of police to help the soldiery in quelling a riot, he assured the messenger that if any of the people were shot he would have the soldiers hanged, and proceeding himself to the scene of riot he was successful in preventing bloodshed. A still more signal proof of his courage is said to have been given in the Aylesbury case. He declared in favour of the Aylesbury burgesses, who had been committed to Newgate for complaining about the non-registry of their votes. On this account his commitment was moved by the Tories, but the result of the motion is uncertain. There is a tradition, however, which whether true or not is equally a tribute to his integrity, that the House of Commons summoned him to appear before them, and that when, on his disregarding the summons, the speaker himself made his appearance, Holt told him that unless he returned to his chair within five minutes he would have him sent to Newgate. While steadfast in his sympathies with the Whig party, Holt maintained on the bench entire political impartiality, and always held himself aloof from political intrigue. On the retirement of Somers from the chancellorship in 1700 he was offered the great seal, but declined it. His death took place 3d March 1710, and he was buried in the chancel of Redgrave church, where a fine monument in white marble was erected by his brother to his memory.

Reports of Cases determined by Sir John Holt, 1681-1710, appeared at London in 1738; and *The Judgments delivered in the case of Ashby v. White and others, and in the case of John Paty and others, printed from original MSS.*, at London, 1837. See Burnet's *Own Times*; *Tatler*, No. xiv.; a Life, published in 1764; Welsby, *Lives of Eminent English Judges of the 17th and 18th Centuries*, 1846; and Campbell's *Lives of the Lord Chief Justices*.

HÖLTY, LUDWIG HEINRICH CHRISTOPH (1748–1776), German poet, and one of the founders of the "Hainbund," was born at Mariensee in Hanover, December 21, 1748. His father, who was a pastor, was three times married, and Hölty was the eldest of his ten children. His second wife, Hölty's mother, died in 1758, and her children were tenderly brought up by the third wife, together with her own large family. In his ninth year, Hölty, till then a beautiful and lively child, was smitten with smallpox, and was for some time nearly blind. On his recovery, his features and disposition were altered, and he was through life plain, silent, and awkward. From an early age he was an inveterate lover of solitude and books. He was taught at home by his father, besides the ordinary school branches, Latin, French, and Hebrew, and at the age of sixteen was sent to the public school of Celle. On leaving Celle three years later, he went as a theological student to Göttingen, where, however, he devoted his leisure hours to the study of the English and Italian poets, and began his own literary career. The appearance of some of his verses in a Göttingen weekly paper, especially those on the death of Münchhausen, brought his name before the public, and he was shortly afterwards admitted as a member of the "German Society." He now made the acquaintance of Bürger, Miller, Voss, Boie, the brothers Stolberg, and other poets, in conjunction with whom he formed in 1772 the famous poetical brotherhood known as the "Hainbund." The next two years were spent by Hölty in this brilliant and enthusiastic company; and, with the assistance of a scholarship and a post in the philological seminary in Göttingen, he succeeded in making a scanty livelihood by teaching English and Greek and by making translations. In 1774, having abandoned the intention of entering the church, he accompanied his friend Miller to Leipsic, where he remained for a year in the hopes of obtaining a private tutorship. The penniless young poet had for some time been silently attached to a lady, who about this time married some more eligible suitor. His health now began to cause him anxiety, and symptoms of consumption, inherited from his mother, made their appearance. His prospects were further altered by the death of his father in 1775; and Hölty found himself not only thrown entirely on his own resources, but obliged in some measure to assist his family. Towards the end of 1775 he settled in Hanover, to be near his physician Zimmermann and his friend Boie, and there he died in his twenty-eighth year, September 1, 1776. Hölty was a writer of ballads, idylls, elegies, and odes. His conceptions, if not lofty, are always graceful, his style finished, his language and rhythm faultless. He was from the first one of the shining lights of the "Hainbund," and during his short career became one of the most popular of German lyric poets. Many of his songs have become folk-songs, and his ballads have been ranked with those of Bürger.

Hölty was engaged when he died in collecting and revising his poems for the press; and after his death his friends Boie and Voss undertook the charge of their publication. In 1782, however, an incorrect edition of his works appeared edited by Geissler, which contained many poems not by Hölty. The correct edition was first published by Voss and Stolberg in 1783, and again, revised, in 1804. An edition of his *Gedichte*, with a biographical introduction and notes by Karl Halm, was published by Brockhaus in the *Bibliothek der Deutschen Nationalliteratur* (1870).

HOLYHEAD (Welsh, *Caer-Gybi*, the fort of Gybi), a market-town and parliamentary borough of Anglesey, North Wales, is situated on a small island on the western extremity of the county and at the terminus of the Chester and Holyhead Railway, 24 miles from Bangor. It is connected with the mainland by an embankment three-quarters of a mile long, over which pass both the railway and the coach road. Underneath the bridge in the centre the tide rushes with great velocity. The town, formerly a small fishing village, has since the reign of William III. acquired importance as the station of the mail packets for Dublin, and it now possesses a magnificent harbour of refuge begun in 1847, and formally opened in September 1873. The original plan included the erection of a north breakwater 5360 feet in length from the coast-line, and also of an east breakwater 2000 feet in length, but the scheme of the east breakwater, of which the chief object was to cover the Platter's and Skinner's Rocks, was subsequently abandoned, and their positions were marked instead by buoys. On account of the number of vessels which began to take advantage of the shelter that was being provided for them it was also resolved to lengthen the northern breakwater in a north-easterly direction by 2000 feet, and subsequently by 500 feet more, making its total length 7860 feet. By these additions a sheltered roadstead of 400 acres in extent was obtained, besides the enclosed area of 267 acres. The breakwater consists of a rubble mound, upon which is erected a solid central wall of massive masonry rising to a height of 38 feet 9 inches above low water. On the wall there is a promenade sheltered on the sea side by a parapet. The breakwater is terminated by a head 150 feet long and 50 feet wide, on which is erected a lighthouse. The whole cost of the works was £1,479,538. In 1873 works were commenced by the railway company for extending the old harbour and increasing the length of the quay to 4000 feet. They were opened by the prince of Wales in June 1880. The cost has been nearly half a million sterling. Upon the pier of the old harbour there is an arch of Mona marble, commemorative of the visit of George IV. in 1821 on his way to Ireland. The church, an old embattled building, is said to occupy the site of an ancient monastery founded by St Gybi about 610; and in the south porch there is a rude figure of the patron saint under a canopy. The churchyard is surrounded by a wall 6 feet thick, supposed by some to be of Roman construction.

Holyhead Harbour.

The town possesses assembly-rooms and baths. On the rock south of the harbour is an obelisk erected in memory of Captain Skinner, commander of the steam packet, who in 1833 lost his life by being washed overboard. About 2 miles from the town, Pen-Caer-Gybi, or the hill of Holyhead, rises perpendicularly from the sea to the height of 700 feet, affording a fine view of the town and harbour, and the irregularities of the rock-bound coast. On the sides of the hill there are traces of an extensive British fortification, and on the summit are remains of a circular building, which in all probability was a Roman watch-tower. The inhabitants are chiefly engaged in the coasting trade and in shipbuilding. Holyhead unites with Beaumaris in returning a member to parliament. The population of the parliamentary borough in 1871 was 8131.

HOLY ISLAND, or LINDISFARNE, an irregularly shaped island in the North Sea, 10 miles S.S.E. of Berwick, and 2 miles from the coast of Northumberland, in which county it is included. It is joined to the mainland at low water by flat sands, over which a track, marked by wooden posts and practicable for vehicles, leads to the island. The parish of Holy Island includes Fenham and Goswick townships on the mainland, and had in 1871 a population of 876. The area of the island is about 1000 acres, of which about 400 are under cultivation, producing abundant crops of barley, oats, turnips, carrots, and potatoes. The northern part consists chiefly of barren sand-hills on which rabbits and eider-ducks breed. There are several fresh springs on the island, and in the north-east is a lake of 6 acres. Lime, quarried and burned on the island, is exported chiefly to Dundee. Four vessels are engaged in the trade. Rabbits, fish, cattle, corn, and potatoes are also exported. At the south-west angle is the little fishing village, formerly much larger, which is now a favourite summer watering-place. Salmon, cod, haddocks, crabs, lobsters, and herrings are the principal fish taken. There are two churches and a national school on the island. The population of the island proper in 1871 was 553.

Holy Island derives its name from a monastery founded on it in 635 by Oswald, king of Northumbria, which, after being plundered and destroyed by the Danes in the three preceding centuries, was restored by the Normans in 1082 as a cell of the Benedictine monastery at Durham. Its ruins, still extensive and now carefully preserved, justify Scott's description of it as a "solemn, huge, and dark-red pile." Holy Island was also an episcopal see (finally transferred to Durham), of which St Cuthbert was consecrated bishop in 685. The castle, situated to the east of the village, on a basaltic rock about 90 feet high, dates from a very early period. In 1646 it was garrisoned by parliament, and in 1715 an abortive attempt was made by two Jacobites to hold it for the Pretender.

HOLYOKE, a city of Hamden county, Massachusetts, is situated on the west bank of the Connecticut river, crossed there by a bridge, and on the Connecticut River railroad and the Holyoke and Westfield branch of the New Haven and Northampton line, 8 miles north of Springfield. It is well supplied with schools and churches, and has three hotels and a public library. It was a small village until 1849, when the construction of a dam across the river supplied it with water-power for its manufactories, which now include paper-mills, cotton-mills both for spinning and weaving, woollen-mills, planing-mills, a flour-mill, a wire-mill, and machine works. Originally the village was a part of Springfield, and in 1786 it was incorporated with West Springfield under the name of Ireland parish. It was incorporated into a town in 1850, and in 1873 it was made a city. The population, which in 1870 was 10,733, was 21,915 in 1880.

HOLY WATER (*aqua benedicta*, *lustralis*, *exorcizata*, *aspersoria* or *aspersionis*, ἁγιασμός, ὕδωρ εὐλογίας), in Roman Catholic ritual, is a specially exorcized and consecrated mixture of salt and water, believed to possess, when duly sprinkled, peculiar potency as a remedy for sickness, mental or bodily, and as a protection to property. According to present usage prescribed in the *Missal*, it is prepared in the sacristy on Sunday by the priest who is to celebrate high mass (or by some other on whom the duty is devolved): robed in alb and superpelliceum and wearing his stole, he first exorcizes the salt and the water separately; next he mixes the two in the name of Father, Son, and Holy Ghost; and finally he pronounces the prayer of consecration over the mixture. Thereupon he assumes his pluvial, goes to the altar, and takes from the deacon the aspergillum, with which he sprinkles the altar, himself, his assistants, and the congregation, meanwhile repeating the words of Ps. li. 7. The faithful who desire it are afterwards permitted to carry a supply home with them for application to the sick and for similar purposes. Holy water is solemnly used, not only in the consecration of sacred objects, such as churches, churchyards, bells, images, vestments, and the like, but also on various domestic occasions such as marriages and funerals. A holy-water stoup is placed at every church door and the faithful are expected to make use of it both on entering and on leaving the building.

The present Occidental usage with regard to holy water admits of being traced substantially, without a break, back to the Carolingian period. In the pseudo-Isidorian decretals, Alexander, bishop of Rome (*c.* 109 A.D.), commenting on Heb. ix. 13, is represented as applying that text to prove the purifying power of consecrated salt and water;[1] and in a genuine charge to his clergy Leo IV. (847 A.D.) says, "Every Lord's day before mass bless water wherewith the people may be sprinkled, and for this have a proper vessel." Hincmar of Rheims to a similar injunction adds permission to all who may wish to carry some of the water home in their own clean vessels, and sprinkle it "over their dwellings and fields and vineyards, over their cattle also and their provender, and likewise over their own meat and drink." In Gratian the decree runs —"We bless water sprinkled with salt, that all being therewith besprinkled may be sanctified and purified. Which also we recommend to be done by all priests."[2] But from the Ordo Romanus (i. 42) we learn that, in Rome, if not elsewhere in the West, a peculiar sacredness and magical efficacy were attributed, to baptismal water at least, two centuries before the publication of the forged decretals. After the usual consecration of the font on Easter eve, "the whole people, whoever wished, took a blessing in their vessels of the water itself, before the children were baptized in it, to sprinkle about their houses and vineyards and fields and fruits." We learn from Chrysostom (*De Bapt. Chr.*) that in the East a similar custom prevailed even in his time, while the *Apostolical Constitutions* (viii. 29) show that at a somewhat later period (probably in the 5th century) it had become usual also to bless water and oil without any reference to baptismal uses. An indication of later Oriental practice is gathered from Theodore Balsamon (*c.* 1200), according to whom, by immemorial custom, holy water was in his day consecrated in Greek churches at the beginning of every lunar month. The use of holy water at the church door can be traced back to pre-Christian practice, both Jewish and pagan. The laver in front of the altar (Exod. xxx. 18–21) in the old ritual of Israel had its analogue in the vessels with consecrated water (περιῤῥαντήρια or ἀποῤῥαντήρια) at the entrance of the peribolos of the Greek temple; from these the entrants used to sprinkle themselves, or to be sprinkled by the priests, to symbolize the purity required of those who sought to enter the sanctuary of God. There is evidence that, as early as Tertullian (*De Orat.*, 11) at least, it was customary to place outside Christian places of worship in the atrium (αἴθριον) a fountain or cistern of water (κρήνη, φιάλη, φρέαρ, ἐμβάτης, κολυμβεῖον, λεοντάριον, nymphaeum, cantharus) in which persons about to enter were expected to wash their hands and (perhaps) also the face. The vessel was not taken into the church and placed near the entrance of the nave until after the 8th century. It is not evident at what date it became customary within the Christian Church to mix salt with the water employed for sacramental or quasi-sacramental purposes; this practice also, however, must be traced to pre-Christian usage (see *Iliad* i. 314; Aristoph., *Plut.*, 656; and *cf.* Tzetzes, *Schol. in Lycoph.*, 135—τὸ ἁλικὸν καὶ θαλάσσιον ὕδωρ καθαρτικώτερον φύσει τῶν γλυκέων).

HOLY WEEK (ἑβδομὰς μεγάλη, ἁγία or τῶν ἁγίων, ξηροφαγίας, ἄπρακτος, also ἡμέραι παθημάτων, ἡμέραι σταυρώσιμαι; *hebdomas* [or *septimana*] *major*, *sancta*, *authentica* [*i.e.*, *canonizata*, Du Cange], *ultima*, *pœnosa*, *luctuosa*, *nigra*, *inofficiosa*, *muta*, *crucis*, *lamentationum*, *indulgentiæ*), in the ecclesiastical year the week immediately preceding that of Easter. The earliest allusion to the custom of marking this week as a whole with special observances is to be found in the *Apostolical Constitutions* (v. 18, 19), dating from the latter half of the 3d century A.D. Abstinence from wine and flesh is there commanded for all the days, while for the Friday and Saturday an absolute fast is enjoined. Dionysius Alexandrinus also, in his canonical epistle (260 A.D.), refers to the six fasting days (ἑξ τῶν νηστειῶν ἡμέραι) in a manner which implies that the observance of them had already become an established usage in his time. There is some doubt about the genuineness of an ordinance attributed to Constantine, in which abstinence from public business was enforced for the seven days immediately preceding Easter Sunday, and also for the seven which followed it; the *Codex Theodosianus*, however, is explicit in ordering that all actions at law should cease, and the doors of all courts of law be closed during those fifteen days (l. ii. tit. viii.). Of the particular days of the "great week" the earliest to emerge into special prominence was naturally that which commemorated the supreme crisis of the passion; next came the Sabbatum Magnum (Holy Saturday or Easter Eve) with its vigil, which in the early church was associated with an expectation that the second advent would occur on an Easter Sunday. The Dominica Palmarum or in Palmis (ἑορτὴ τῶν βαΐων) was, as we learn from Chrysostom, known and observed under that name in his day; for the fact of its observance in the Western Church, however, probably our earliest authority is the Venerable Bede. Maundy Thursday (ἡ μεγάλη πέμπτη, feria quinta paschæ) is referred to both by Chrysostom and by Augustine as having been in their time marked by a general and solemn celebration of the sacrament of the supper; the latter writer also (*Ep.* 118, *Ad Januarium*) alludes to a partial observance of the pedilavium or footwashing which in later centuries became the most conspicuous feature in the church services of the day. For details of the elaborate ceremonial observed in the Roman Catholic Church during this week, reference must be made to the *Missal* and *Breviary*. In the Eastern Church the week is marked by similar practices, but with less elaboration and differentiation of rite. See also EASTER and GOOD FRIDAY.

HOLYWELL (Welsh, *Treffynnon*, the town of the well), a parliamentary borough and market-town of Flintshire, North Wales, is beautifully situated on an eminence near the left bank of the estuary of the Dee, and about 2 miles from the station on the Chester and Holyhead line, 17 miles from Chester. The streets are irregular, but spacious and well-paved, while many of the buildings are substantial and elegant, and give the town an air of prosperity and opulence. The parish church, dedicated to St Winifred, and erected in 1769, but retaining some columns of a more ancient structure, is a plain edifice with a strong embattled tower. Near the railway station are the remains of Basingwerk abbey, partly Saxon and partly Early Pointed. Of the old fort called Basingwerk castle scarcely any traces now remain. Until the commencement of the present century the size of Holywell was inconsiderable, but since then its prosperity has been uninterruptedly increasing, owing to the lead quarries and the lead, copper, and zinc mines of the vicinity. The town possesses lead smelting works, a shot manufactory, and copper, brass, and zinc works. The population of the parliamentary borough in 1871 was 7961.

The well of St Winifred, from which the town takes its name, long considered one of the wonders of Wales, is a spring of water which rushes up at the rate of 21 tons a minute. Its temperature is higher than that of ordinary spring water, and varies very little with the different seasons. The stones at the bottom of the well have a slightly reddish colouring due to vegetable substances, a fact which doubtless suggested the legend according to which the spring gushed up on the spot where rested the head of the virgin Winifred, who had been decapitated by a lover offended at her constancy to her monastic vows. The well is covered by a fine Gothic building said to have been erected by Margaret, countess of Richmond, mother of Henry VII., but having some portions which are of earlier date. The exquisite chapel above has been restored, and is used for public service. Many Roman Catholics still visit the well, and swimming-baths have been erected for general use.

HOLZMINDEN, the chief town of a circle in the duchy of Brunswick, Germany, is situated on the right bank of the Weser, at the foot of the Sollinger mountains, and on the railway from Kreiensen to Altenbeken, 56 miles south-west of Brunswick. It is the seat of a circle administration, of a circle and common court, and of a general superintendent. The educational establishments include a gymnasium and an architectural school, the latter attended by upwards of 1000 scholars. The prosperity of the town

[1] Nam si cinis vitulæ adspersus sanguine populum sanctificabat atque mundabat, multo magis aqua sale adspersa divinisque precibus sacrata populum sanctificat atque mundat.

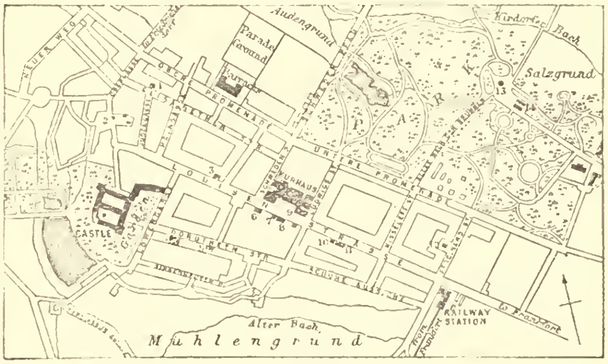
[2] Gratian, *De Cons.*, d. iii. c. 20; Labbe, *Conc.*, viii. 37; comp. Baluze, *Append. ad. lib. Reginonis de Eccl. Discipl.*, pp. 503–9.

depends chiefly on agriculture and the manufacture of iron and steel-wares, but weaving and the making of pottery are also carried on, and there are baryta mills and polishing-mills for sandstone. By means of the Weser it carries on a lively trade. Holzminden obtained town rights from Count Otto of Eberstein in 1245. In 1410 it came into the possession of Brunswick. The population in 1875 was 6887.

HOMAGE (from *homo*, through the Low Latin *hominaticum*, which occurs in a document of 1035) was one of the ceremonies used in the granting of a fief, and indicated the submission of a vassal to his lord. It could be received only by the suzerain in person. With head uncovered the vassal humbly requested to be allowed to enter into the feudal relation; he then laid aside his sword and spurs, ungirt his belt, and kneeling before his lord uttered words to this effect:—"I become your man from this day forth, of life and limb, and will hold faith to you for the lands I claim to hold of you." The oath of fealty, which could be received by proxy, followed the act of homage; then came the ceremony of investiture, either directly on the ground or by the delivery of a turf, a handful of earth, a stone, or some other symbolical object. Homage was done not only by the vassal to whom feudal lands were first granted but by every one in turn by whom they were inherited, since they were not granted absolutely but only on condition of military and other service. An infant might do homage, but he did not thus enter into full possession of his lands. The ceremony was of a preliminary nature, securing that the fief would not be alienated; but the vassal had to take the oath of fealty, and to be formally invested, when he reached his majority. The obligations involved in the act of homage were more general than those associated with the oath of fealty, but they provided a strong moral sanction for more specific engagements. They essentially resembled the obligations undertaken towards a Teutonic chief by the members of his "comitatus" or "gefolge," one of the institutions from which feudalism directly sprang. Besides *homagium ligeum*, there was a kind of homage which imposed no feudal duty; this was *homagium per paragium*, such as the dukes of Normandy rendered to the kings of France, and as the dukes of Normandy received from the dukes of Britanny. The act of liege homage to a particular lord did not interfere with the vassal's allegiance as a subject to his sovereign, or with his duty to any other suzerain of whom he might hold lands.

HOMBERG, Wilhelm (1652-1715), an eminent natural philosopher, born at Batavia, January 8, 1652, was educated in Holland, studied law at Jena and Leipsic, and became an advocate at Magdeburg in 1674. In that town he interested himself in botany and astronomy, and made the acquaintance of Otto von Guericke, under whose influence, renouncing his profession, he finally devoted himself exclusively to the natural sciences. Having travelled in Italy, France, and England, and profited by the instructions of the anatomist Graaf in Holland, he took the degree of doctor of medicine at Wittemberg; and, after visiting Germany, Hungary, Bohemia, and Sweden, he in 1685 settled in Rome, where he practised physic with great success. At Paris, whither he repaired in 1691, he was elected a member of the Academy of Sciences, and became (1702) teacher of physics and (1705) private physician to the duke of Orleans. He died at Paris, September 24, 1715. In 1702 Homberg discovered boracic acid, termed at first the *sal sedativum Hombergi*, the true nature of which was ascertained by Bergman in 1775. What is known as "Homberg's phosphorus" is a mixture of calcium chloride and lime, which, after heating in a sealed tube and exposure to sunlight, phosphoresces in the dark. Numerous treatises by Homberg, chiefly chemical, were published in the *Recueil de l'Académie des Sciences*, 1692, &c. See Chauffepié, *Dictionnaire*, and Chemistry, vol. v. p. 461.

HOMBURG-vor-der-Höhe, chief town of the circle of Obertaunus in the Wiesbaden government district of the Prussian province of Hesse-Nassau, is prettily situated on a small stream at the foot of a spur of the Taunus mountains, about 11 miles north of Frankfort-on-the-Main, with which it is connected by rail. Homburg consists of an old and a new town, the latter, founded by the landgrave Frederick II., being regular and well-built. Besides the palatial edifices erected in connexion with the mineral water-cure, the most important buildings are the theatre, the synagogue, and the various churches, schools, and benevolent institutions. On a neighbouring hill stands the castle of the former landgraves, built in 1680, and subsequently enlarged and improved. The White Tower, 183 feet in height, is said to date from Roman times, and certainly existed under the lords of Eppstein, who held the district in the 12th century. The castle is surrounded by extensive grounds, laid out in the manner of an English park. The woollen and linen manufactures of Homburg are unimportant, the prosperity of the town being almost entirely due to the annual influx



Plan of Homburg.

1. Synagogue.	6. Hesse Hotel.	11. Four Seasons Hotel.
2. Rathhaus Platz.	7. Hôtel de France.	12. English Church.
3. Post-Office.	8. Europe Hotel.	13. Kaiser Spring.
4. Reformed Church.	9. Theatre.	14. Park Bath House.
5. Roman Catholic Church.	10. Victoria Hotel.	

of visitors, which in the season lasting from May to October inclusive averages 9000 or 10,000. The five mineral springs which form the chief attraction to strangers are very saline, and contain a considerable proportion of carbonate of lime. Their use is beneficial for diseases of the stomach and intestines, and externally for diseases of the skin and rheumatism. The population of the town in 1875, including the garrison, was 8294.

Homburg first came into repute as a watering-place in 1834, and owing to its gambling tables, which were set up soon after, it rapidly became one of the favourite and most fashionable health-resorts of the Continent. In 1849 the town was occupied by Austrian troops for the purpose of enforcing the imperial decree against gambling establishments, but immediately on their withdrawal the bank was again opened, and play continued unchecked till 1872, when the Prussian Government refused to renew the lease for gambling purposes which then expired. As the capital of the former landgraviate of Hesse-Homburg the town shared the vicissitudes of that state.

See Schudt's *Homburg und seine Umgebungen*, 11th ed., 1875.

HOME, Henry. See Kames, Lord.

HOME, John (1722-1808), a Scottish dramatic poet, was born on 20th September 1722 at Leith, where his father, Alexander Home, filled the office of town-clerk. He was educated at the grammar school of his native town, and at the university of Edinburgh, where he graduated as M.A. in 1742. Though in his youth he was distinguished for vivacity, and showed a fondness for the profession of arms, he ultimately studied divinity, and was licensed by the presbytery of Edinburgh in 1745. In the same year he joined as a volunteer against the Pretender, and was taken prisoner at the battle of Falkirk. Along with many others he was carried to the castle of Doune, from which, however, he soon effected his escape. In July 1746 Home was presented to the parish of Athelstaneford in Haddingtonshire, vacant by the death of Robert Blair, the author of *The Grave.* There he devoted himself to dramatic literature, and his first production, *The Tragedy of Agis*, was finished in 1749. He took it to London and submitted it to Garrick for representation at Drury Lane, but it was rejected as unsuitable for the stage. Being but little disappointed, he projected a new work, and having heard a lady sing the ballad of Gil Morice, he formed the idea of *The Tragedy of Douglas*, which after five years' labour he completed, and took to London for Garrick's opinion. It also was rejected, but on his return to Edinburgh his friends resolved that it should be brought out in that city, where it met with overwhelming success, in spite of the opposition of the clergy, who suspended one member of the presbytery for a month for having attended its representation. As the author of the tragedy might count on being dealt with yet more severely, Home resigned his charge in 1757, and shortly afterwards he was appointed lecturer in a Presbyterian chapel in Silver Street, London. In 1758 he became private secretary to Lord Bute, then secretary of state; and three years later his patron's influence procured him a pension of £300 per annum. *A Letter from a Blacksmith to the Ministers and Elders of the Church of Scotland*, in which the manner of public worship in that church is considered, published in 1759, has been attributed to his pen. In 1760 Home brought out another tragedy, *The Siege of Aquileia*, which was put on the stage, Garrick taking the part of Æmilius. In 1763 he was appointed to the sinecure office of conservator of Scots privileges at Campvere. In 1769 Home's tragedy of *The Fatal Discovery* had a run of nine nights; *Alonzo* also (1773) had fair success in the representation; but his last tragedy, *Alfred* (1778), was so coolly received that he gave up writing for the stage. From 1767 he resided either at Edinburgh or at a villa which he built at Kilduff near his former parish. It was at this time that he wrote his *History of the Rebellion of* 1745, which appeared in 1802. Home died at Merchiston Bank, near Edinburgh, in 1808, in his eighty-sixth year. He was a man of great amiability of character, and numbered among his friends most of the Scottish literati of the last century. His writings, while they display fervid feeling, and have less artificiality than the works of the poets of his time, are now, with the exception of *Douglas*, comparatively little known.

The works of Home were collected and published by Henry Mackenzie in 1822 (3 vols. 8vo), but several of his smaller poems seem to have escaped the editor's observation. These are—"The Fate of Cæsar," "Verses upon Inveraray," "Epistle to the Earl of Eglintoun," "Prologue on the Birthday of the Prince of Wales, 1759," and several "Epigrams," which are printed in vol. ii. of *Original Poems by Scottish Gentlemen*, 1762.

HOMEL, or GOMEL, a town of Russia in Europe, in the government of Mohileff, 132 miles S. of Mohileff, on the highway to Tchernigoff, and on the right bank of the Sosh, which joins the Dnieper about 45 miles further down. It is a place of considerable importance, possessing (according to the *St Petersburg Calendar* for 1878) a population of 13,030, the suburb of Bielitsa being included. Most of the houses are of wood, but there are a good number of churches, several hospitals, and public schools. Three of the Orthodox churches were built by Rumantzeff, who lies buried in St Peter's. The sugar-refineries are the most important of the industrial establishments. A good trade is carried on in the agricultural produce of the surrounding district, partly with Warsaw and partly with Riga. In 1860, when the population amounted to 13,659, there were 3637 Raskolniks (separatists) and 6518 Jews.

Homel, which appears in the older documents as Gomie or Gomi and Gom, is mentioned for the first time in 1142, when it belonged to the Tchernigoff principality. The first inhabitants were Rodimitchians. In the 12th century we find Izyaslaff Daviditch taking refuge at Homel on his expulsion from Kieff. Along with Tchernigoff the town passed under the power of Lithuania; but in the 15th century Simeon, son of John of Mozhaisk, to whom it had been entrusted by King Alexander, entered the service of John III. of Moscow, and it was not till 1537 that it was recovered for Sigismund Augustus by Prince Radzivill and a body of Crim Tatars. The bailiwick was granted to the Polish grandees; and by the last of these—Prince Tcharovizhski—a strong oaken castle was erected. In 1648 the town suffered from the invasion of Bogudan Khmelnitzki, who put to death 1500 Roman Catholics and Jews. In 1655 it passed voluntarily to the side of the insurgent Cossacks, but at the peace of Andrusoff it remained with Poland. It was not incorporated with White Russia till the reign of Catherine II., who assigned it to Field-Marshal Rumantzeff Zadunaiski. In 1834 it was purchased by Prince Paskevitch, and in 1852 it was made the chief town of a district.

HOMER (Ὅμηρος) was by the general consent of antiquity the first and greatest of poets. Many of the works once attributed to him are lost; those which remain are the two great epics, the *Iliad* and the *Odyssey*, about thirty *Hymns*, a mock epic (the *Battle of the Frogs and Mice*), and some pieces of a few lines each (the so-called *Epigrams*).

Ancient Accounts of Homer.—Of the date of Homer probably no record, real or pretended, ever existed. Herodotus (ii. 53) maintains that Hesiod and Homer lived not more than 400 years before his own time, consequently not much before 850 B.C. From the controversial tone in which he expresses himself it is evident that others had made Homer more ancient; and accordingly the dates given by later authorities, though very various, generally fall within the 10th and 11th centuries B.C. It is needless to go into the questions raised by these statements, none of which has any claim to the character of external evidence.[1]

The extant lives of Homer (edited in Westermann's *Vitarum Scriptores Græci minores*) are eight in number, including the piece called the *Contest of Hesiod and Homer.* The longest is written in the Ionic dialect, and bears the name of Herodotus, but is certainly spurious. According to Joh. Schmidt (in the *Dissertationes philologicæ Halenses*, vol. ii. pp. 97–219), it belongs to the time which was fruitful beyond all others in literary forgeries, viz., the 2d century of our era. The other lives are probably not more ancient. They contain a strange medley, ranging from the simplest outgrowth of popular fancy to the frigid inventions of the age which would not confess itself ignorant of the name of Hecuba's mother. Thus the story that Homer was the son of the Meles (the river on which Smyrna is situated) and the nymph Critheis is evidently a local legend. Another story of a primitive cast describes the manner of Homer's death in the island of Ios. Seeing some young fishermen on the beach with their nets, he asked them—

"Fishermen sprung of Arcadia, have we aught?"

To which they answered in a riddle—

"What we caught we left behind,
What we caught not we bear with us."

Homer could not explain this, and then he remembered an oracle which had told him to beware of the young men's riddle. He wrote an epitaph for himself, and died on the third day after. This story comes from a lost work of Aristotle. On the other hand, when we are told in the Herodotean life that Critheis was a daughter of Melanopus, one of the colonists who came to Cyme from Magnesia, that being found to be with child she was sent with the fresh

[1] See Lauer, *Gesch. der Homer. Poesie*, pp. 115–30; Sengebusch, *Homerica dissertatio posterior*, p. 77.

colony that founded Smyrna, that she there brought forth Homer on the banks of the Meles, whence he was called Melesigenes,—in this form of the story it is easy to recognize the hand of the critic. There is an evident desire to get rid of the primitive supernatural element, and also to reconcile the claims of two cities, Cyme and Smyrna, to the envied distinction of giving birth to Homer. There are other incidents in the Herodotean life which seem devised merely to fit certain of the minor characters in the Homeric poems. Phemius, we are told, was a schoolmaster of Smyrna, who was kind to the young Melesigenes, and was accordingly immortalized as the singer in the *Odyssey*; the original of Mentor was a man of Ithaca, who entertained Homer and tended him in illness; and so on.

The chief value of these "Lives," and especially of the Herodotean life, lies in the curious short poems which they have preserved. These poems are the *Epigrams* which used to be printed at the end of Homer, but are banished by the somewhat inconvenient purism of modern editors. One of them (*Epigr.* iv.) is put in the mouth of a native of "Æolian Smyrna," whose poetical aid has been spurned by the people of Cyme, and who is accordingly departing to some other city. *Epigr.* vi. is a prayer to Poseidon for safe arrival at Erythræ; *Epigr.* vii. describes the rocky soil of that place. There is also an Epigram addressed to the people of Neonteichos (*Epigr.* i.), and another which brings in the pine woods of Mount Ida and the iron-mines of that district (*Epigr.* x.). Besides these pieces, the interest of which is topographical, there is an interesting little poem addressed to potters, beginning—

"If you give me hire I will sing, O potters,"

and another called Εἰρεσιώνη, which, according to the author of the life, was sung by the children in Samos when they went round begging at the festival of Apollo; also certain verses addressed to sailors (viii., ix.), to a goat-herd (xi.), &c. All these short poems have a common character. They are "rhymes" such as every country possesses in greater or less number, treasured by the people as a kind of proverbs. Some of them may be fragments of longer poems, but they are certainly not the work of any one poet. The circumstance that they are ascribed to Homer merely shows that his name had gained such a hold on the imagination of the Ionian and Æolian Greeks as to draw to itself all ancient and popular verse.

Such being the true character of the *Epigrams*, it follows that, so far from being "occasional verses," suggested by moments in Homer's life, they are really the original documents, to which the narrative was afterwards adjusted. Even the leading incident of the Herodotean life—the birth of Homer at Smyrna—may have been originally derived from *Epigr.* iv. The epithet "Æolian" indicates high antiquity; for Smyrna (according to Herodotus) was lost by the Æolians about 688 B.C. Similarly, the claim of Cyme was doubtless supported (not quite so logically) by the mention of that place in *Epigr.* iv. and i.

The same line of argument may be extended to the *Hymns*, and even to some of the lost works of the "Cyclic" poets; with the result of making it probable that most of the traditions about Homer rest ultimately on poems commonly ascribed to him. Thus—

1. The hymn to the Delian Apollo ends with an address of the poet to his audience. When any stranger comes and asks who is the sweetest singer, they are to answer with one voice, the "blind man that dwells in rocky Chios; his songs deserve the prize for all time to come." Thucydides, who quotes this passage to show the ancient character of the Delian festival, seems to have no doubt of the Homeric authorship of the hymn. Hence we may most naturally account for the belief that Homer was a Chian. That it was a general belief is shown by a passage (interesting as the earliest express quotation from Homer) in which Simonides calls him simply the "man of Chios" (fr. 85):—

Ἓν δὲ τὸ κάλλιστον Χῖος ἔειπεν ἀνήρ,
Οἵη περ φύλλων γενεή, τοίη δε καὶ ἀνδρῶν.

It was also supported by the Chian family or gens of Homeridæ, of whom more will be said hereafter.

2. The *Margites*—a humorous poem which kept its ground as the reputed work of Homer down to the time of Aristotle—began with the words, "There came to Colophon an old man, a divine singer, servant of the Muses and Apollo." Hence doubtless the claim of Colophon to be the native city of Homer—a claim supported in the early times of Homeric learning by the Colophonian poet and grammarian Antimachus.

3. The poem called the *Cypria* was said to have been given by Homer to Stasinus of Cyprus as a daughter's dowry. The connexion with Cyprus appears further in the predominance given in the poem to Aphrodite. From the argument preserved by Proclus it is evident that Aphrodite held the same place in the *Cypria* which Athene has in the *Odyssey*.

4. The *Little Iliad* and the *Phocaïs*, according to the Herodotean life, were composed by Homer when he lived at Phocæa with a certain Thestorides, who carried them off to Chios and there gained fame by reciting them as his own. The name Thestorides occurs in *Epigr.* v.

These indications make it probable that the stories connecting Homer with different cities and islands do not rest upon any better foundation than supposed allusions in poems, none of which, to all appearance, can make good the claim to Homeric authorship. And this result is confirmed by the want of positive authority in favour of any one version. The number of opinions is proverbial, and most of them are supported by relatively ancient testimony.

It is plain that the contention for Homer began at a time when his real history had been lost. And since the inevitable legend found no clue in the *Iliad* and *Odyssey*, it was driven to seek for one in poems of secondary value.

A singular exception is formed by Miletus, one of the greatest of Ionian cities, for which no legend claims even a visit from Homer. Yet Arctinus of Miletus is said to have been a "disciple of Homer," and his *Æthiopis* was a continuation of the *Iliad*. Another equally exceptional fact is that no poem of Arctinus is ever ascribed to Homer. Are we to suppose that the authorship of the poems of Arctinus never fell into doubt? If so, it is a confirmation, from the negative side, of the theory advanced above, viz., that the stories of Homer's connexion with different places are suggested for the most part by the poems which came to be assigned to him in popular belief.

Recitation of the Poems.—The recitation of epic poetry was called in historical times "rhapsody" (ῥαψῳδία). The word ῥαψῳδός is post-Homeric, but occurs in Pindar, who gives two different explanations of it—"singer of stitched verse" (ῥαπτῶν ἐπέων ἀοιδοί), and "singer with the wand" (ῥαβδός). Of these the first is etymologically correct (except that it should rather be "stitcher of verse"); the second agrees with the fact, for which there is early evidence, that the reciter was accustomed to hold a wand in his hand—perhaps, like the sceptre in the Homeric assembly, as a symbol of the right to a hearing.[1]

The first notice of rhapsody meets us at Sicyon, in the reign of Clisthenes (600–560 B.C.), who, as Herodotus tells us (v. 67), "put down the rhapsodists on account of the poems of Homer, because they are all about Argos and the Argives." This description applies very well to the *Iliad*, in which Argos and Argives occur on almost every page. It may have suited the *Thebaid* still better, but there is no

[1] Compare the branch of myrtle at an Athenian feast (Aristoph., *Nub.*, 1364).

need to understand it only of that poem, as Mr Grote does (Part i. c. 21). In any case the incident shows that the poems of the Ionic Homer had gained in the 6th century B.C., and in the Doric parts of the Peloponnesus, the ascendency, the national importance, and the almost canonical character which they ever afterwards retained.[1]

At Athens there was a law that the Homeric poems should be recited (ῥαψῳδεῖσθαι) on every occasion of the Panathenæa. This law is appealed to as an especial glory of Athens by the orator Lycurgus (*Leocr.*, 102). Perhaps therefore the custom of public recitation was exceptional, and unfortunately we do not know when or by whom it was introduced. The Platonic dialogue *Hipparchus* attributes it to Hipparchus, son of Pisistratus. This, however, is part of the historical myth, in the Platonic style, of which the dialogue mainly consists. The choice of a member of the tyrant family as the type of an enlightened despot was evidently made, not on grounds of evidence, but merely as a sign of reaction against popular sentiment. Moreover, the author of the dialogue makes (perhaps wilfully) all the historical mistakes which Thucydides notices in a well-known passage (vi. 54–59). In one point, however, his testimony is valuable. He tells us that the law required the rhapsodists to recite "taking each other up in order (ἐξ ὑπολήψεως ἐφεξῆς), as they still do." This recurs in a different form in the statement of Diogenes Laertius (i. 2, 57) that Solon made a law that the poems should be recited "with prompting" (so we must understand ἐξ ὑποβολῆς). The question as between Solon and Hipparchus cannot be settled; but it is at least clear that a due order of recitation was secured by the presence of a person charged to give the rhapsodists their cue (ὑποβάλλειν). It was necessary, of course, to divide the poem to be recited into parts, and to compel each contending rhapsodist to take the part assigned to him. Otherwise they would choose favourite or show passages.

The practice of poets or rhapsodists (we cannot always tell which) contending for the prize at the great religious festivals is of considerable antiquity, though apparently post-Homeric. It is brought vividly before us in the Hymn to Apollo (see the passage mentioned above), and in two Hymns to Aphrodite (v. and ix.). The latter of these may evidently be taken to belong to Salamis in Cyprus and the festival of the Cyprian Aphrodite, in the same way that the hymn to Apollo belongs to Delos and the Delian gathering. The germ of such contests may, however, be found in the story of Thamyris, the Thracian singer, who boasted that he could conquer even the Muses in song (*Il.* ii. 594 *ff.*).

Much has been made in this part of the subject of a family or clan (γένος) of Homeridæ in the island of Chios. On the one hand, it seemed to follow from the existence of such a family that Homer is a mere "eponymus," or mythical ancestor; on the other hand, it became easy to imagine the Homeric poems handed down orally in a family whose hereditary occupation it was to recite them, possibly to add new episodes from time to time, or to combine their materials in new ways, as their poetical gifts permitted. But, although there is no reason to doubt the existence of a family of "Homeridæ," it is far from certain that they had anything to do with Homeric poetry. The word occurs first in Pindar (*Nem.* 2, 2), who applies it to the rhapsodists (Ὁμηρίδαι ῥαπτῶν ἐπέων ἀοιδοί). On this a scholiast says that "Homeridæ" denoted originally the descendants of Homer, who sang his poems in succession, but afterwards the rhapsodists who did not claim descent from him. He adds that there was a famous rhapsodist, Cynæthus of Chios, who was said to be the author of the Hymn to Apollo, and to have first recited Homer at Syracuse about the 69th Olympiad. Nothing here connects the Homeridæ with Chios. Our knowledge of Chian Homeridæ comes chiefly from the lexicon of Harpocration, where we are told that Acusilaus and Hellanicus said that they were so called from the poet, but that Seleucus pronounced this to be an error. Strabo, also, says that the Chians put forward the Homeridæ as an argument in support of their claim to Homer. These Homeridæ, then, belonged to Chios, but there is no indication of their being rhapsodists. On the contrary, Plato uses the word to include interpreters and admirers—in short, the whole "spiritual kindred"—of Homer (*Rep.*, 599 E; *Phædr.*, 252 B; *Ion*, 530 D). And although we hear of "descendants of Creophylus" as in possession of the Homeric poems, there is no similar story about descendants of Homer himself. Such is the evidence on which so many inferences are based.

The result of the notices now collected is to show that the early history of epic recitation consists of (1) passages in the Homeric hymns showing that poets contended for the prize at the great festivals, (2) the passing mention in Herodotus of rhapsodists at Sicyon, and (3) a law at Athens, of unknown date,[2] regulating the recitation at the Panathenæa. Let us now compare these data with the account given in the Homeric poems. The word "rhapsode" does not yet exist; we hear only of the "singer" (ἀοιδός), who does not carry a wand or laurel-branch, but the lyre (φόρμιγξ), with which he accompanies his "song." In the *Iliad* even the epic "singer" is not met with, but Achilles himself sings the stories of heroes (κλέα ἀνδρῶν) in his tent, and Patroclus is waiting apparently to take up the song in his turn (*Il.* ix. 191). Again we do not hear of poetical contests (except in the story of Thamyris already mentioned) or of recitation of epic poetry at festivals. The *Odyssey* gives us pictures of two great houses, in Ithaca and in Phæacia; and each has its singer. The song is on a subject taken from the Trojan war, at some point chosen by the singer himself, or by his hearers. Thus Phemius pleases the suitors by singing of the calamitous return of the Greeks; Demodocus sings of a quarrel between Ulysses and Achilles, and then, on being asked to change the theme, of the wooden horse and the capture of Troy.

It may be granted that the author of the *Odyssey* can hardly have been just such a singer as he himself describes. The songs of Phemius and Demodocus are too short, and have too much the character of improvisations. Nor is it necessary to suppose that epic poetry, at the time to which the picture in the *Odyssey* belongs, was confined to the one type represented. Yet in several respects the conditions under which the singer finds himself in the house of a chief like Odysseus or Alcinous are more in harmony with the character of Homeric poetry than those of the later rhapsodic contests. The subdivision of a poem like the *Iliad* or *Odyssey* among different and necessarily unequal performers must have been injurious to the effect. The highly theatrical manner of recitation which was fostered by the spirit of competition, and by the example of the stage, cannot have done justice to the even movement of the epic style. It is not certain indeed that the practice of reciting a long poem by the agency of several competitors was ancient, or that it prevailed elsewhere than at Athens; but as rhapsodists were numerous, and popular favour throughout Greece became more and more confined to one or two great works, it must have become almost a

[1] We may compare the exclamation of the Spartan envoys to Hiero, ἦ κε μέγ' οἰμώξειεν ὁ Πελοπίδης Ἀγαμέμνων, &c.,—showing that the glories of the early Achæan empire, with Homer for its *vates sacer*, were adopted without reserve by the Dorian conquerors.

[2] For the assertions of the Platonic *Hipparchus* and of Diogenes Laertius are contradictory. The orators Lycurgus and Isocrates give no date. The question is complicated by the stories about Pisistratus.

necessity. That it was the mode of recitation contemplated by the author of the *Iliad* or *Odyssey* it is impossible to believe.

The difference made by substituting the wand or branch of laurel for the lyre of the Homeric singer is a slighter one, though not without significance. The recitation of the Hesiodic poems was from the first unaccompanied by the lyre,[1] *i.e.*, they were confessedly *said*, not *sung*; and it was natural that the example should be extended to Homer. For it is difficult to believe that the Homeric poems were ever "sung" in the strict sense of the word. We can only suppose that the lyre in the hands of the epic poet or reciter was in reality a piece of convention, a "survival" from the stage in which narrative poetry had a lyrical character. Probably the poets of the Homeric school—that which dealt with war and adventure—were the genuine descendants of minstrels whose "lays" or "ballads" were the amusement of the feasts in an earlier heroic age; whereas the Hesiodic compositions were non-lyrical from the first, and were only in verse because that was the universal form of literature.

It seems, then, that if we imagine Homer as a singer in a royal house of the Homeric age, but with more freedom regarding the limits of his subject, and a more tranquil audience than is allowed him in the rapid movement of the *Odyssey*, we shall probably not be far from the truth.

Time and Place of Homer.—The oldest direct references to the *Iliad* and *Odyssey* are in Herodotus, who quotes from both poems (ii. 53). The quotation from the *Iliad* is of interest because it is made in order to show that Homer supported the story of the travels of Paris to Egypt and Sidon (whereas the Cyclic poem called the *Cypria* ignored them), and also because the part of the *Iliad* from which it comes is cited as the "Aristeia of Diomede." This was therefore a recognized part of the poem.[2]

The earliest mention of the name of Homer is found in a fragment of the philosopher Xenophanes (of the 6th century B.C., or possibly earlier), who complains of the false notions implanted through the teaching of Homer (ἐξ ἀρχῆς καθ' Ὅμηρον ἐπεὶ μεμαθήκασι πάντες). The passage shows, not merely that Homer was well known at Colophon in the time of Xenophanes, but also that the great advance in moral and religious ideas which forced Plato to banish Homer from his republic had made itself felt in the days of the early Ionic philosophers.

Failing external testimony, the time and place of the Homeric poems can only be determined (if at all) by internal evidence. This is of two main kinds:—(1) evidence of history, consisting in a comparison of the political and social condition, the geography, the institutions, the manners, arts, and ideas of Homer with those of other times; (2) evidence of language, consisting in a comparison with later dialects, in respect of grammar and vocabulary. To these may be added, as occasionally of value, (3) evidence of the direct influence of Homer upon the subsequent course of literature and art.

(1) The political condition of Greece in the earliest times known to history is separated from the Greece of Homer by an interval which can hardly be overestimated. The great national names are different: instead of Achæans, Argives, Danai, we find Hellenes, Dorians, Ionians, Æolians—names either unknown to Homer, or mentioned in terms more significant than silence. Mycenæ is no longer the centre of empire; new empires, polities, and civilizations have grown up,—Sparta with its military discipline, Delphi with its religious supremacy, Miletus with its commerce and numberless colonies, Æolis and Ionia, Sicily and Magna Græcia.

While the political centre of Homeric Greece is Mycenæ, the real centre is evidently Bœotia. The Catalogue of the Ships begins with Bœotia; the list of Bœotian towns is much the longest; and they sail, not from the bay of Argos, but from the Bœotian harbour of Aulis. This position is not due to its chiefs, who are all of inferior rank. The importance of Bœotia for civilization is further shown by the ancient worship of the Muses on Mount Helicon, and the fact that the oldest poet whose birthplace is known was the Bœotian Hesiod. Next to Bœotia and the neighbouring countries, Phocis, Locris, Athens, it appears that the Peloponnesus, Crete, and Thessaly are the most important seats of Greek population.

In the Peloponnesus the face of things was completely altered by the Dorian conquest, no trace of which is found in Homer. The only Dorians known in Homer are those that the *Odyssey* (xix. 177) places in Crete. It seems difficult to connect them with the Dorians of history.

The eastern shores of the Ægean, which the earliest historical records represent to us as the seat of a brilliant civilization, giving way before the advance of the great military empires (Lydia and afterwards Persia), are almost a blank in Homer's map. The line of settlements can be traced in the Catalogue from Crete to Rhodes, and embraces the neighbouring islands of Cos and Calymnos. The colonization of Rhodes by Tlepolemus is related (*Il.* ii. 661 *ff.*), and seems to mark the furthest point reached in the Homeric age. Between Rhodes and the Troad the only name is Miletus, and that is still in the hands of "barbarous speaking" Carians. Even the Cyclades—Naxos, Paros, Melos—are unknown to the Homeric world. The disposition of the Greeks to look to the west for the centres of religious feeling appears in the mention of Dodona and the Dodonæan Zeus, put in the mouth of the Thessalian Achilles.

To the north we find the Thracians, known from the stories of Thamyris the singer (*Il.* ii. 595), and Lycurgus, the enemy of the young god Dionysus (*Il.* vi. 130). Here the Trojan empire begins. It does not appear, however, that the Trojans are thought of as people of a different language. As this is expressly said of the Carians, and of the Trojan allies who were "summoned from afar," the contrary rather is implied regarding Troy itself.

The mixed type of government described by Homer—consisting of a king guided by a council of elders, and bringing all important resolutions before the assembly of the fighting men—does not seem to have been universal in Indo-European communities, but to have grown up in many different parts of the world under the stress of similar conditions. The king is the commander in war, and the office probably owed its existence to military necessities. It is not surrounded with any special sacredness. There were ruling families, laying claim to divine descent, from whom the king was naturally chosen, but his own fitness is the essence of his title. The aged Laertes is set aside; the young Telemachus does not succeed as a matter of course. Nor are any very definite rights attached to the office. Each tribe in the army before Troy was commanded by its own king (or kings); but Agamemnon was supreme, because he was "more a king" (βασιλεύτερος) than any other. The assembly is summoned on all critical occasions, and its approval is the ultimate sanction. A king there-

[1] So Pausanias (ix. 30, 2), who supports his opinion from Hesiod, *Theog.*, 30-32. And so Aristophanes (*Nub.*, 1355-64) distinguishes between *singing* an ode from Simonides and *saying* (λέξαι) a piece of Æschylus. In the second case the myrtle branch is taken instead of the lyre.

[2] The difficulty which has been made because the title Διομήδους Ἀριστεία is given in the MSS. to the fifth book, whereas the quotation in question comes from the sixth, is due to an oversight. Putting aside the modern division into books, and looking to the narrative, we see that the Aristeia of Diomede extends from the beginning of Book v. to ver. 311 in Book vi. See the *Journal of Philology*, vol. ii. p. 214.

fore stands in almost as much need of oratory as of warlike skill and prowess. Even the division of the spoil is not made in the *Iliad* by Agamemnon, but by "the Achæans" (*Il.* i. 162, 368). The taking of Briseïs from Achilles was an arbitrary act, and against all rule and custom. The council is more difficult to understand. The "elders" (γέροντες) of the *Iliad* are the same as the subordinate "kings"; they are summoned by Agamemnon to his tent, and form a small council of nine or ten persons. In Troy we hear of elders of the people (δημογέροντες) who are with Priam, and are men past the military age. So in Ithaca there are elders who have not gone to Troy with the army. It would seem therefore that the meeting in Agamemnon's tent was only a copy or adaptation of the true constitutional "council of elders," which indeed was essentially unfitted for the purposes of military service.

Priesthood in Homer is found in the case of particular temples, where an officer is naturally wanted to take charge of the sacred inclosure and the sacrifices offered within it. It is perhaps an accident that we do not hear of priests in Ithaca. Agamemnon performs sacrifice himself, not because a priestly character was attached to the kingly office, but simply because he was "master in his own house."

The conception of "law" is foreign to Homer. The later words for it (νόμος, ῥήτρα) are unknown, and the terms which he uses (δίκη and θέμις) mean merely "custom." Judicial functions are in the hands of the elders, who "have to do with suits" (δικασπόλοι), and "uphold judgments" (θέμιστας εἰρύαται). On such matters as the compensation in cases of homicide, it is evident that there were no rules, but merely a feeling, created by use and wont, that the relatives of the slain man should be willing to accept payment. The sense of anger which follows a violation of custom has the name of "Nemesis"—righteous displeasure.

As there is no law in Homer, so there is no morality. That is to say, there are no general principles of action, and no words which indicate that acts have been classified as good or bad, right or wrong. Moral *feeling*, indeed, existed, and was denoted by "Aidos"; but the numerous meanings of this word—shame, veneration, pity—show how rudimentary the idea was. And when we look to practice we find that cruel and even treacherous deeds are spoken of without the least sense that they deserve censure. The heroes of Homer are hardly more moral agents than the giants and enchanters of a fairy tale.[1]

The religious ideas of Homer differ in some important points from those of later Greece. The Apollo of the *Iliad* has the character of a local deity—"ruler of Chryse and goodly Cilla and Tenedos." He may be compared with the Clarian and the Lycian god, but he is unlike the Apollo of Dorian times, the "deliverer" and giver of oracles. Again, the worship of Dionysus, and of Demeter and Persephone, is mainly or wholly post-Homeric. The greatest difference, however, lies in the absence of hero-worship from the Homeric order of things. Castor and Polydeuces, for instance, are simply brothers of Helen who died before the expedition to Troy (*Il.* iii. 243).

The military tactics of Homer belong to the age when the chariot was the principal engine of warfare. Cavalry is unknown, and the battles are mainly decided by the prowess of the chiefs. The use of the trumpet is also later. It has been supposed indeed that the art of riding was known in Homer's own time, because it occurs in comparisons. But the riding which he describes (*Il.* xv. 679) is a mere exhibition of skill, such as we may see in a modern circus. And though he mentions the trumpet (*Il.* xviii. 219), there is nothing to show that it was used, as in historical times, to give the signal for the charge. The chief industries of Homeric times are those of the carpenter (τέκτων), the worker in leather (σκυτοτόμος), the smith or worker in metal (χαλκεύς),—whose implements are the hammer and pincers,—and the potter (κεραμεύς); also spinning and weaving, which were carried on by the women. The fine arts are represented by sculpture in relief, carving in wood and ivory, embroidery. Statuary is later; it appears to have come into existence in the 7th century, about the time when casting in metal was invented by Rhœcus of Samos. In general, as has been well shown by Mr A. S. Murray,[2] Homeric art does not rise above the stage of *decoration*, applied to objects in common use; while in point of style it is characterized by a richness and variety of ornament which is in the strongest contrast to the simplicity of the best periods. It is the work, in short, not of artists but of skilled workmen; the ideal artist is "Dædalus," a name which implies mechanical skill and intricate workmanship, not beauty of design. Mr Murray further shows (following Professor Brunn of Munich) that the Greek art of the Homeric period is identical in origin with contemporary Assyrian work. The sculptures on the shield of Achilles, in particular, are quite Assyrian in type: and the same may be said of the work which has the best claim to equal antiquity with the Homeric poems—the lions sculptured in flat relief over the gate of Mycenæ.

One art of the highest importance remains. The question whether writing was known in the time of Homer was raised in antiquity, and has been debated with especial eagerness ever since the appearance of Wolf's *Prolegomena*. In this case we have to consider not merely the indications of the poems, but also the external evidence which we possess regarding the use of writing in Greece. This latter kind of evidence is much more considerable now than it was in Wolf's time. It will be found in a very convenient form in A. Kirchoff's *Studien zur Geschichte des griechischen Alphabets* (Berlin, 1877).

The oldest known stage of the Greek alphabet appears to be represented by inscriptions of the islands of Thera, Melos, and Crete, which are referred to the 40th Olympiad (620 B.C.). The oldest specimen of a distinctively Ionian alphabet is the famous inscription of the mercenaries of Psammetichus, in Upper Egypt, as to which the only doubt is whether the Psammetichus in question is the first or the second, and consequently whether the inscription is to be dated Ol. 40 or Ol. 47. Considering that the divergence of two alphabets (like the difference of two dialects) requires both time and familiar use, we may gather from these facts that writing was well known in Greece early in the 7th century B.C.[3]

The rise of prose composition in the 6th century B.C. has been thought to mark the time when memory was practically superseded by writing as a means of preserving literature,—the earlier use of letters being confined to short documents, such as lists of names, treaties, laws, &c. This conclusion, however, is by no means necessary. It may be that down to comparatively late times poetry was not commonly read, but was recited from memory. But the question is—From what time are we to suppose that the preservation of long poems was generally secured by the existence of written copies? Now, without counting the Homeric

[1] "The incidents which, as we read them in Homer, touch us as we are touched by a fairy tale" (Conington's *Virgil*, ii. p. 11). This subject is well treated by Mr Mahaffy in his *Social Life of Greece*, ch. ii.

[2] *Contemporary Review*, vol. xxiii. p. 218 *ff.*

[3] The fact that the Phœnician Vau (Ϝ) was retained in the Greek alphabets, and the vowel υ added, shows that when the alphabet was introduced the sound denoted by Ϝ was still in full vigour. Otherwise Ϝ would have been used for the vowel υ, just as the Phœnician consonant Yod became the vowel ι. But in the Ionic dialect the sound of Ϝ died out soon after Homer's time, if indeed it was still pronounced then. It seems probable therefore that the introduction of the alphabet is not later than the composition of the Homeric poems.

poems—which doubtless had exceptional advantages in their fame and popularity—we find a body of literature dating from the 8th century B.C. to which the theory of oral transmission is wholly inapplicable. In the Trojan cycle alone we know of the two epics of Arctinus, the *Little Iliad* of Lesches, the *Cypria*, the *Nostoi*. The Theban cycle is represented by the *Thebaid* (which Callinus, who was of the 7th century, ascribed to Homer) and the *Epigoni*. Other ancient epics—ancient enough to have passed under the name of Homer—are the *Taking of Œchalia*, and the *Phocaïs*. Again, there are the numerous works attributed to Hesiod and other poets of the didactic and the quasi-historical schools,—Eumelus of Corinth, Cinæthon of Sparta, Agias of Trœzen, and many more. The preservation of this vast mass is not explained by any of the various considerations which have been brought to bear on the Homeric poems—national interest, families of rhapsodists, public recitation, &c. It can only be attributed to writing, which must therefore have been in use for two centuries or more before there was any considerable prose literature. Nor is this in itself improbable. On the contrary, when we see how gradual and tentative progress is, and how great is the influence of an established literary form, we must feel it to be probable that the art of writing had been applied to the existing kinds of literature long before it led to the creation of a new type.

The further question, whether the *Iliad* and *Odyssey* were originally written, is much more difficult. External evidence does not reach back so far, and the internal evidence is curiously indecisive. The only passage which can be interpreted as a reference to writing occurs in the story of Bellerophon, told by Glaucus in the sixth book of the *Iliad*. Prœtus, king of Corinth, sent Bellerophon to his father-in-law the king of Lycia, and gave him "baneful tokens, scratching on a folded tablet many spirit-destroying things, and bade him show this to his father-in-law, that he might perish." The king of Lycia asked duly (on the tenth day from the guest's coming) for a token (ᾔτεε σῆμα ἰδέσθαι), and then knew what Prœtus wished to be done.[1] In this account there is nothing to show exactly how the message of Prœtus was expressed. The use of writing for the purpose of the token between "guest-friends" (*tessera hospitalis*) is certainly very ancient. Mommsen (*Röm. Forsch.*, i. p. 338 *ff.*) aptly compares the use in treaties, which are the oldest species of public documents. But we may suppose that tokens of some kind—like the marks which the Greek chiefs make on the lots (*Il.* vii. 175 *ff.*)—were in use before writing was known. In any system of signs there were doubtless means of recommending a friend, or giving warning of the presence of an enemy. There is no difficulty, therefore, in understanding the message of Prœtus without alphabetical writing. But, on the other hand, there is no reason for so understanding it.

If the language of Homer is so ambiguous where the use of writing would naturally be mentioned, we cannot expect to find more decisive references elsewhere. Arguments have been founded upon the descriptions of the blind singers in the *Odyssey*, with their songs inspired directly by the Muse; upon the appeals of the poet to the Muses, especially in such a place as the opening of the Catalogue; upon the Catalogue itself, which is a kind of historical document put into verse to help the memory; upon the shipowner in the *Odyssey*, who has "a good memory for his cargo," &c. It may be answered, however, in the first place, that much of this is traditional, handed down from the time when all poetry was unwritten, and in the second place that the form of poetry is determined by the manner in which it is used,—the recitation or performance, if we may give a wide meaning to that term,—not by the manner in which it is composed or preserved. And the "performance" of epic poetry still depended upon the power of memory long after written copies were in existence. In short, it is one thing to recognize that a literature is essentially oral in its form, characteristic of an age which was one of hearing rather than of reading, and quite another to hold that the same literature was preserved entirely by oral transmission. And finally, if writing was used in Homeric times, the absence of all mention of it may be connected with the peculiar silence—imposed doubtless by the tradition of his art—which the poet observes regarding himself and his circumstances.

The result of these various considerations seems to be that the age which we may call the Homeric—the age which is brought before us in vivid outlines in the *Iliad* and *Odyssey*—lies beyond the earliest point to which history enables us to penetrate. And so far as we can draw any conclusion as to the author (or authors) of the two poems, it is that the whole debate between the cities of Æolis and Ionia was wide of the mark. The author of the *Iliad*, at least, was evidently a European Greek who lived before the colonization of Asia Minor; and the claims of the Asiatic cities mean no more than that in the days of their prosperity these were the chief seats of the fame of Homer.[2]

This is perhaps the place to consider whether the poems are to be regarded as possessing in any degree the character of historical record. The question is one which in the absence of satisfactory criteria will generally be decided by taste and predilection. A few suggestions, however, may be made.

1. The events of the *Iliad* take place in a real locality, the general features of which are kept steadily in view. There is no doubt about Sigeum and Rhœteum, or the rivers Scamander and Simois, or the islands Imbros, Lemnos, and Tenedos. It is at least remarkable that a legend of the national interest of the "tale of Troy" should be so definitely localized, and that in a district which was never famous as a seat of Greek population.

2. The discoveries of Schliemann prove that the Homeric Troy (which can hardly be other than Hissarlik, see TROY) was an ancient seat of pre-Hellenic population. This circumstance perhaps adds something to the probability that the legend was founded on fact.

3. The story of the *Iliad* is singularly free from the exaggerated and marvellous character which belongs to most legends. The apple of discord, the arrows of Philoctetes, the invulnerability of Achilles, and similar fancies, are the additions of later poets. This sobriety, however, belongs not to the whole *Iliad*, but to the events and characters of the war. Such figures as Bellerophon, Niobe, the Amazons, which are thought of as traditions from an earlier generation, show the marvellous element at work.

4. Certain persons and events in the story have a distinctly mythical stamp. Helen is a figure of this kind. There was another story according to which she was carried off by Theseus, and recovered by her brothers the Dioscuri. There are even traces of a third version, in which the Messenian twins, Idas and Lynceus, appear.

5. The analogy of the French epic, the *Chanson de Roland*, favours the belief that there was some nucleus of fact. The defeat of Roncevaux was really suffered by a part of Charlemagne's army. But the Saracen army is purely mythical, the true enemy having been the Gascons. Thus the element of fact is found in the *place* where the battle was fought, and the *name* of the great emperor. If similarly we leave, as historical, the plain of Troy, and the name Agamemnon, we shall perhaps not be far wrong.

(2) The dialect of Homer is properly to be called Old Ionic: that is to say, it is the dialect of which the New Ionic of Herodotus and the Attic are varieties, but it is in a much earlier stage of development. The proof of this proposition is to be obtained chiefly by comparing the grammatical formation and the syntax of Homer with those of Attic. The comparison of the vocabulary is in the nature of things less conclusive on the question of date. It would be impossible to give the evidence in full without writing a Homeric grammar, but a few specimens may be of interest.

[1] The word σῆμα means the whole message or document. Hence σήματα λυγρά are not "baneful marks" or "characters," but "a token which" (instead of being one of friendly recommendation, as it purported to be) "was a message of death."

[2] On this point, see Mr Gladstone's *Homeric Synchronism*, ch. iii.

1. The first aorist in Greek being a "weak" tense, *i.e.*, formed by a suffix (-σᾰ), whereas the second aorist is a "strong" tense, distinguished by the form of the root-syllable, we expect to find a constant tendency to diminish the number of second aorists in use. No new second aorists, we may be sure, were formed any more than new "strong" tenses, such as *came* or *sang*, can be formed in English. Now in Homer there are upwards of 80 second aorists (not reckoning aorists of "Verbs in μι," such as ἔστην, ἔβην), whereas in all Attic prose not more than 30 are found. In this point therefore the Homeric language is manifestly older. In Attic poets, it is true, the number of such aorists is much larger than in prose. But here again we find that they bear witness to Homer. Of the poetical aorists in Attic the larger part are also Homeric. Others are not really Attic at all, but borrowed from earlier Æolic and Doric poetry. It is plain, in short, that the later poetical vocabulary was separated from that of prose mainly by the forms which the influence of Homer had saved from being forgotten.

2. While the whole class of "strong" aorists diminished, certain smaller groups in the class disappeared altogether. Thus we find in Homer—

(*a.*) The second aorist middle without the "thematic" ε or ο: as ἔβλη-το, *was struck*; ἔφθι-το, *perished*; ἆλ-το, *leaped*.

(*b.*) The aorist formed by reduplication: as δέδαεν, *taught*; λελαβέσθαι, *to seize*. These constitute a distinct formation, generally with a "causative" meaning; the solitary Attic specimen is ἤγαγον.

3. Another "exception," which is really a survival from a former rule, is seen in the short syllable of the plural of οἶδα (ἴσμεν, in Homer ἴδ-μεν, ἴστε, &c.). Other examples occur in Homer, both in the indicative and in the participle, as ἀρηρώς, fem. ἀρᾰρυῖα; so μεμακυῖα, ἰδυῖα, &c.). But this variation of the stem in different parts of a single tense is exactly one of the complexities from which language is ever striving to free itself; and accordingly in Attic it has all but disappeared.

4. It had long been known that the subjunctive in Homer often takes a short vowel (*e.g.*, in the plural, -ομεν, -ετε instead of -ωμεν, -ητε, and in the Mid. -ομαι, &c., instead of -ωμαι, &c.). This was generally said to be done by "poetic licence," or *metri gratia*. In fact, however, the Homeric subjunctive is almost quite "regular," though the rule which it obeys is a different one from the Attic. It may be summed up by saying that the subjunctive takes ω or η when the indicative has ο or ε, and not otherwise. Thus Homer has ἴ-μεν, *we go*, ἴ-ο-μεν, *let us go*. The later ἴ-ω-μεν was at first a solecism, an attempt to conjugate a "verb in μι" like the "verbs in ω." It will be evident that under this rule the perfect and first aorist subjunctive should always take a short vowel; and this accordingly is the case, with very few exceptions.

5. The article (ὁ, ἡ, τό) in Homer is chiefly used as an independent pronoun (*he*, *she*, *it*), a use which in Attic appears only in a few combinations (such as ὁ μὲν .... ὁ δέ, *the one .... the other*). This difference is parallel to the relation between the Latin *ille* and the article of the Romance languages.

6. The prepositions offer several points of comparison. What the grammarians called "tmesis," the separation of the preposition from the verb with which it is compounded, is peculiar to Homer. The true account of the matter is that in Homer the place of the preposition is not rigidly fixed, as it was afterwards. Again "with" is in Homer σύν (with the dative), in Attic prose μετά with the genitive. Here Attic poetry is intermediate; the use of σύν is retained as a piece of poetical tradition.

7. In addition to the particle ἄν, Homer has another, κεν, hardly distinguishable in meaning. The Homeric uses of ἄν and κεν are different in several respects from the Attic, the general result being that the Homeric syntax is more elastic. Thus ἄν and κεν are used in Homer with the future, and with the subjunctive in simple sentences (οὐκ ἄν τοι χραίσμῃ, *shall not avail thee*). Again in clauses introduced by the relative, or by εἰ, *if*, the subjunctive is found both with and without ἄν or κεν; whereas in Attic (except in a few poetical instances) ἄν is always found (ὅς ἄν, ἐάν). And yet the Homeric syntax is perfectly definite and precise. Homer uses no constructions loosely or without corresponding differences of meaning. His rules are equally strict with those of the later language, but they are not the same rules. And they differ chiefly in this, that the less common combinations of the earlier period were disused altogether in the later.

8. In the vocabulary the most striking difference is that many words appear from the metre to have contained a sound which they afterwards lost, viz., that which is written in some Greek alphabets by the "digamma" ϝ. Thus the words ἄναξ, ἄστυ, ἔργον, ἔπος, and many others must have been written at one time ϝάναξ, ϝάστυ, ϝέργον, ϝέπος. This letter, however, died out earlier in Ionic than in most dialects, and there is no proof that the Homeric poems were ever written with it.

The points that have been mentioned, to which many others might be added, make it clear that the Homeric and Attic dialects are separated by differences which affect the whole structure of the language, and require a considerable time for their development. At the same time there is hardly one of these differences which cannot be accounted for by the natural growth of the language. It has been thought indeed that the Homeric dialect was a mixed one, containing Æolic and even Doric forms, but the proof of this is scanty and doubtful. There are doubtless many Homeric forms which were unknown to the later Ionic and Attic, and which are found in Æolic or other dialects. In general, however, these are *older* forms, which must have existed in Ionic at one time, and may very well have belonged to the Ionic of Homer's time. So too the digamma is called "Æolic" by grammarians, and is found on Æolic and Doric inscriptions. But the letter was one of the original alphabet, and was retained universally as a numeral. It can only have fallen into disuse by degrees, as the sound which it denoted ceased to be pronounced. The fact that there are so many traces of it in Homer is a strong proof of the antiquity of the poems, but no proof of admixture with Æolic.

There is one sense, however, in which an admixture of dialects may be recognized. It is clear that the variety of forms in Homer is too great for any actual spoken dialect. To take a single instance: it is impossible that the genitives in -οιο and in -ου should both have been in everyday use together. The form in -οιο must have been poetical or literary, like our *-eth* of the third person singular, or like *ye* for *you*, *whoso* for *whoever*, and the like. The origin of such double forms is not far to seek. The effect of dialect on style was always recognized in Greece, and the dialect which had once been adopted by a particular kind of poetry was ever afterwards adhered to. The Epic of Homer was doubtless formed originally from a spoken variety of Ionic, but became literary and conventional with time. It is Homer's own testimony that all the Greeks spoke one language (*Il.* iv. 437),—that is to say, that they understood one another, in spite of the inevitable local differences. In these circumstances experience shows that some one dialect gains a literary supremacy to which the whole nation yields. So Tuscan became the type of Italian, and Anglian of English. But as soon as the dialect is adopted, it begins to diverge from the colloquial form. Just as modern poetical Italian uses many older grammatical forms peculiar to itself, so the language of poetry, even in Homeric times, had formed a deposit (so to speak) of archaic grammar. There were doubtless poets before Homer, as well as brave men before Agamemnon; and indeed the formation of a conventional dialect such as the Homeric must have been the work of several generations.

The use of Ionic (instead of Æolic) by the Bœotian poet Hesiod, in a kind of poetry which was not of the Homeric type, tends to confirm the conclusion that the literary ascendency of Ionic was anterior to the *Iliad* and *Odyssey*. It follows that the choice of Ionic as the language of the Homeric poems is no argument for the Ionian birth of their author (or authors).

The argument for the antiquity of Homer founded upon the traces of Homeric influence in later poetry cannot be profitably discussed without going into details which would be out of place here. When a phrase or idea is found in Homer, and again in a later author, we have to inquire whether it may not belong to the common stock from which the poet of the *Iliad* or *Odyssey* himself drew, and then whether it proves anything as to the antiquity of the poems *in their present form*. Hence it is seldom that such considerations yield a satisfactory proof.[1] The case is

[1] This is not the place to notice the argument which has been founded upon the differences between Homer and later poets. It may be observed, however, that, while agreement between poets widely separated by time calls for notice and explanation, difference is only what we expect.

somewhat different with the arguments derived from the early epic poems called "cyclic." The fragments of these poems, indeed, are so scanty that we cannot compare them with Homer in respect of style or language, but enough is known of their subjects to indicate that they presuppose an *Iliad* and *Odyssey* of something like their present form and extent. The *Æthiopis* of Arctinus (who was of the 8th century) took up the story of the Trojan war at the point where the *Iliad* leaves it, and similarly the *Telegoneia* of Eugammon (fl. 568 B.C.) is a mere continuation of the *Odyssey*.

Study of Homer.—The Homeric Question.—The critical study of Homer began in Greece almost with the beginning of prose writing. The first name is that of Theagenes of Rhegium, contemporary of Cambyses (525 B.C.), who is said to have founded the "new grammar" (the older "grammar" being the art of reading and writing), and to have been the inventor of the allegorical interpretations by which it was sought to reconcile the Homeric mythology with the morality and speculative ideas of the 6th century B.C. The same attitude in the "ancient quarrel of poetry and philosophy" was soon afterwards taken by Anaxagoras; and after him by his pupil Metrodorus of Lampsacus, who explained away all the gods, and even the heroes, as elementary substances and forces (Agamemnon as the upper air, &c.).

The next writers on Homer of the "grammatical" type were Stesimbrotus of Thasos (contemporary with Cimon) and Antimachus of Colophon, himself an epic poet of mark. The *Thebaid* of Antimachus, however, was not popular, and seems to have been a great storehouse of mythological learning rather than a poem of the Homeric school.

Other names of the pre-Socratic and Socratic times are mentioned by Xenophon, Plato, and Aristotle. These were the "ancient Homerics" (οἱ ἀρχαῖοι Ὁμηρικοί), who busied themselves much with the hidden meanings of Homer; of whom Aristotle says, with his profound insight, that they see the small likenesses and overlook the great ones (*Metaph.*, xii.).

The text of Homer must have attracted some attention when Antimachus came to be known as the "corrector" (διορθωτής) of a distinct edition (ἔκδοσις). Aristotle is said himself to have made a recension for the use of Alexander the Great. His remarks on Homer (in the *Poetics* and elsewhere) show that he had made a careful study of the structure and leading ideas of the poems, but do not throw much light on the text.

The real work of criticism became possible only when great collections of manuscripts began to be made by the princes of the generation after Alexander, and when men of learning were employed to sift and arrange these treasures. In this way the great Alexandrian school of Homeric criticism began with Zenodotus, the first chief of the Museum, and was continued by Aristophanes and Aristarchus. In Aristarchus ancient philology culminated, as philosophy had done in Socrates. All earlier learning either passed into his writings, or was lost; all subsequent research turned upon his critical and grammatical work.

The means of forming a judgment of the criticism of Aristarchus are scanty. The literary form which preserved the works of the great historians was unfortunately wanting, or was not sufficiently valued, in the case of the grammarians. Abridgments and newer treatises soon drove out the writings of Aristarchus and other founders of the science. Moreover, a recension could not be reproduced without new errors soon creeping in. Thus we find that Didymus, writing in the time of Cicero, does not quote the readings of Aristarchus as we should quote a *textus receptus*. Indeed, the object of his work seems to have been to determine what those readings were. Enough, however, remains to show that Aristarchus had a clear notion of the chief problems of philology (except perhaps those concerning etymology). He saw, for example, that it was not enough to find a meaning for the archaic words (the γλῶσσαι, as they were called), but that common words (such as πόνος, φόβος) had their Homeric uses, which were to be gathered by due induction. In the same spirit he looked upon the ideas and beliefs of Homer as a consistent whole, which might be determined from the evidence of the poems. He noticed especially the difference between the stories known to Homer and those given by later poets, and made many comparisons between Homeric and later manners, arts, and institutions. Again, he was sensible of the paramount value of manuscript authority, and appears to have introduced no readings from mere conjecture. The frequent mention in the Scholia of "better" and "inferior" texts may indicate a classification made by him. His use of the "obelus" to distinguish spurious verses, which made so large a part of his fame in antiquity, has rather told against him with modern scholars.[1] It is chiefly interesting as a proof of the confusion in which the text must have been before the Alexandrian times; for it is impossible to understand the readiness of Aristarchus to suspect the genuineness of verses unless the state of the copies had pointed to the existence of numerous interpolations. On this matter, however, we are left to mere conjecture. The quotations from Homer in pre-Alexandrian authors are so inaccurate as to throw little or no light on the text which they used. It is at least clear that our manuscripts are much more trustworthy than the recollection of these ancient writers.[2]

Our knowledge of Alexandrian criticism is derived almost wholly from a single document, the famous *Iliad* of the library of St Mark in Venice (*Codex Venetus*, or *Ven. A*), first published by the French scholar Villoison in 1788 (*Scholia antiquissima ad Homeri Iliadem*). This manuscript, written in the 10th century, contains (1) the best text of the *Iliad*, (2) the critical marks of Aristarchus, and (3) Scholia, consisting mainly of extracts from four grammatical works, viz., Didymus (contemporary of Cicero) on the recension of Aristarchus, Aristonicus (fl. 24 B.C.) on the critical marks of Aristarchus, Herodian (fl. 16 A.D.) on the accentuation, and Nicanor (fl. 127 A.D.) on the punctuation, of the *Iliad*.

These extracts present themselves in two distinct forms. One series of scholia is written in the usual way, on a margin reserved for the purpose. The other consists of brief scholia, written in very small characters (but of the same period) on the narrow space left vacant round the text. Occasionally a scholium of this kind gives the substance of one of the longer extracts; but as a rule they are distinct. It would seem, therefore, that after the manuscript was finished the "marginal scholia" were discovered to be extremely defective, and a new series of extracts was added in a form which interfered as little as possible with the appearance of the book.[3]

The mention of the Venetian Scholia leads us at once to the Homeric controversy; for the immortal *Prolegomena* of Wolf[4] appeared a few years after Villoison's publication, and was founded in great measure upon the fresh and abundant materials which it furnished. Not that the "Wolfian theory" of the Homeric poems is directly supported by anything in the Scholia; the immediate object of the *Prolegomena* was not to put forward that theory, but to elucidate the new and remarkable conditions under which the text of Homer had to be settled, viz., the discovery of an *apparatus criticus* of the 2d century B.C. The questions regarding the original structure and early history of the poems were raised (forced upon him, it may be said) by the critical problem; but they were really originated by facts and ideas of a wholly different order.

The 18th century, in which the spirit of classical correctness had the most absolute dominion, did not come to an end before a powerful reaction set in, which affected not only literature but also speculation and politics. In this movement the leading ideas were concentrated in the word Nature. The natural condition of society, natural law, natural religion, the morality of feeling, the poetry of nature, gained a singular hold, first on the English philosophers from Hume onwards, and then (through Rousseau chiefly) on the general drift of thought and action in Europe. In literature the effect of these ideas was to set up a false opposition between nature and art. As political writers imagined a patriarchal innocence prior to codes of law, so men of letters sought in popular unwritten poetry the freshness and simplicity which were wanting in the prevailing styles. The blind minstrel was the counterpart of the noble savage. The supposed discovery of the poems of Ossian fell in with this train of sentiment, and created an enthusiasm for the study of early popular poetry. Homer was soon drawn into the circle of inquiry. Blackwell (Professor of Greek at Aberdeen) had insisted, in a book published in 1735, on the "naturalness" of Homer; and Wood (*Essay on the Original Genius of Homer*, London, 1769) was the first who maintained that Homer composed without the help of writing,

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[1] See the chapter in Cobet's *Miscellanea Critica*, pp. 225–239.

[2] For example, Æschines says that the words φήμη δ' ἐς στρατὸν ἦλθε occur repeatedly in the *Iliad*, whereas they never occur there. Had Æschines lived two centuries earlier, how decisive this would have seemed against the antiquity of "our Homer!" As it is, it only proves the weakness of all such arguments. On the Homeric quotations in Aristotle, see Cope's edition of Aristotle's *Rhetoric*, vol. iii. p. 48.

[3] The existence of two groups of the Venetian Scholia was first noticed by Professor La Roche, and they were first distinguished in the edition of W. Dindorf (Oxford, 1875). There is also a group of Scholia, chiefly exegetical, a collection of which was published by Villoison from a second Venetian MS. in his edition of 1788, and has been again edited by W. Dindorf (Oxford, 1877). The most important collection of this group is contained in the *Codex Townleianus* of the British Museum, which is still unedited, though a MS. probably copied from it, the *Codex Victorianus* at Munich, was used by Bekker for his edition of the Scholia (Berlin, 1825). The vast commentary of Eustathius (of the 12th century) marks a third stage in the progress of ancient Homeric learning.

[4] *Prolegomena ad Homerum, sive de operum Homericorum prisca et genuina forma variisque mutationibus et probabili ratione emendandi*, scripsit Frid. Aug. Wolfius. Volumen i.

and supported his thesis by ancient authority, and also by the parallel of Ossian. Both these books were translated into German, and their ideas passed into the popular philosophy of the day. Everything in short was ripe for the reception of a book that brought together, with masterly ease and vigour, the old and the new Homeric learning, and drew from it the historical proof that Homer was no single poet, writing according to art and rule, but a name which stood for a golden age of the true spontaneous poetry of genius and nature.

The part of the *Prolegomena* which deals with the original form of the Homeric poems occupies pp. xl.–clx. (in the first edition). Wolf shows how the question of the date of writing meets us on the threshold of the textual criticism of Homer, and accordingly enters into a full discussion, first of the external evidence, then of the indications furnished by the poems. Having satisfied himself that writing was unknown to Homer, he is led to consider the real mode of transmission, and finds this in the Rhapsodists, of whom the Homeridæ were an hereditary school. And then comes the conclusion to which all this has been tending: "the die is cast"—the *Iliad* and *Odyssey* cannot have been composed in the form in which we know them without the aid of writing. They must therefore have been, as Bentley had said, "a sequel of songs and rhapsodies," "loose songs not collected together in the form of an epic poem till about 500 years after." This conclusion he then supports by the character attributed to the "Cyclic" poems (whose want of unity showed that the structure of the *Iliad* and *Odyssey* must be the work of a later time), by one or two indications of imperfect connexion, and by the doubts of ancient critics as to the genuineness of certain parts. These, however, are matters of conjecture. "Historia loquitur." The voice of antiquity is unanimous in declaring that "Pisistratus first committed the poems of Homer to writing, and reduced them to the order in which we now read them."

The appeal of Wolf to the "voice of all antiquity" is by no means borne out by the different statements on the subject. According to Heraclides Ponticus (pupil of Plato), the poetry of Homer was first brought to the Peloponnesus by Lycurgus, who obtained it from the descendants of Creophylus (*Polit.*, fr. 2). Plutarch in his *Life of Lycurgus* (c. 4) repeats this story, with the addition that there was already a faint report of the poems in Greece, and that certain detached fragments were in the possession of a few persons (ἐκέκτηντο δὲ οὐ πολλοὶ μέρη τινὰ σπο ράδην τῆς ποιήσεως ὡς ἔτυχε διαφερομένης). Again, the Platonic dialogue *Hipparchus* (which though not genuine is probably earlier than the Alexandrian times) asserts that Hipparchus, son of Pisistratus, first brought the poems to Athens, and obliged the rhapsodists at the Panathenæa to follow the order of the text, "as they still do," instead of reciting portions chosen at will. The earliest authority for attributing any work of the kind to Pisistratus is the well known passage of Cicero (*De Orat.*, 3, 34: "Quis doctior eisdem temporibus illis, aut cujus eloquentia litteris instructior fuisse traditur quam Pisistrati? qui primus Homeri libros, confusos antea, sic disposuisse dicitur ut nunc habemus"). To the same effect Pausanias (vii. p. 594) says that the change of the name Donoessa to Gonoessa (in *Il.* ii. 573) was thought to have been made by "Pisistratus or one of his companions," when he collected the poems, which were then in a fragmentary condition (διεσπασμένα τε καὶ ἄλλα ἀλλαχοῦ μνημονευόμενα ἤθροιζε). Finally, Diogenes Laertius (i. 57) says that Solon made a law that the poems should be recited with the help of a prompter (ἐξ ὑποβολῆς), so that each rhapsodist should begin where the last left off; and he argues from this that Solon did more than Pisistratus to make Homer known. The argument is directed against a certain Dieuchidas of Megara, who appears to have maintained that the verses about Athens in the Catalogue (*Il.* ii. 546–556) were interpolated by Pisistratus. The passage is unfortunately corrupt, but it is at least clear that in the time of Solon, according to Diogenes, there were complete copies of the poems, such as could be used to control the recitations. Hence the account of Diogenes is quite irreconcilable with the notices on which Wolf relied.

It is needless to examine the attempts which have been made to harmonize these accounts. Such attempts usually start with the tacit assumption that each of the persons concerned—Lycurgus, Solon, Pisistratus, Hipparchus—must have done *something* for the text of Homer, or for the regulation of the rhapsodists. But we have first to consider whether any of the accounts come to us on such evidence that we are bound to consider them as containing a nucleus of truth.

In the first place, the statement that Lycurgus obtained the poems from descendants of Creophylus must be admitted to be purely mythical. But if we reject it, have we any better reason for believing the parallel assertion in the Platonic *Hipparchus*? It is true that Hipparchus is undoubtedly a real person. On the other hand it is evident that the Pisistratidæ soon became the subject of many fables. Thucydides notices as a popular mistake the belief that Hipparchus was the eldest son of Pisistratus, and that consequently he was the reigning "tyrant" when he was killed by Aristogiton. The Platonic *Hipparchus* follows this erroneous version, and may therefore be regarded as representing (at best) mere local tradition. We may reasonably go further, and see in this part of the dialogue a piece of historical romance, designed to put the "tyrant" family in a favourable light, as patrons of literature and learning.

Again, the account of the *Hipparchus* is contradicted by Diogenes Laertius, who says that Solon provided for the due recitation of the Homeric poems. The only good authorities as to this point are the orators Lycurgus and Isocrates, who mention the law prescribing the recitation, but do not say when or by whom it was enacted. The inference seems a fair one, that the author of the law was really unknown.

With regard to the statements which attribute some work in connexion with Homer to Pisistratus, it was noticed by Wolf that Cicero, Pausanias, and the others who mention the matter do so *nearly in the same words*, and therefore appear to have drawn from a common source. This source was in all probability an epigram quoted in two of the short lives of Homer, and there said to have been inscribed on the statue of Pisistratus at Athens. In it Pisistratus is made to say of himself that he "collected Homer, who was formerly sung in fragments (ὃς τὸν Ὅμηρον ἤθροισα σποράδην τὸ πρὶν ἀειδόμενον), for the golden poet was a citizen of ours, since we Athenians founded Smyrna." The other statements repeat these words with various minor additions, chiefly intended to explain how the poems had been reduced to this fragmentary condition, and how Pisistratus set to work to restore them. Thus all the authority for the work of Pisistratus "reduces itself to the testimony of a single anonymous inscription" (Nutzhorn, p. 40). Now, what is the value of that testimony? It is impossible of course to believe that a statue of Pisistratus was set up at Athens in the time of the free republic. The epigram is almost certainly a mere literary exercise. And what exactly does it say? Only that Homer was *recited in fragments* by the rhapsodists, and that these partial recitations were made into a continuous whole by Pisistratus; which does not necessarily mean more than that Pisistratus did what other authorities ascribe to Solon and Hipparchus, viz., regulated the recitation.

Against the theory which sees in Pisistratus the author of the first complete text of Homer we have to set the absolute silence of Herodotus, Thucydides, the orators, and the Alexandrian grammarians. And it can hardly be thought that their silence is accidental. Herodotus and Thucydides seem to tell us all that they know of Pisistratus. The orators Lycurgus and Isocrates make a great deal of the recitation of Homer at the Panathenæa, but know nothing of the poems having been collected and arranged at Athens, a fact which would have redounded still more to the honour of the city. Finally, the Scholia of the *Ven. A* contain no reference or allusion to the story of Pisistratus. As these Scholia are derived in substance from the writings of Aristarchus, it seems impossible to believe that the story was known to him. The circumstance that it is referred to in the later *Scholia Victoriana*, and in Eustathius, gives additional weight to this argument.

The result of these considerations seems to be that nothing rests on good evidence beyond the fact that Homer was recited by law at the Panathenaic festival. The rest of the story is probably the result of gradual expansion and accretion. It was inevitable that later writers should speculate about the authorship of such a law, and that it should be attributed with more or less confidence to Solon or Pisistratus or Hipparchus. The choice would be determined in great measure by political feeling. It is probably not an accident that Dieuchidas, who attributed so much to Pisistratus, was a Megarian. The author of the *Hipparchus* is evidently influenced by the anti-democratical tendencies in which he only followed Plato. In the times to which the story of Pisistratus can be traced, the 1st century B.C., the substitution of the "tyrant" for the legislator was extremely natural. It was equally natural that the importance of his work as regards the text of Homer should be exaggerated. The splendid patronage of letters by the successors of Alexander, and especially the great institutions which had been founded at Alexandria and Pergamus, had made an impression on the imagination of learned men which was reflected in the current notions of the ancient despots. It may even be suspected that anecdotes in praise of Pisistratus and Hipparchus were a delicate form of flattery addressed to the reigning Ptolemy. Under these influences the older stories of Lycurgus bringing Homer to the Peloponnesus, and Solon providing for the recitation at Athens, were thrown into the shade.

In the later Byzantine times it was believed that Pisistratus was aided by seventy grammarians, of whom Zenodotus and Aristarchus were the chief. The great Alexandrian grammarians had become figures in a new mythology. It is true that Tzetzes, one of the writers from whom we have this story, gives a better version, according to which Pisistratus employed four men, viz., Onomacritus, Zopyrus of Heraclea, Orpheus of Croton, and one whose name is corrupt (written ἐπικόγκυλος). Many scholars (among them Ritschl) accept this account as probable. Yet it rests upon no better evidence than the other.

The effect of the *Prolegomena* was so overwhelming that, although a few protests were made at the time, the true Homeric controversy did not begin till after the death of Wolf (1824). His speculations were thoroughly in harmony with the ideas and sentiment of the time, and his historical arguments, especially his long array of testimonies to the work of Pisistratus, were hardly challenged.

The first considerable antagonist of the Wolfian school was G. W. Nitzsch, whose writings cover the space 1828-1862, and deal with every side of the controversy. In the earlier part of his *Meletemata* (1830) he took up the question of written or unwritten literature, on which Wolf's whole argument turned, and showed that the art of writing must be anterior to Pisistratus. In the later part of the same series of discussions (1837), and in his chief work (*Die Sagenpoesie der Griechen*, 1852), he investigated the structure of the Homeric poems, and their relation to the other epics of the Trojan cycle. These epics had meanwhile been made the subject of a work which for exhaustive learning and delicacy of artistic perception has few rivals in the history of philology, the *Epic Cycle* of F. G. Welcker. The confusion which previous scholars had made between the ancient post-Homeric poets (Arctinus, Lesches, &c.) and the learned mythological writers (such as the "scriptor cyclicus" of Horace) was first cleared up by Welcker. Wolf had argued that if the cyclic writers had known the *Iliad* and *Odyssey* which we possess, they would have imitated the unity of structure which distinguishes these two poems. The result of Welcker's labours was to show that the Homeric poems had influenced both the form and the substance of epic poetry.

In this way there arose a conservative school who admitted more or less freely the absorption of pre-existing lays in the formation of the *Iliad* and *Odyssey*, and also the existence of considerable interpolations, but assigned the main work of formation to prehistoric times, and to the genius of a great poet. Whether the two epics were by the same author remained an open question; the tendency of this group of scholars was decidedly towards separation. Regarding the use of writing too they were not unanimous. K. O. Müller, for instance, maintained the view of Wolf on this point, while he strenuously combated the inference which Wolf drew from it.

The *Prolegomena* bore on the title page the words "Volumen I."; but no second volume ever appeared, nor was any attempt made by Wolf himself to carry his theory further. The first important steps in that direction were taken by Gottfried Hermann, chiefly in two dissertations, *De interpolationibus Homeri* (Leips., 1832), and *De iteratis Homeri* (Leips., 1840), called forth by the writings of Nitzsch. As the word "interpolation" implies, Hermann did not maintain the hypothesis of a congeries of independent "lays." Feeling the difficulty of supposing that all the ancient minstrels sang of the "wrath of Achilles" or the "return of Ulysses" (leaving out even the capture of Troy itself), he was led to assume that two poems of no great compass dealing with these two themes became so famous at an early period as to throw other parts of the Trojan into the background, and were then enlarged by successive generations of rhapsodists. Some parts of the *Iliad*, moreover, seemed to him to be older than the poem on the wrath of Achilles; and thus in addition to the "Homeric" and "post-Homeric" matter he distinguished a "pre-Homeric" element.

The conjectures of Hermann, in which the Wolfian theory found a modified and tentative application, were presently thrown into the shade by the more trenchant method of Lachmann, who (in two papers read to the Berlin Academy in 1837 and 1841) sought to show that the *Iliad* was made up of sixteen independent "lays," with various enlargements and interpolations, all finally reduced to order by Pisistratus. The first book, for instance, consists of a lay on the anger of Achilles (1-347), and two continuations, the return of Chryseis (430-492) and the scenes in Olympus (348-429, 493-611). The second book forms a second lay, but several passages, among them the speech of Ulysses (278-332), are interpolated. In the third book the scenes in which Helen and Priam take part (including the making of the truce) are pronounced to be interpolations; and so on. Regarding the evidence on which these sweeping results are founded, opinions will vary. The degree of smoothness or consistency which is to be expected on the hypothesis of a single author will be determined by taste rather than argument. The dissection of the first book, for instance, turns partly on a chronological inaccuracy which might well escape the poet as well as his hearers. In examining such points we are apt to forget that the contradictions by which a story is shown to be untrue are quite different from those by which a confessedly untrue story would be shown to be the work of different authors.

Structure of the Iliad.—The subject of the *Iliad*, as the first line proclaims, is the "anger of Achilles." The manner in which this subject is worked out will appear from the following summary, in which we distinguish (1) the plot, *i.e.*, the story of the quarrel, (2) the main course of the war, which forms a sort of underplot, and (3) subordinate episodes.

I.	Quarrel of Achilles with Agamemnon and the Greek army—Agamemnon, having been compelled to give up his prize Chryseis, takes Briseis from Achilles—Thereupon Achilles appeals to his mother Thetis, who obtains from Zeus a promise that he will give victory to the Trojans until the Greeks pay due honour to her son—Meanwhile Achilles takes no part in the war.
II.	Agamemnon is persuaded by a dream sent from Zeus to take the field with all his forces.
	His attempt to test the temper of the army nearly leads to their return.
	Catalogue of the army.
	Trojan muster—Trojan catalogue.
III.	Meeting of the armies—Paris challenges Menelaus—Truce made.
	"Teichoscopy," Helen pointing out to Priam the Greek leaders.
	The duel—Paris is saved by Aphrodite.
IV.	Truce broken by Pandarus.
	Advance of the armies—Battle.
V.	Aristeia of Diomede—his combat with Aphrodite
VI.	—Meeting with Glaucus—Visit of Hector to
(1-311)	the city, and offering of a peplus to Athene.
(312-529)	Visit of Hector to Paris—to Andromache.
VII.	Return of Hector and Paris to the field.
	Duel of Ajax and Hector.
	Truce for burial of dead.
	The Greeks build a wall round their camp.
VIII.	Battle—The Trojans encamp on the field.
IX.	Agamemnon sends an embassy by night, offering Achilles restitution and full amends—Achilles refuses.
X.	Doloneia—Night expedition of Odysseus and Diomede.
XI.	Aristeia of Agamemnon—he is wounded—Wounding of Diomede and Odysseus.
	Achilles sends Antilochus to inquire about Machaon.
XII.	Storming of the wall—the Trojans reach the ships.
XIII.	Zeus ceases to watch the field—Poseidon secretly comes to the aid of the Greeks.
XIV.	Sleep of Zeus, by the contrivance of Here.
XV.	Zeus awakened—Restores the advantage to the Trojans—Ajax alone defends the ships.
XVI.	Achilles is persuaded to allow Patroclus to take the field.
	Patroclus drives back the Trojans—kills Sarpedon—is himself killed by Hector.
XVII.	Battle for the body of Patroclus—Aristeia of Menelaus.
XVIII.	News of the death of Patroclus is brought to Achilles—Thetis comes with the Nereids—promises to obtain new armour for him from Hephæstus.
	The shield of Achilles described.
XIX.	Reconciliation of Achilles—His grief and desire to avenge Patroclus.
XX.	The gods come down to the plain—Combat of Achilles with Æneas and Hector, who escape.
XXI.	The Scamander is choked with slain—rises against Achilles, who is saved by Hephæstus.
XXII.	Hector alone stands against Achilles—his flight round the walls—he is slain.
XXIII.	Burial of Patroclus—Funeral games.
XXIV.	Priam ransoms the body of Hector—his burial.

Such is the "action" (πρᾶξις) which in Aristotle's opinion showed the superiority of Homer to all later epic poets. But the proof that his scheme was the work of a great poet does not depend merely upon the artistic unity which excited the wonder of Aristotle. A number of separate "lays" might conceivably be arranged and connected by a man of poetical taste in a manner that would satisfy all requirements. In such a case, however, the connecting passages would be slight and weak. Now, in the *Iliad* these passages are the finest and most characteristic. The element of connexion and unity is the story of the "wrath of Achilles"; and we have only to look at the books which give the story of the wrath to see how essential they are. Even if the ninth book is rejected (as Grote proposed), there remain the speeches of the first, sixteenth, and nineteenth books. These speeches form the cardinal points in the action of the *Iliad*—the framework into which everything else is set; and they have also the best title to the name of Homer.

The further question, however, remains,—What shorter narrative piece fulfilling the conditions of an independent poem has Lachmann succeeded in disengaging from the existing *Iliad*? It must be admitted that when tried by this test his "lays" generally fail. The "quarrel of the chiefs," the "muster of the army," the "duel of Paris and Menelaus," &c., are excellent beginnings, but have no satisfying conclusion. And the reason is not far to seek. The *Iliad* is not a history, nor is it a series of incidents in the history, of the siege. It turns entirely upon a single incident, occupying a few days only. The several episodes of the poem are not so many distinct stories, each with an interest of its own. They are only parts of a single main event. Consequently the type of epic poem which would be produced by an aggregation of shorter lays is not the type which we have in the *Iliad*. Rather the *Iliad* is itself a single lay which has grown with the growth of poetical art to the dimensions of an epic.

But the original nucleus and parts of the incidents may be the work of a single great poet, and yet other episodes may be of different authorship, wrought into the structure of the poem in later times. Various theories have been based on this supposition. Grote in particular held that the original poem, which he called the Achilleïs, did not include books ii.–vii., ix., x., xxiii., xxiv. Such a view may be defended somewhat as follows.

Of the books which relate the events during the absence of Achilles from the Greek ranks (ii.–xv.), the last five are directly related to the main action. They describe the successive steps by which the Greeks are driven back, first from the plain to the rampart, then to their ships. Moreover three of the chief heroes, Agamemnon, Diomede, and Ulysses are wounded, and this circumstance, as Lachmann himself admitted, is steadily kept in mind throughout. It is otherwise with the earlier books (especially ii.–vii.). The chief incidents in that part of the poem—the panic rush to the ships, the duels of Paris and Menelaus, and of Hector and Ajax, the Aristeia of Diomede—stand in no relation to the mainspring of the poem, the promise made by Zeus to Thetis. It is true that in the thirteenth and fourteenth books the purpose of Zeus is thwarted for a time by other gods; but in books ii.–vii. it is not so much thwarted as ignored. Further, the events follow without sufficient connexion. The truce of the third book is broken by Pandarus, and Agamemnon passes along the Greek ranks with words of encouragement, but without a hint of the treachery just committed. The Aristeia of Diomede ends in the middle of the sixth book; he is uppermost in all thoughts down to ver. 311, but from this point, in the meetings of Hector with Helen and Andromache, and again in the seventh book when Hector challenges the Greek chiefs, his prowess is forgotten. Once more, some of the incidents seem to belong properly to the beginning of the war. The joy of Menelaus on seeing Paris, Priam's ignorance of the Greek leaders, the speeches of Agamemnon in his review of the ranks (in book iv.), the building of the wall—all these are in place after the Greek landing, but hardly in the ninth year of the siege.

On the other hand, it may be said, the second book opens with a direct reference to the events of the first, and the mention of Achilles in the speech of Thersites (ii. 239 *ff.*) is sufficient to keep the main course of events in view. The Catalogue is connected with its place in the poem by the lines about Achilles (686-694). When Diomede is at the height of his Aristeia Helenus says (*Il.* vi. 99), "We did not so fear even Achilles." And when in the third book Priam asks Helen about the Greek captains, or when in the seventh book nine champions come forward to contend with Hector, the want of the greatest hero of all is sufficiently felt. If these passages do not belong to the period of the wrath of Achilles, how are we to account for his conspicuous absence?

Further, the want of smoothness and unity which is visible in this part of the *Iliad* may be due to other causes than difference of date or authorship. A national poet such as the author of the *Iliad* cannot always choose or arrange his matter at his own will. He is bound by the traditions of his art, and by the feelings and expectations of his hearers. The poet who brought the exploits of Diomede into the *Iliad* doubtless had his reasons for doing so, which were equally strong whether he was the poet of the Achilleis or a later Homerid or rhapsodist. And if some of the incidents (those of the third book in particular) seem to belong to the beginning of the war, it must be considered that poetically, and to the hearers of the *Iliad*, the war opens in the third book, and the incidents are of the kind that is required in such a place. The truce makes a pause which heightens the interest of the impending battle; the duel and the scene on the walls are effective in bringing some of the leading characters on the stage, and in making us acquainted with the previous history. The story of Paris and Helen especially, and the general position of affairs in Troy, is put before us in a singularly vivid manner. The book in short forms so good a *prologue* to the action of the war that we can hardly be wrong in attributing it to the genius which devised the rest of the *Iliad*.

The case against the remaining books is of a different kind. The ninth and tenth seem like two independent pictures of the night before the great battle of xi.–xvii. Either is enough to fill the space in Homer's canvas; and the suspicion arises (as when two Platonic dialogues bear the same name) that if either had been genuine, the other would not have come into existence. If one of the two is to be rejected it must be the tenth, which is certainly the less Homeric. It relates a picturesque adventure, conceived in a vein more approaching that of comedy than any other part of the *Iliad*. Moreover, the language in several places exhibits traces of post-Homeric date. The ninth book, on the other hand, was rejected by Grote, chiefly on the grounds that the embassy to Achilles ought to have put an end to the quarrel, and that it is ignored in later passages, especially in the speeches of Achilles (xi. 609; xvi. 72, 85). His argument, however, rests on an assumption which we are apt to bring with us to the reading of the *Iliad*, but which is not borne out by its language, viz., that there was some definite atonement demanded by Achilles, or due to him according to the custom and sentiment of the time. But in the *Iliad* the whole stress is laid on the anger of Achilles, which can only be satisfied by the defeat and extreme peril of the Greeks.[1] He is influenced by his own feeling, and by nothing else. Accordingly, in the ninth book, when they are still protected by the rampart (see 348 *ff.*), he rejects gifts and fair words alike; in the sixteenth he is moved by the tears and entreaties of Patroclus, and the sight of the Greek ships on fire; in the nineteenth his anger is quenched in grief. But he makes no conditions, either in rejecting the offers of the embassy or in returning to the Greek army. And this conduct is the result, not only of his fierce and inexorable character, but also (as the silence of Homer shows) of the want of any general rules or principles, any code of morality or of honour, which would have required him to act in a different way.

Finally, Grote objected to the two last books that they prolong the action of the *Iliad* beyond the exigencies of a coherent scheme. Of the two, the twenty-third could more easily be spared. In language, and perhaps in style and manner, it is akin to the tenth; while the twenty-fourth is in the pathetic vein of the ninth, and like it serves to bring out new aspects of the character of Achilles.

[1] On this point see a paper by Professor Packard in the *Trans. of the American Philological Association*, 1876.

A recent writer (Dr E. Kammer) has given some strong reasons for doubting the genuineness of the passage in book xx. describing the duel between Achilles and Æneas (79–352). The incident is certainly very much out of keeping with the vehement action of that part of the poem, and especially with the moment when Achilles returns to the field, eager to meet Hector and avenge the death of his friend. The interpolation (if it is one) is probably due to local interests. It contains the well-known prophecy that the descendants of Æneas are to rule over the Trojans,—pointing to the existence of an Ænead dynasty in the Troad. So, too, the legend of Anchises in the Hymn to Aphrodite is evidently local; and Æneas becomes more prominent in the later epics, especially the *Cypria* and the Ἰλίου πέρσις of Arctinus.

Structure of the Odyssey.—In the *Odyssey*, as in the *Iliad*, the events related fall within a short space of time. The difficulty of adapting the long wanderings of Ulysses to a plan of this type is got over by the device—first met with in the *Odyssey*—of making the hero tell the story of his own adventures. In this way the action is made to begin almost immediately before the actual return of Ulysses. Up to the time when he reaches Ithaca it moves on three distinct scenes: we follow the fortunes of Ulysses, of Telemachus on his voyage in the Peloponnesus, and of Penelope with the suitors. The art with which these threads are woven together was recognized by Wolf himself, who admitted the difficulty of applying his theory to the "admirabilis summa et compages" of the poem. Of the comparatively few attempts which have been made to dissect the *Odyssey*, the most moderate and attractive is that of Professor A. Kirchoff of Berlin.[1]

According to Kirchoff, the *Odyssey* as we have it is the result of additions made to an original nucleus. There was first of all a "Return of Odysseus," relating chiefly the adventures with the Cyclops, Calypso, and the Phaeacians; then a continuation, the scene of which lay in Ithaca, embracing the bulk of books xiii.–xxiii. The poem so formed was enlarged at some time between Ol. 30 and Ol. 50 by the stories of books x.–xii. (Circe, the Sirens, Scylla, &c.), and the adventures of Telemachus. Lastly, a few passages were interpolated in the time of Pisistratus.

The proof that the scenes in Ithaca are by a later hand than the ancient "Return" is found chiefly in a contradiction discussed by Kirchoff in his sixth dissertation (pp. 135 *ff.*, ed. 1869). Sometimes Ulysses is represented as aged and worn by toil, so that Penelope, for instance, cannot recognize him; sometimes he is really in the prime of heroic vigour, and his appearing as a beggarly old man is the work of Athene's wand. The first of these representations is evidently natural, considering the twenty eventful years that have passed; but the second, Kirchoff holds, is the Ulysses of Calypso's island and the Phaeacian court. He concludes that the aged Ulysses belongs to the "continuation" (the change wrought by Athene's wand being a device to reconcile the two views), and hence that the continuation is the work of a different author.

Ingenious as this is, there is really very slender ground for Kirchoff's thesis. The passages in the second half of the *Odyssey* which describe the appearance of Ulysses do not give *two* well-marked representations of him. Sometimes Athene disguises him as a decrepit beggar, sometimes she bestows on him supernatural beauty and vigour. It must be admitted that we are not told exactly how long in each case the effect of these changes lasted. But neither answers to his natural appearance, or to the appearance which he is imagined to present in the earlier books. In the palace of Alcinous, for instance, it is noticed that he is vigorous but "marred by many ills" (κακοῖσι συνέρρηκται πολέεσσι, *Od.* viii. 137); and this agrees with the scenes of recognition in the latter part of the poem.

The arguments by which Kirchoff seeks to prove that the stories of books x.–xii. are much later than those of book ix. are not more convincing. He points out some resemblances between these three books and the Argonautic fables, among them the circumstance that a fountain Artacia occurs in both. In the Argonautic story this fountain is placed in the neighbourhood of Cyzicus, and answers to an actual fountain known in historical times. Kirchoff argues that the Artacia of the Argonautic story must have been taken from the real Artacia, and the Artacia of the Odyssey again from that of the Argonautic story. And as Cyzicus was settled from Miletus, he infers that both sets of stories must be comparatively late. It is more probable, surely, that the name Artacia occurred independently (as most geographical names are found to occur) in more than one place. Or it may be that the Artacia of the *Odyssey* suggested the name to the colonists of Cyzicus, whence it was adopted into the later versions of the Argonautic story. The further argument that the *Nostoi* recognized a son of Calypso by Ulysses but no son of Circe, consequently that Circe was unknown to the poet of the *Nostoi*, rests (in the first place) upon a conjectural alteration of a passage in Eustathius, and moreover has all the weakness of an argument from silence, in addition to the uncertainty arising from our very slight knowledge of the author whose silence is in question. Finally, when Kirchoff finds traces in books x.–xii. of their having been originally told by the poet himself instead of being put in the mouth of his hero, we feel that inaccuracies of this kind are apt to creep in whenever a fictitious story is thrown into the form of an autobiography.

Inquiries conducted with the refinement which characterizes those of Kirchoff are always instructive, and his book contains very many just observations; but it is impossible to admit his main conclusions. And perhaps we may infer that no similar attempt can be more successful. It does not indeed follow that the *Odyssey* is free from interpolations. The Νέκυια of book xi. may be later (as Lauer maintained), or it may contain additions, which could easily be inserted in a description of the kind. And the last book is probably by a different hand, as the ancient critics believed. But the unity of the *Odyssey* as a whole is apparently beyond the reach of the existing weapons of criticism.

Chorizontes.—When we are satisfied that each of the great Homeric poems is either wholly or mainly the work of a single poet, a question remains which has been matter of controversy in ancient as well as modern times—Are they the work of the same poet? Two ancient grammarians, Xeno and Hellanicus, were known as the separators (οἱ χωρίζοντες); and Aristarchus appears to have written a treatise against their heresy. In modern times some of the greatest names have been on the side of the "Chorizontes."

If, as has been maintained in the preceding pages, the external evidence regarding Homer is of no value, the problem now before us may be stated in this form:—Given two poems of which nothing is known except that they are of the same school of poetry, what is the probability that they are by the same author? We may find a fair parallel by imagining two plays drawn at hazard from the works of the great tragic writers. It is evident that the burden of proof would rest with those who held them to be by the same hand.

The arguments used in this discussion have been of very various calibre. The ancient Chorizontes observed that the messenger of Zeus is Iris in the *Iliad*, but Hermes in the *Odyssey*; that the wife of Hephæstus is one of the Charites in the *Iliad*, but Aphrodite in the *Odyssey*; that the heroes in the *Iliad* do not eat fish; that Crete has a hundred cities according to the *Iliad*, and only ninety according to the *Odyssey*; that προπάροιθε is used in the *Iliad* of place, in the *Odyssey* of time, &c. Modern scholars have added to the list, especially by making careful comparisons of the two poems in respect of vocabulary and grammatical forms. Nothing is more difficult than to assign the degree of weight to be given to such facts. The difference of subject between the two poems is so great that it leads to the most striking differences of detail, especially in the vocabulary. For instance, the word φόβος, which in Homer means "flight in battle" (not "fear"), occurs thirty-nine times in the *Iliad*, and only once in the *Odyssey*; but then there are no battles in the *Odyssey*. Again, the verb ῥήγνυμι, "to break," occurs forty-eight times in the *Iliad*, and once in the *Odyssey*,—the reason being that it is constantly used of breaking the armour of an enemy, the gate of a city, the hostile ranks, &c. Once more, the word σκότος, "darkness," occurs fourteen times in the *Iliad*, once in the *Odyssey*. But in every one of the fourteen places it is used of "darkness" coming over the sight of a fallen warrior. On the other side, if words such as ἀσάμινθος, "a bath," χέρνιψ, "a basin for the hands," λέσχη, "a place to meet and talk," &c., are peculiar to the *Odyssey*, we have only to remember that the scene in the *Iliad* is hardly ever laid

[1] *Die Composition der Odyssee*, Berlin, 1869. A full discussion of this book is given by Dr E. Kammer, *Die Einheit der Odyssee*, Leipsic, 1873.

within any walls except those of a tent. These examples will show that mere statistics of the occurrence of words prove little, and that we must begin by looking to the subject and character of each poem. When we do so, we at once find ourselves in the presence of differences of the broadest kind. The *Iliad* is much more historical in tone and character. The scene of the poem is a real place, and the poet sings (as Ulysses says of Demodocus) as though he had been present himself, or had heard from one who had been. The supernatural element is confined to an interference of the gods, which to the common eye hardly disturbs the natural current of affairs. The *Odyssey*, on the contrary, is full of the magical and romantic—"speciosa miracula," as Horace called them. Moreover, these marvels—which in their original form are doubtless as old as anything in the *Iliad*, since in fact they are part of the vast stock of popular tales (*Märchen*) diffused all over the world—are mixed up in the *Odyssey* with the heroes of the Trojan war. This has been especially noticed in the case of the story of Polyphemus, one that is found in many countries, and in versions which cannot all be derived from Homer. W. Grimm has pointed out that the behaviour of Ulysses in that story is senseless and foolhardy, utterly beneath the wise and much-enduring Ulysses of the Trojan war. The reason is simple; he is not the same Ulysses, but a being of the same world as Polyphemus himself—the world of giants and ogres. The question then is—How long must the name of Ulysses have been familiar in the legend (*Sage*) of Troy before it made its way into the tales of giants and ogres (*Märchen*), where the poet of the *Odyssey* found it?

Again, the Trojan legend has itself received some extension between the time of the *Iliad* and that of the *Odyssey*. The story of the Wooden Horse is not only unknown to the *Iliad*, but is of a kind which we can hardly imagine the poet of the *Iliad* admitting. The part taken by Neoptolemus seems also to be a later addition. The tendency to amplify and complete the story shows itself still more in the Cyclic poets. Between the *Iliad* and these poets the *Odyssey* often occupies an intermediate position.

This great and significant change in the treatment of the heroic legends is accompanied by numerous minor differences (such as the ancients remarked) in belief, in manners and institutions, and in language. These differences bear out the inference that the *Odyssey* is of a later age. The progress of reflexion is especially shown in the higher ideas entertained regarding the gods. The turbulent Olympian court has almost disappeared. Zeus has acquired the character of a supreme moral ruler; and although Athene and Poseidon are adverse influences in the poem, the notion of a direct contest between them is scrupulously avoided. The advance of morality is shown in the more frequent use of terms such as "just" (δίκαιος), "piety" (ὁσίη), "insolence" (ὕβρις), "god-fearing" (θεουδής), "pure" (ἁγνός); and also in the plot of the story, which is distinctly a contest between right and wrong. In matters bearing upon the arts of life it is unsafe to press the silence of the *Iliad*. We may note, however, the difference between the house of Priam, surrounded by distinct dwellings for his many sons and daughters, and the houses of Ulysses and Alcinous, with many chambers under a single roof. The singer, too, who is so prominent a figure in the *Odyssey* can hardly be thought to be absent from the *Iliad* merely because the scene is laid in a camp.

Style of Homer.—A few words remain to be said on the style and general character of the Homeric poems, and on the comparisons which may be made between Homer and analogous poetry in other countries.

The cardinal qualities of the style of Homer have been pointed out once for all by Mr Matthew Arnold. "The translator of Homer," he says, "should above all be penetrated by a sense of four qualities of his author—that he is eminently rapid; that he is eminently plain and direct, both in the evolution of his thought and in the expression of it, that is, both in his syntax and in his words; that he is eminently plain and direct in the substance of his thought, that is, in his matter and ideas; and finally, that he is eminently noble" (*On Translating Homer*, p. 9).

The peculiar rapidity of Homer is due in great measure to his use of the hexameter verse. It is characteristic of early literature that the evolution of the thought—that is, the grammatical form of the sentence—is guided by the structure of the verse; and the correspondence which consequently obtains between the rhythm and the grammar—the thought being given out in lengths, as it were, and these again divided by tolerably uniform pauses—produces a swift flowing movement, such as is rarely found when the periods have been constructed without direct reference to the metre. That Homer possesses this rapidity without falling into the corresponding faults—that is, without becoming either "jerky" or monotonous—is perhaps the best proof of his unequalled poetical skill. The plainness and directness, both of thought and of expression, which characterize Homer were doubtless qualities of his age; but the author of the *Iliad* (like Voltaire, to whom Mr Arnold happily compares him) must have possessed the national gift in a surpassing degree. The *Odyssey* is in this respect perceptibly below the level of the *Iliad*.

Rapidity or ease of movement, plainness of expression, and plainness of thought, these are not the distinguishing qualities of the great epic poets—Virgil, Dante, Milton. On the contrary, they belong rather to the humbler epico-lyrical school for which Homer has been so often claimed. The proof that Homer does not belong to that school—that his poetry is not in any true sense "ballad-poetry"—is furnished by the higher artistic structure of his poems (already discussed), and as regards style by the fourth of the qualities distinguished by Mr Arnold—the quality of *nobleness*. It is his noble and powerful style, sustained through every change of idea and subject, that finally separates Homer from all forms of "ballad-poetry" and "popular epic."[1]

But while we are on our guard against a once common error, we may recognize the historical connexion between the *Iliad* and *Odyssey* and the "ballad" literature which undoubtedly preceded them in Greece. It may even be admitted that the swift-flowing movement, and the simplicity of thought and style, which we admire in the *Iliad* are an inheritance from the earlier "lays"—the κλέα ἀνδρῶν such as Achilles and Patroclus sang to the lyre in their tent. Even the metre—the hexameter verse—may be assigned to them. But between these lays and Homer we must place the cultivation of epic poetry as an art.[2] The pre-Homeric lays doubtless furnished the elements of such a poetry—the alphabet, so to speak, of the art; but they must have been refined and transmuted before they formed poems like the *Iliad* and *Odyssey*.

A single example will illustrate this. In the scene on the walls of Troy, in the third book of the *Iliad*, after Helen has pointed out Agamemnon, Ulysses, and Ajax in answer to Priam's questions, she goes on unasked to name Idomeneus. Lachmann, whose mind is full of the ballad manner, fastens upon this as an irregularity. "The unskil-

[1] "As a poet Homer must be acknowledged to excel Shakespeare in the truth, the harmony, the sustained grandeur, the satisfying completeness of his images" (Shelley, *Essays*, &c., vol. i. p. 51, ed. 1852).

[2] "The old English balladist may stir Sir Philip Sidney's heart like a trumpet, and this is much; but Homer, but the few artists in the grand style, can do more—they can refine the raw natural man, they can transmute him" (*On Translating Homer*, p. 61).

ful transition from Ajax to Idomeneus, about whom no question had been asked," he cannot attribute to the original poet of the lay (*Betrachtungen*, p. 15, ed. 1865). But, as has lately been pointed out,[1] this is exactly the variation which a *poet* would introduce to relieve the primitive *ballad-like* sameness of question and answer; and moreover it forms the transition to the lines about the Dioscuri by which the scene is so touchingly brought to a close.

Analogies.—The development of epic poetry (properly so called) out of the oral songs or ballads of a country is a process which in the nature of things can seldom be observed. It seems clear, however, that the hypothesis of epics such as the *Iliad* and *Odyssey* having been formed by putting together or even by working up shorter poems finds no support from analogy.

Narrative poetry of great interest is found in several countries (such as Spain and Servia), in which it has never attained to the epic stage. In Scandinavia, in Lithuania, in Russia, according to M. Gaston Paris (*Histoire poétique de Charlemagne*, p. 9), the national songs have been arrested in a form which may be called intermediate between contemporary poetry and the epic. The true epics are those of India, Persia, Greece, Germany, Britain, and France. Most of these, however, fail to afford any useful points of comparison, either from their utter unlikeness to Homer, or because there is no evidence of the existence of anterior popular songs. The most instructive, perhaps the only instructive, parallel is to be found in the French "chansons de geste," of which the *Chanson de Roland* is the earliest and best example. These poems are traced back with much probability to the 10th century. They are epic in character, and were recited by professional *jongleurs* (who may be compared to the ἀοιδοί of Homer). But as early as the 7th century we come upon traces of short lays (the so-called cantilènes) which were in the mouths of all, and were sung in chorus. It has been held that the chansons de geste were formed by joining together "bunches" of these earlier cantilènes, and this was the view taken by M. Léon Gautier in the first edition of his great work, *Les Épopées françaises*, published in 1865. In the second edition, of which the first volume appeared in 1878, he has abandoned this theory. He still believes that the epics were generally composed under the influence of earlier songs. "Our first epic poets," he now says, "did not actually and materially patch together pre-existent cantilènes. They were only inspired by these popular songs; they only borrowed from them the traditional and legendary elements. In short, they took nothing from them but the ideas, the spirit, the life; they 'found' (ils ont trouvé) all the rest" (p. 80). But he admits that "some of the old poems may have been borrowed from tradition, without any intermediary" (*ibid.*); and when it is considered that the traces of the "cantilènes" are slight, and that the degree in which they inspired the later poetry must be a matter of impression rather than of proof, it does not surprise us to find other scholars (notably M. Paul Meyer) attaching less importance to them, or even doubting their existence.[2]

When M. Léon Gautier shows how history passes into legend, and legend again into romance, we are reminded of the difference noticed above between the *Iliad* and the *Odyssey*, and between Homer and the early Cyclic poems. And as has been recently pointed out, the peculiar degradation of Homeric characters which appears in some poets (especially Euripides) finds a parallel in the later chansons de geste.[3]

The comparison of Homer with the great literary epics calls for more discursive treatment than would be in place here. Some external differences have been already indicated. Like the French epics, Homeric poetry is indigenous, and is distinguished by this fact, and by the ease of movement and the simplicity which result from it, from poets such as Virgil, Dante, and Milton. It is also distinguished from them by the comparative absence of underlying motive or sentiment. In Virgil's poetry a sense of the greatness of Rome and Italy is the leading motive of a passionate rhetoric, partly veiled by the "chosen delicacy" of his language. Dante and Milton are still more faithful exponents of the religion and politics of their time. Even the French epics are pervaded by the sentiment of fear and hatred of the Saracens. But in Homer the interest is purely dramatic. There is no strong antipathy of race or religion; the war turns on no political event; the capture of Troy lies outside the range of the *Iliad*. Even the heroes are not the chief national heroes of Greece. The interest lies wholly (so far as we can see) in the picture of human action and feeling.

Bibliography.—A complete bibliography of Homer would fill volumes. The following list is intended to include those books only which are of first-rate importance, or which would be found of use to a student at the present time.

The *editio princeps* of Homer, published at Florence in 1488, by Demetrius Chalcondylas, and the Aldine editions of 1504 and 1517, have still some value beyond that of curiosity. The chief modern critical editions are those of Wolf (Halle, 1794-95; Leipsic, 1804-7), Spitzner (Gotha, 1832-36), Bekker (Berlin, 1843; Bonn, 1858), and La Roche (*Odyssey*, 1867-68; *Iliad*, 1873-76, both at Leipsic). The commentaries of Barnes, Clarke, and Ernesti are practically superseded; but Heyne's *Iliad* (Leipsic, 1802), and Nitzsch's commentary on the *Odyssey* (books i.-xii., Hanover, 1826-40) are still useful. Nägelbach's *Anmerkungen zur Ilias* (A, B 1-483, Γ) is of great value, especially the third edition (by Autenrieth, Nuremberg, 1864). The school editions of Faesi, Ameis, and La Roche should be added to the corresponding English books. The unique *Scholia Veneta* on the *Iliad* were first made known by Villoison (*Homeri Ilias ad veteris codicis Veneti fidem recensita, Scholia in eam antiquissima ex eodem codice aliisque nunc primum edidit, cum Asteriscis, Obeliscis, aliisque signis criticis, Joh. Baptista Caspar d'Ansse de Villoison*, Venice, 1788); reprinted, with many additions from other MSS., by Bekker (*Scholia in Homeri Iliadem*, Berlin, 1825-26). A new edition is being published by the Oxford Press (*Scholia Græca in Homeri Iliadem*, ed. Gul. Dindorfius); four volumes have appeared (1875-77). The vast commentary of Eustathius was first printed at Rome in 1542; the last edition is that of Stallbaum (Leipsic, 1827). The Scholia on the *Odyssey* were published by Buttmann (Berlin, 1821), and with greater approach to completeness by W. Dindorf (Oxford, 1855). Although Wolf at once perceived the value of the Venetian Scholia on the *Iliad*, the first scholar who thoroughly explored them was K. Lehrs (*De Aristarchi studiis Homericis*, Königsberg, 1833; 2d ed. Leipsic, 1865). Of the studies in the same field which have appeared since, the most important are:—Aug. Nauck, *Aristophanis Byzantii fragmenta* (Halle, 1848); L. Friedländer, *Aristonici* περὶ σημείων Ἰλιάδος *reliquiæ* (Göttingen, 1853); M. Schmidt, *Didymi Chalcenteri fragmenta* (Leipsic, 1854); L. Friedländer, *Nicanoris* περὶ Ἰλιακῆς στιγμῆς *reliquiæ* (Berlin, 1857); Aug. Lentz, *Herodiani Technici reliquiæ* (Leipsic, 1867); J. La Roche, *Die homerische Textkritik im Alterthum* (Leipsic, 1866), and *Homerische Untersuchungen* (Leipsic, 1869); Ad. Römer, *Die Werke der Aristarcheer im Cod. Venet. A.* (Munich, 1875).

The literature of the "Homeric Question" begins practically with Wolf's *Prolegomena* (Halle, 1795). Of the earlier books

[1] By A. Römer, *Die Exegetischen Scholien der Ilias*, p. vii.

[2] "On comprend que des chants populaires nés d'un événement éclatant, victoire ou défaite, puissent contribuer à former la tradition, à en arrêter les traits; ils peuvent aussi devenir le centre de légendes qui se forment pour les expliquer; et de la sorte leur substance au moins arrive au poëte épique qui l'introduit dans sa composition. Voilà ce qui a pu se produire pour de chants très-courts, dont il est d'ailleurs aussi difficile d'affirmer que de nier l'existence. Mais on peut expliquer la formation des chansons de geste par une autre hypothèse" (Meyer, *Recherches sur l'Épopée française*, p. 65). "Ce qui a fait naître la théorie des chants 'lyrico-épiques' ou des cantilènes, c'est le système de Wolf sur les poëmes homériques, et de Lachmann sur les *Nibelungen*. Mais, au moins en ce qui concerne ce dernier poëme, le système est détruit. . . . On tire encore argument des romances espagnoles, qui, dit-on, sont des 'cantilènes' non encore arrivées à l'épopée. . . . Et c'est le malheur de cette théorie: faute de preuves directes, elle cherche des analogies au dehors; en Espagne, elle trouve des 'cantilènes,' mais pas d'épopée; en Allemagne, une épopée, mais pas de cantilènes!" (*Ibid.*, p. 66).

[3] A. Lang, *Contemporary Review*, vol. xvii., n.s., p. 588.

Wood's *Essay on the Original Genius and Writings of Homer* is the most interesting. Wolf's views were skilfully popularized in W. Müller's *Homerische Vorschule* (2d. ed., Leipsic, 1836). G. Hermann's dissertations *De interpolationibus Homeri* (1832) and *De iteratis apud Homerum* (1840) are reprinted in his *Opuscula*. Lachmann's two papers (*Betrachtungen über Homer's Ilias*) were edited together by M. Haupt (2d ed., Berlin, 1865). Besides the somewhat voluminous writings of Nitzsch, and the discussions contained in the histories of Greek literature by K. O. Müller, Bernhardy, Ulrici, and Th. Bergk, and in Grote's *History of Greece*, the chief books are:—Welcker, *Der epische Cyclus oder die homerischen Dichter* (Bonn, 1835–49); Lauer, *Geschichte der homerischen Poesie* (Berlin, 1851); Sengebusch, two dissertations prefixed to the two volumes of W. Dindorf's *Homer* in the Teubner series (1855–56); Friedländer, *Die Homerische Kritik von Wolf bis Grote* (Berlin, 1853); Nutzhorn, *Die Entstehungsweise der Homerischen Gedichte, mit Vorwort von J. N. Madvig* (Leipsic, 1869); E. Kammer, *Zur homerischen Frage* (Königsberg, 1870); A. Kirchoff, *Die Composition der Odyssee* (Berlin, 1869); Volkmann, *Geschichte und Kritik der Wolf'schen Prolegomena* (Leipsic, 1874). The interest taken in the question by English students is sufficiently shown in the writings of Mr Gladstone, Professor Blackie, Mr Paley, Dr Hayman (in the Introduction to his *Odyssey*), and Professor Geddes.

The Homeric dialect must be studied in the books (such as those of G. Curtius) that deal with Greek on the comparative method. The best special work is the *Griechische Formenlehre* of H. L. Ahrens (Göttingen, 1852). On Homeric syntax the chief book is B. Delbrück's *Syntactische Forschungen* (Halle, 1871–79), especially vols. i. and iv.; on metre, &c., Hartel's *Homerische Studien* (i.–iii., Vienna), and Knös, *De digammo Homerico quæstiones* (Upsala, 1872–73–78). The papers reprinted in Bekker's *Homerische Blätter* (Bonn, 1863–72) and Cobet's *Miscellanea Critica* (Leyden, 1876) are of the highest value. Hoffmann's *Quæstiones Homericæ* (Clausthal, 1842) is a useful collection of facts. Buttmann's *Lexilogus*, as an example of method, is still worth study.

The antiquities of Homer—using the word in a wide sense—may be studied in the following books:—Völcker, *Ueber Homerische Geographie und Weltkunde* (Hanover, 1830); Nägelsbach's *Homerische Theologie* (2d ed., Nuremberg, 1861); H. Brunn, *Die Kunst bei Homer* (Munich, 1868); W. W. Lloyd, *On the Homeric Design of the Shield of Achilles* (London, 1854); Buchholz, *Die homerischen Realien* (Leipsic, 1871–73).

Among other aids should be mentioned the *Index Homericus* of Seber (Oxford, 1780); Mr Prendergast's *Concordance to the Iliad* (London, 1875); Autenrieth's *Homeric Dictionary* (London, 1877); and the *Lexicon Homericum*, edited by H. Ebeling (in the course of publication). (D. B. M.)

HOMESTEAD

THE laws of the United States give to every citizen who is the head of a family, or who has arrived at the age of twenty-one years, the right to a homestead of 160 acres, to be selected at will from any of the surveyed and otherwise unappropriated public lands, without cost, except entry fees. The tract thus taken as a homestead must be located in a compact body, upon land which is agricultural in character, and must conform to the legal subdivisions established by the official survey. It is set apart from the general estate of the householder as a sacred provision for the family, and is protected from alienation by the householder, and from execution for his general debts. The administration of the homestead and other land laws is committed to the general land office, a bureau of the interior department of the National Government at Washington, presided over by a commissioner, the secretary of the interior having appellate jurisdiction. For the convenience of applicants, the States and Territories where the public lands are still to be found are divided into districts, in each of which there is established a local land office, in charge of a registrar and a receiver, whose duty it is to attend to the disposal of the public lands.

To obtain a homestead the applicant must make an affidavit before the registrar or receiver that he is over the age of twenty-one years, or the head of a family; that he is a citizen of the United States, or has declared his intention to become such; and that the entry is made for his exclusive use and benefit, and for actual settlement and cultivation. A homestead entry thus made vests in the settler an inceptive right only. He has a "claim" to the land which no one can dispute so long as he complies with the law requiring him to live upon and cultivate it for five years; but he has no title which he can convey. If he abandons the land, or remains absent from it for a period of more than six months, his entry may be contested and cancelled; and then the tract will be open to the first legal applicant. In such a case the original claimant will not be permitted to make another entry, as the law allows but one homestead privilege. It is essential that the person making a homestead entry should know that no one else has located upon the land and begun improvements as the foundation of a claim under the pre-emption laws, for such a claim would antedate his own. Having resided upon and cultivated his claim for five years, the settler is allowed two years more, but no longer, in which to make his "final proof." Final proof consists in the affidavit of the settler and that of two disinterested witnesses, showing that the claimant is a citizen of the United States, that he has made actual settlement upon and cultivated the land in good faith for the time required, and that he has never perfected or abandoned an entry made under the homestead laws. This proof is then transmitted to the commissioner of the general land office at Washington, and if the entry is found to be in all respects lawful, a patent is forwarded to the settler, who thus acquires a permanent and absolute title to his homestead.

The public lands are held by the Government at the minimum price of $1.25 per acre; but where alternate sections have been granted to railroads or other works of internal improvement, the reserved sections are held at $2.50. Of this $2.50 or "double minimum" land, formerly only soldiers and sailors of the War of the Rebellion were allowed to enter as homestead claimants of 160 acres, other citizens being restricted to 80 acres. By the acts of March 3d and July 1st 1879, the privilege of entering 160 acres was extended to all citizens and made general; but there are still some portions of Alabama, Mississippi, and other States where no more than 80 acres of $2.50 land can be taken.

Where homestead entries are made by soldiers and sailors who served ninety days or more in the United States army or navy during the War of the Rebellion, the period of their service, or, if they were discharged on account of wounds or disability incurred in the line of duty, the entire term of enlistment, not to exceed four years, is deducted from the five years' residence required by law. But no one can receive a title to his homestead under any circumstances without having lived upon it at least one year.[1]

For homestead entries on lands in Michigan, Wisconsin, Iowa, Missouri, Minnesota, Kansas, Nebraska, Dakota, Alabama, Mississippi, Louisiana, Arkansas, and Florida, commissions and fees are to be paid according to the following table:—

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[1] A settler who under former laws was restricted in his entry to less than 160 acres is now permitted, except in a few localities, to enter other lands adjoining his original homestead, as an "additional entry," to an amount sufficient to make with his first entry 160 acres; and in this case the time of his residence on the tract originally entered will be deducted from the five years, so that in making his final proof he need show occupancy and cultivation of his additional homestead for one year only. Entries of this class are made without payment of fees and commissions. Instead of making such an additional entry the settler may surrender his existing entry to the Government, and make another of 160 acres. Soldiers and sailors of the War of the Rebellion, who prior to June 22, 1874, had made homestead entries of less than 160 acres, have the further privilege of selecting their additional entries from any unoccupied lands, whether adjoining their original homesteads or not.

Acres.	Price per Acre.	Commissions.		Fee.	Total of Fee and Commissions.
		Payable when Entry is made.	Payable when final Proof is made.	Payable when Entry is made.	
160	$2 50	$8 00	$8 00	$10 00	$26 00
80	2 50	4 00	4 00	5 00	13 00
40	2 50	2 00	2 00	5 00	9 00
160	1 25	4 00	4 00	10 00	18 00
80	1 25	2 00	2 00	5 00	9 00
40	1 25	1 00	1 00	5 00	7 00

On lands in California, Nevada, Oregon, Colorado, and in the Territories of Arizona, Idaho, Montana, New Mexico, Utah, Washington, and Wyoming, the commissions are 50 per cent. greater, but the fees are as given above.

If the settler does not wish to remain five years upon his land, the law permits him to pay for it with cash, military bounty land warrants, or agricultural college, private claim, or certain other scrip, upon making proof of residence and cultivation for a period of not less than six months from date of entry. Scrip is a paper issued by the Government, either as a gratuity, or in lieu of a claim for lands, and made receivable by the land bureau in payment for other lands. When the land is paid for in this way the homestead becomes virtually a "pre-emption." Every person qualified to make a homestead entry is also a qualified pre-emptor, provided he is already the owner of 320 acres of land in the United States, and does not abandon a residence on his own land, in the same State or Territory, to go upon the land he wishes to pre-empt; but only one pre-emption can be made by any citizen. Land to the extent of 160 acres may be obtained by actual settlers under the pre-emption laws, by purchase (sections 2257 to 2288, U. S. Revised Statutes). A residence of at least six months, with cultivation and improvement of the land, is required. Pre-emption claims may be initiated upon unsurveyed lands, although in such a case title cannot be obtained until after the official survey has been made. The first step in securing a pre-emption right is to go upon the land and commence "improvements." When this has been done, if the land is "offered"—that is, if at some time it has been offered at public sale by proclamation of the president, or otherwise—the applicant, within thirty days from date of his settlement, must file with the district land office a declaratory statement setting forth his claim; and within one year from date of settlement he must appear before the registrar and receiver, and make proof of actual residence on and cultivation of the tract. He will then be permitted to obtain title to the land, by locating upon it land warrants or scrip, or by paying for it with cash at the rate of $1.25 per acre, or, if within the limits of a public improvement grant, at the rate of $2.50 per acre. In case the land has not been offered at public sale, the applicant has three months after settlement within which to file his declaratory statement with the local land officers, and thirty-three months from settlement within which to make final proof and payment for the land. If the land is unsurveyed when the settlement is made, the claimant must file his declaratory statement within three months from the date of the receipt at the district land office of the approved plat of survey of the township embracing the tract. Where compliance with the requirements of the homestead or pre-emption laws is rendered difficult or impossible in consequence of the destruction of crops by grasshoppers, an absence of one year is allowed, during which time no adverse right can accrue. Public notice by advertisement must be given, under direction of the registrar, before final proof can be made in homestead and pre-emption entries.

Under the homestead laws the land is virtually a gift to the settler by the Government, in consideration of settlement and cultivation, the fees charged being about sufficient to cover the cost of entry and conveyance. Under the pre-emption laws the right of purchase is conceded to the actual settler only. With regard to the value of improvements which must be put upon the land in order to entitle the claimant to make final proof and obtain a patent, nothing is definitely stated in the laws themselves, and no absolute rule has been laid down by the general land office; it can only be said generally that homestead and pre-emption improvements must be sufficient to satisfy the land officers that settlement has been made in good faith. A habitable house, which must be used as the home of the settler, with his family, if he is the head of a family, is always required, and a part of the claim must be brought under cultivation.

It will be noted that under the homestead laws none but citizens of the United States, native or naturalized, can make final proof and receive a patent, while a pre-emption entry may be made and consummated by a settler who has declared his intention to become a citizen, whether or not he has taken out his final citizenship papers. After a settler has exercised his right of pre-emption, and obtained title to his claim, there is nothing in the laws or in the regulations of the department to prevent him from proceeding to settle upon another tract under the homestead law; and he may also, during the time he is residing upon his pre-emption or homestead claim, make entry of 160 acres under the "timber culture act." It is possible for a settler in this way to acquire title to an aggregate quantity of 480 acres; and this is frequently done. The privileges of the land laws of the United States are extended equally to male and female citizens. Lands entered under the homestead and pre-emption laws are exempt from taxation during the term of residence necessary to acquire title; and in a majority of the States such lands are not taxable until a patent has been issued. Upon the death of a claimant under the homestead, pre-emption, or timber culture laws, any rights he may have acquired accrue to his heirs.

Large portions of the unoccupied public lands of the United States are devoid of timber. "To encourage the growth of timber on the western prairies" the following privileges are granted by the Act of March 3, 1873, and subsequent amendments. Any person who is the head of a family or over twenty-one years of age, and who is a citizen of the United States, or has declared his intention to become such, may enter as a "timber culture" claim one-quarter section (160 acres) of prairie land, upon making affidavit to the fact that he desires for his own benefit to plant and cultivate timber upon the tract. The section of land in which such an entry is made must be naturally devoid of timber, and only one-quarter of any one section can be entered. A person making an entry of 160 acres is required to break or plough 5 acres during the first year and 5 acres in addition during the second year. The 5 acres broken or ploughed during the first year he is required to cultivate during the second year, and to plant in timber, seeds, or cuttings during the third year. The 5 acres broken or ploughed during the second year he is required to cultivate during the third year, and to plant in timber, seeds, or cuttings during the fourth year. Land embraced in entries of a less quantity than one-quarter section must be cultivated and planted during the same periods and in the same proportion, viz., to the amount of one-sixteenth of the area claimed. The trees must be such as are suitable for timber, the cultivation of fruit trees and shrubbery not being sufficient. Provision is made under the act for an extension of time in case the trees, seeds, or cuttings planted should be destroyed by grasshoppers or by extreme and unusual drought. If, at the expiration of eight years from the date of entry, or at any time within five years thereafter, the claimant shall prove by two credible witnesses that he has successfully cultivated the required amount of timber for not less than eight years, according to the provisions of the act of June 14, 1878, he will be entitled to a patent for the land embraced in the entry. At any time after one year from the date of entry, if the applicant fails to comply with any of the requirements of the act, his claim becomes liable to contest, and, upon due proof of such failure, the entry will be cancelled and the land become again subject to entry under the homestead laws, or by some other person, under the Act of June 14, 1878. The fees for timber culture entries are $10 if the tract applied for is more than 80 acres, and $5 if it is 80 acres or less. The commissions on all entries are $4 at the date of entry, and $4 at the date of final proof.

The foregoing statements refer to public lands which are agricultural in character. There are special laws for the disposal of desert lands, mineral lands, town sites on the public domain, and lands which are unfit for cultivation, and valuable chiefly for timber or stone.

By desert lands is meant a class of lands which will not, without irrigation, "produce any agricultural crop." Title to such lands in any of the following States and Territories may be acquired under Act of Congress of March 3, 1877:—the States of California, Oregon, and Nevada, and the Territories of Washington, Idaho, Montana, Utah, Wyoming, Arizona, New Mexico, and Dakota. Any person desiring to avail himself thereof must file with the registrar and receiver of the proper land office a declaration, under oath, setting forth that the applicant is a citizen of the United States or that he has declared his intention to become such, that he has made no other declaration for desert lands, and that he intends to reclaim the tract applied for, not exceeding one section, by conducting water thereon within three years from the date of his declaration; and he must show by the testimony of at least two disinterested and credible witnesses that the tract applied for is desert land. After this proof has been made to the satisfaction of the district officers, 25 cents per acre will be received from the applicant as a preliminary payment for the land. At any time within three years after the date of the filing of his declaration the claimant may offer proof that he has conducted water upon the land, which proof must consist of the testimony of at least two disinterested and credible witnesses. When such proof is satisfactory to the district officers, the final payment of $1 per acre may be made, and the papers will be forwarded to the general land office at Washington, as the basis for a patent.

The laws extending the homestead, pre-emption, timber culture, and desert land entry privileges make *bona fide* settlement or improvement of the land a condition precedent to obtaining title. The United States Government does not offer at public sale any of its lands in the western or north-western States or Territories; but in the States of Florida, Arkansas, Alabama, Mississippi, and Louisiana there are still large tracts of land which may be bought at the minimum price of $1.25, or at the double minimum price of $2.50 per acre.

The laws providing for the reservation and sale of town sites on the public lands are found in title 32, chapter 8, of the revised statutes of the United States. Persons who desire to found a city or town may acquire title by purchase to the extent of the tract occupied for town purposes, depending upon the number of occupants, viz., 100 to 200 inhabitants, 320 acres; 200 to 1000 inhabitants, 640 acres; 1000 inhabitants, 1280 acres; and 320 acres for each additional 1000 inhabitants, not exceeding 5000 in all. If the town be incorporated, the entry must be made by its mayor or legal representative—if unincorporated, by the county court acting as trustee—for the use and benefit of the several occupants. The patent is issued to the mayor or judge in trust for the purchaser, and the State or Territorial legislature must provide the mode of distribution of the lots.

Mineral lands are subject to exploration, occupation, and purchase by citizens or those who have made declaration of intention to become citizens of the United States. Indefinite occupation, without purchase, is secured under some circumstances by certain annual expenditures upon a mining claim. There is no restriction by United States laws of the number of locations one man may make or own by purchase from other locators.

The present area of vacant surveyed Government lands in the United States is about 134,600,000 acres, the area unsurveyed being 1,080,000,000 acres.

The public lands referred to in this article are found only in the States of Alabama, Arkansas, California, Colorado, Florida, Iowa, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, Oregon, Wisconsin, and the Territories of Arizona, Dakota, Idaho, Montana, New Mexico, Utah, Washington, and Wyoming. Throughout these States and Territories the land laws are uniform. When Texas was admitted into the Union the disposal of its public lands was reserved to the State, and it has therefore a land system of its own, which, although rather complicated, does not differ essentially from the land policy of the United States as indicated above. Under the laws of Texas, every person who is the head of a family and without a homestead may acquire title to 160 acres of land, by living upon it and cultivating it for three years; and every single man over the age of eighteen years may so acquire title to 80 acres. "Every person over the age of eighteen years, who is a citizen of the State of Texas, and who shall hereafter in good faith settle upon and occupy any part of the unappropriated public domain, not exceeding 160 acres, shall have the right to purchase the same at the sum of $1 per acre." But this right of pre-emption is not conceded to any one who is the owner of 160 acres of land in Texas, or who abandons a residence on his own land in that State to take up a residence on the public lands. The extensive school lands of Texas are purchasable by actual settlers in tracts of 80 to 160 acres at their actual value, to be determined by appraisement, "but in no case for a less price than $1.50 per acre." (E. P. H.)

HOMEYER, Karl Gustav (1795-1874), was born August 13, 1795, at Wolgast, a small town in Pomerania, which at that time was still Swedish territory. After a four years' stay in Sweden, whither his father, a merchant, had taken him in 1806, and where he may have laid the foundation of that knowledge of the languages and laws of the North which is so conspicuous in his later works, he was in 1810 received into the house of his uncle Rühs, the learned historian, who had just been called to the professorship of history at the newly-founded university of Berlin. He subsequently went through the course of law study at the universities of Berlin, Göttingen, and Heidelberg (1813–1817). It was in Berlin especially that he was introduced to the principles of the so-called historical school of the science of law by Savigny and Eichhorn, who were his principal teachers. In 1821 he settled as a privat-docent at the university of Berlin, where he was promoted to an extraordinary professorship in 1824, and to the ordinary German law chair in 1827. His principal works are his edition of the *Sachsenspiegel* (in 3 vols., containing also some other important sources of Saxon or Low German law), which is still unsurpassed in accuracy and sagacity of research, and his book on *Die Haus- und Hofmarken* (1870), in which he has given a history of the use of trade-marks among all the Teutonic nations of Europe, and which is full of important elucidations of the history of law and also contains valuable contributions to the history of art and civilization. In 1850 Homeyer was elected a member of the Berlin Academy of Sciences, in the *Transactions* of which he published various papers exhibiting profound learning ("Ueber die Heimath," 1852; "Genealogie der Handschriften des Sachsenspiegels," 1859; "Die Stadtbücher des Mittelalters," 1860; "Der Dreissigste," 1864, &c.). He died October 20, 1874.

HOMICIDE, in law, is the act of killing a human being, whether such act be criminal or not. Blackstone distinguishes three kinds of homicide—(1) justifiable, (2) excusable, and (3) felonious.

The most important case of justifiable homicide is the execution of a criminal in due course of public justice. This condition is most stringently interpreted. "To kill the greatest of malefactors deliberately, uncompelled, and extra-judicially is murder. . . . And further, if judgment of death be given by a judge not authorized by lawful commission, and execution is done accordingly, the judge is guilty of murder" (Stephen's *Commentaries*, book vi. c. iv.). The execution must be carried out by the proper officer or his deputy: any person executing the sentence without such authority, were it the judge himself, would be guilty of murder. And the sentence must be strictly pursued: to execute a criminal by a kind of death other than that to which he has been judicially condemned is murder.

Homicide committed by an officer of justice in the course of carrying out his duty, as such, is also justifiable; *e.g.*, where a person resists a legal arrest and is killed in the struggle; where officers in dispersing a riotous assemblage kill any of the mob, &c. In these cases the homicide must be shown to have been absolutely necessary. Again, homicide committed for the prevention of forcible and heinous crime, such as violent robbery, or murder, or house-breaking during the night, is justifiable.

Excusable homicide is homicide committed either by misadventure or in self-defence. In the former case, where a man in the course of doing some lawful work, accidentally and without intention kills another, the homicide is excused; *e.g.*, shooting at a mark and undesignedly hitting and killing a man. The act must be strictly lawful, and death by misadventure in unlawful sports is not a case of excusable homicide. Homicide in self-defence is excusable when the slayer is himself in immediate danger of death, and has done all he could to avoid the assault. Accordingly, if he strikes and kills his assailant after the assault is over, this is not excusable homicide. And if the assault has been premeditated, as in the case of a duel, the death of either antagonist is murder, and not excusable homicide. The excuse of *se defendendo* covers the case in which a person in defence of others whom it is his duty to protect—children, wife, master, &c.—kills an assailant. It has been considered doubtful whether the plea of self-defence is available to one who has himself provoked a fray, in the course of which he is so pressed by his antagonist that his only resource is to kill him.

The distinction between excusable and justifiable homicides refers back to a period in the history of the law when the former were considered to carry with them some taint of guilt, and to require some kind of punishment or expiation. In early law homicide, however innocent, subjects the slayer to the lawful vengeance of the kindred of the dead man. We have a good example of this feeling in the Jewish institution of cities of refuge, to which innocent manslayers might flee from the avenger of blood. The case mentioned in Deut. xix. 5 is a typical instance of what we should call excusable homicide:—"A man goeth into the wood with his neighbour to hew wood, and his hand fetcheth a stroke with the axe to cut down the tree, and the head slippeth from the helve, and lighteth upon his neighbour, that he die." In English law, the same feeling long remained. Excusable homicide involved at least forfeiture of goods, which, however, might be recovered as a matter of course by the innocent criminal obtaining a pardon and writ of restitution. Afterwards judges appear to have been in the habit of directing an acquittal in such cases. It is only by a statute so recent as 9 Geo. IV. c. 31 that the innocence of excusable homicide is expressly declared.

Felonious homicide includes SUICIDE, MANSLAUGHTER, and MURDER—the law relating to which is discussed under the different headings. These distinctions of the English law correspond generally to those of other systems. The chief difficulty is the definition of murder—the distinction between the highest and second degree of criminal homicide. In English law the element of malice aforethought chiefly distinguishes murder from manslaughter. In Scotland the term culpable homicide is the equivalent of the manslaughter of English law.

HOMILY, HOMILIARIUM, BOOKS OF HOMILIES. The word ὁμιλία from ὁμιλεῖν (ὁμοῦ, εἴλω), meaning communion, intercourse, and especially interchange of thought and feeling by means of words (conversation), was early employed in classical Greek to denote the instruction which a philosopher gave to his pupils in familiar talk (Xen., *Mem.*, I. ii. 6, 15). This usage of the word was long preserved (Ælian, *V. H.*, iii. 19); and the ὁμιλήσας of Acts xx. 11 may safely be taken to assign not only a free and informal but also a didactic character to the apostle Paul's discourse in the upper chamber at Troas, when "he talked a long while, even till break of day." That the "talk" on that occasion partook of the nature of the "exposition" (דְּרָשָׁה) of Scripture, which, undertaken by a priest, elder, or other competent person, had become a regular part of the service of the Jewish synagogue,[1] may also with much probability be assumed. The custom of delivering expositions or comments more or less extemporaneous on the lessons of the day at all events passed over soon and readily into the Christian Church, as may be gathered from the first *Apology* (c. 67) of Justin Martyr, where we read that, in connexion with the practice of reading portions from the collected writings of the prophets and from the memoirs of the apostles, it had by that time become usual for the presiding minister to deliver a discourse in which "he admonishes the people, stirring them up to an imitation of the good works which have been brought before their notice." This discourse, from its explanatory character, and from the easy conversational manner of its delivery, was for a long time called ὁμιλία rather than λόγος; it was regarded as part of the regular duty of the bishop, but he could devolve it, if he thought fit, on a presbyter, or deacon, or even on a layman. An early and well-known instance of such delegation is that mentioned by Eusebius (*H. E.*, vi. 19) in the case of Origen (216 A.D.).[2] In course of time the exposition of the lesson for the day came more frequently to assume a more elaborate character, and to pass into the category of a λόγος or even φιλοσοφία or φιλοσόφημα; but when it did so the fact was as far as possible denoted by a change of name, the word ὁμιλία being reserved for the expository or exegetical lecture as distinguished from the pulpit oration or sermon.[3] While the church of the 3d and 4th centuries could point to a brilliant succession of great preachers, whose discourses were wont to be taken down in short hand and circulated among the Christian public as edifying reading, it does not appear that the supply of ordinary homiletical talent kept pace with the rapidity of her extension throughout the Roman empire. In the smaller and remoter communities it not uncommonly happened that the minister was totally unqualified to undertake the work of preaching; and though, as is curiously shown by the case of Rome (Sozom., *H. E.*, vii. 19), the regular exposition of the appointed lessons was by no means regarded as part of the necessary business of a church, it was generally felt to be advisable that some provision should be made for the public instruction of congregations. Even in Jerome's time (*De Vir. Ill.*, c. 115), accordingly, it had become usual to read, in the regular meetings of the churches which were not so fortunate as to possess a competent preacher, the written discourses of celebrated fathers; and at a considerably later period we have on record the canon of at least one provincial council (that of Vaux, probably the third, held in 529 A.D.), positively enjoining that if the presbyter through any infirmity is unable himself to preach, "homilies of the holy fathers" (homiliæ sanctorum patrum) are to be read by the deacons. Thus the finally fixed meaning of the word homily as an ecclesiastical term came to be a written discourse (generally possessing the sanction of some great name) read in church by or for the officiating clergyman when from any cause he was unable to deliver a sermon of his own. As the standard of clerical education sank during the dark ages, the habit of using the sermons of others became almost universal. Among the authors whose works were found specially serviceable in this way may be mentioned the Venerable Bede, who is credited with no fewer than 140 homilies in the Basel and Cologne editions of his works, and who certainly was the author of many *Homiliæ de Tempore* which were much in vogue during the 8th and following centuries. Prior to Charlemagne it is probable that several other collections of homilies had obtained considerable popularity, but in the time of that emperor these had suffered so many mutilations and corruptions that an authoritative revision was felt to be imperatively necessary. The result was the well-known *Homiliarium*, prepared by Paul Warnefrid, otherwise known as Paulus Diaconus.[4] It consists of 176 homilies arranged in order for all the Sundays and festivals of the ecclesiastical year; and probably was completed before the year 780. Though written in Latin, its discourses were doubtless intended to be delivered in the vulgar tongue; the clergy, however, were often too indolent or too ignorant for this, although by more than one provincial council they were enjoined to exert themselves so that they might be able to do so.[5] Hence an important form of literary activity came to be the translation of the homilies approved by the church into the vernacular. Thus we find Alfred the Great translating the homilies of Bede; and in a similar manner arose

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[1] See Philo, *Quod omnis probus liber*, sec. 12 (ed. Mangey, ii. 458; *cf.* ii. 630).

[2] Sozomen (*H. E.* vii. 19) mentions that in Alexandria in his day the bishop alone was in the custom of preaching; but this, he implies, was a very exceptional state of matters, dating only from the time of Arius.

[3] To the more strictly exegetical lectures the names ἐξηγήσεις, ἐξηγήματα, ἐξηγητικά, ἐκθέσεις, were sometimes applied. But as no popular discourse delivered from the pulpit could ever be exclusively expository and as on the other hand every sermon professing to be based on Scripture required to be more or less "exegetical" and "textual," it would obviously be sometimes very hard to draw the line of distinction between ὁμιλία and λόγος. It would be difficult to define very precisely the difference in French between a "conférence" and a "sermon;" and the same difficulty seems to have been experienced in Greek by Photius, who says of the eloquent pulpit orations of Chrysostom, that they were ὁμιλίαι rather than λόγοι.

[4] It was first printed at Spires in 1482. In the Cologne edition of 1530 the title runs—*Homiliæ seu mavis sermones sive conciones ad populum, præstantissimorum ecclesiæ doctorum Hieronymi, Augustini, Ambrosii, Gregorii, Origenis, Chrysostomi, Bedæ, &c., in hunc ordinem digestæ per Alchuinum levitam, idque injungente ei Carolo M. Rom. Imp. cui a secretis fuit.* Though thus attributed here to Alcuin, who is known to have revised the Lectionary or *Comes Hieronymi*, the compilation of the *Homiliarium* is in the emperor's own commission entrusted to Paul, to whom it is assigned in the earlier printed editions also.

[5] Neander, *Church History*, v. 174 (Eng. transl. of 1851).

Ælfric's Anglo-Saxon *Homilies* and the German *Homiliarium* of Ottfried of Weissenburg. Such *Homiliaria* as were in use in England down to the end of the 15th century were at the time of the Reformation eagerly sought for and destroyed, so that they are now extremely rare, and the few copies which have been preserved are generally in a mutilated or imperfect form.[1]

The *Books of Homilies* referred to in the 35th Article of the Church of England originated at a convocation in 1542, at which it was agreed "to make certain homilies for stay of such errors as were then by ignorant preachers sparkled among the people." Certain homilies accordingly, composed by dignitaries of the lower house, were in the following year produced by the prolocutor; and after some delay a volume was published in 1547 entitled *Certain sermons or homilies appointed by the King's Majesty to be declared and read by all parsons, vicars, or curates every Sunday in their churches where they have cure.* In 1563 a second Book of Homilies was submitted along with the 39 Articles to convocation; it was issued the same year under the title *The second Tome of Homilies of such matters as were promised and instituted in the former part of Homilies, set out by the authority of the Queen's Majesty, and to be read in every Parish Church agreeably.* Of the twelve homilies contained in the first book, four (the 1st, 2d, 3d, and 4th) are probably to be attributed to Cranmer, and one (the 12th) possibly to Latimer; one (the 6th) is by Bonner; another (the 2d) is by Harpsfield, archdeacon of London, and a third (the 11th) by Becon, one of Cranmer's chaplains. The authorship of the 8th and 10th is quite unknown; and Becon and Ridley have been only doubtfully conjectured as the authors of the 7th and 9th respectively. The second book consists of twenty-two homilies, of which the 1st, 2d, 3d, 7th, 8th, 9th, 16th, and 17th have been assigned to Jewel, the 4th to Grindal, the 5th and 6th to Pilkington, and the 18th to Parker. See the critical edition by Griffiths, Oxford, 1869. For *The Clementine Homilies* see Apostolic Fathers, vol. ii. p. 196.

HOMŒOPATHY (from ὁμοιοπάθεια, a similarity of feeling or condition) as a distinctive system of medicine owes its origin to Hahnemann, a German physician (see Hahnemann). It is customary to regard homœopathy as a mere system of therapeutics, having reference only to the question how and on what principle is disease to be treated. But a careful student of Hahnemann or of his *Organon* will soon discover that the system with which his name is fundamentally associated is one not merely of therapeutics but of pathology, and that any complete exposition of it must embrace an account of Hahnemann's views of the ultimate nature and cause of disease, as well as of the remedies by which it is to be combated, and the principles or principle on which these are to be selected.

Hahnemann taught that disease is to be regarded as consisting essentially of the symptoms of it as experienced and expressed by the patient, or as detected by the physician; in other words, that the chief symptoms, or the "totality of the symptoms," constitute the disease, and that disease is in no case caused by any material substance, but is only and always a peculiar, virtual, dynamic derangement of the health. "Diseases" (Introduction to the *Organon*, p. 17) "will not cease to be spiritual dynamic derangements of our spiritual vital principle." He says on page 3 of the *Organon*, "For as far the greatest number of diseases are of dynamic (spiritual) origin and dynamic (spiritual) nature, their cause is therefore not perceptible to the senses;" and at page 18, referring "to small-pox, a disease accompanied by almost general suppuration," he asks, "is it possible to entertain the idea of a material morbific matter being introduced into the blood?" He held that the psoric miasm, of which the itch is the outward and visible and comparatively harmless sign, was at the root of nearly all chronic disease, viz., of all chronic disease that was not due to syphilis or sycosis. He tells us in a note to the 80th section of the *Organon* that he spent twelve years in the investigations which led to the discovery of that great source of chronic disease and of its remedies (antipsoric remedies). It was a very essential part of Hahnemann's teaching that nature is a bad physician, and not to be much trusted; that drugs are the real curative agents provided by the beneficence of the Almighty; that drugs given to healthy persons have a power of producing symptoms of disease. The ascertainment of the symptoms produced by drugs in healthy persons is called technically "proving," and the record of such provings constitutes a large part of the literature of homœopathy. This power of drugs he perpetually refers to as their "pathogenetic power." His great therapeutical doctrine, for formulating which his followers call him, with doubtful taste, "the Messiah of Medicine," was to this effect, that there is a correspondence between the symptoms produced by any given drug administered to a healthy person and its power of curing any given disease, and that the remedy for any given disease, that is, for any set of symptoms "in their totality," is that drug which, given to any healthy person, will produce the most perfect imitation of the said set of symptoms; in other words, *Similia similibus curantur.* Further, the dose of medicine is to be so attenuated as to cure the disease without hurting the patient. This attenuation of medicines constitutes, not only the most popular note of the system of Hahnemann, but that feature of it which is most characteristic of his own views and practice, and which in well-known words he declared to be established beyond the reach of cavil from future experience either of allopaths or of practitioners of the "new mongrel system made up of a mixture of allopathic and homœopathic processes." He gives minute directions as to the processes by which this attenuation is to be achieved, the principal of which are trituration, succussion, and dilution. These processes developed what he called the "spiritual power which lies hid in the inner nature of medicines" (20th section of the *Organon*). Hahnemann held that medicines became, for curative purposes, more powerful as they became more attenuated; in his last edition of the *Organon* (1833), and in its last pages, he gave the most expressive evidence of his belief in the virtue of attenuation by saying that he could scarcely name one disease which in the last year he and his assistants had not treated with the most happy results, solely by means of "olfaction"; and he added that a patient even destitute of the sense of smell may expect an equally perfect action and cure from the medicine by olfaction. He condemned strongly the administration simultaneously of a number of medicines, and insisted that only one should be given at a time. Finally, it would be unjust to him not to bear in mind that he claimed to base his views and practice on experience and sound experiment. Some points of his system were borrowed by Hahnemann from previous writers—as, indeed, he himself, though imperfectly, admits. Not to mention others, he was anticipated by Hippocrates, and especially by Paracelsus (1495–1541), in his doctrine of *Similia similibus curantur*, if not in its exclusive application. These identical words occur in the Geneva edition (1658) of the works of Paracelsus, as a marginal heading to one of the paragraphs; and in the "Fragmenta Medica," *Op. Omnia*, vol. i. 168, 169, occurs the following passage:—

[1] An ancient English metrical homiliarium exists in the library of the university of Cambridge, of which earlier versions have existed, and a portion of perhaps the earliest copy, dating from about the middle of the 13th century, was published in 1862 by Mr J. Small, librarian to the university of Edinburgh.

Simile similis cura; non contrarium.

"Quisquis enim cum laude agere Medicum volet, is has nugas longe valere jubeat. Nec enim ullus unquam morbus calidus per frigida sanatus fuit, nec frigidus per calida. Simile autem suum simile frequenter curavit, scilicet Mercurius sulphur, et sulphur Mercurium; et sal illa, velut et illa sal. Interdum quidem cum proprietate junctum frigidum sanavit calidum; sed id non factum est ratione frigidi, verum ratione naturæ alterius, quam a primo illo omnino diversam facimus."

It is very remarkable that in Hahnemann's enumeration of authors who anticipated him in regard to the doctrine of *Similia*, he makes no mention of the views of Paracelsus, though the very words seem to be taken from the works of that physician. The other point in Hahnemann's doctrine—that medicines should be tried first on healthy persons—he admits to have been enunciated by Haller. Roughly it has been acted on by physicians in all ages, but certainly more systematically since Hahnemann's time, though the result is often not such as to support his theory in regard to the action of medicine on the diseased as compared with the healthy body.

In the most characteristic feature of Hahnemann's practice—"the potentizing," "dynamizing," of medicinal substances—he appears to have been original. It has been generally affirmed that he was led to adopt his doctrine of "attenuation" by the fact that the medicines he administered produced similar effects to those of the disease, and that in any gross quantity, as he admitted, they would aggravate matters. But another and a chief reason is to be found in his views of the "spiritual," "immaterial," "dynamic" origin of disease, and his resentment against the old modes of practice of medicine.

The followers of Hahnemann are true to him in making light comparatively of pathological facts, and giving their main attention to therapeutics. They are still concerned mainly with medicines, and one very large American encyclopædia is devoted exclusively to a record of "Provings"; it is edited by Dr Timothy Allen, professor of materia medica and therapeutics in the New York Homœopathic Medical College. For some years Hahnemann's disciples continued pretty faithful to the doctrine of *Similia similibus curantur*, but they were not long in making some changes in it. We can only notice a few of the leading deviations. Dr Sharp, of Rugby, who has striven hard to overcome objectors, while admitting the doctrine of *Similia*, requires that it have regard, not to mere symptoms, but to the seat and pathology of the case; that the drug used be one which shall affect the organ at fault. Homœopathy cannot become a science till it is founded on what he calls Organopathy, or a much more careful consideration of the seat of disease than is involved in Hahnemann's views, who, he complains, passionately rejected pathology and morbid anatomy. Recently a leading homœopathist has published a book, the very title of which contradicts the doctrine of his master. Hahnemann maintains that cures never were effected in any other manner than by means of medicines of homœopathic power (*Organon*, p. 100), and that, whenever cures were wrought by those who did not understand homœopathy, it was in virtue of the homœopathic law, "the only law consonant to nature." But in 1878 Dr Kidd, the leading consultant among homœopathic practitioners in London, published a book on the *Laws of Therapeutics*. It is true that he does not carry the pluralizing far: he only substitutes two for Hahnemann's one law; but it is not the less a very remarkable departure. He is still faithful to the idea of a relationship between the action of medicines on the healthy and their curative value in sickness; but the law of *Similia* is sadly compromised. "In most cases that relationship is either of *similarity* or of *contrariety*." "Looking," says he, "to the observation of facts apart from theoretic speculations, two primary laws of therapeutics unfold themselves. Those two laws of therapeutics may well be called Galen's law, founded upon the rule of *contraria contrariis*, and Hahnemann's or the homœopathic law, founded upon the relationship of similars." This is certainly a comprehensive if a rather unphilosophical generalization. The practice of Hahnemann as to the use of highly attenuated doses of medicine is evidently not more closely adhered to than his doctrine of *Similia*. This fact is the subject of complaint in homœopathic journals. The *Medical Investigator*, in 1876, says reprovingly: "How many claiming to be homœopaths are daily entirely disregarding the law of *Similia*. It is getting to be quite a rare thing to hear of a homœopathic practitioner conducting a serious case from beginning to end without using as such cathartics, sudorifics, diuretics, &c., in direct opposition to our law; not only are these drugs used in this way, but there are some also go so far as to say that they cannot be dispensed with." Dr Wyld, the vice-president of the British Homœopathic Society, in a letter to Dr W. B. Richardson, published in the *Lancet* of June 2, 1877, arguing for an abolition of the schism of the profession on this question, thus sums up the admissions which he as a somewhat representative man was prepared to make:—"*First*, that the views expressed by Hahnemann are often extravagant and incorrect; *Secondly*, that Hippocrates was right when he said some diseases are best treated by similars and some by contraries, and therefore it is unwise and incorrect to assume the title of homœopathist; *Thirdly*, that although many believe that the action of the infinitesimal in nature can be demonstrated, its use in medicine is practically by a large number in this country all but abandoned." It must not, however, be supposed that there are not many true believers in Hahnemann's doctrines both of *Similia*, &c., and of infinitesimal doses, extending even to olfactions. In fact, one recent writer goes beyond Hahnemann. In the *Homœopathic Observer*, after many years of anxious experimenting, he claims to have discovered decided results from olfaction, or the smelling of medicines, but more especially by means of medicines contained in *closed* vessels held in the hand. Mons. Granier, of Nîmes, carries the dynamic theory of Hahnemann farther than its author. "Medicines," he says, "are fluidic powers, they are beings (*êtres*) that man may create at his will. I wish I could say they are occult powers, forming the chain of fluidic connection between the world and the tomb; but I am convinced in my own mind that, placed on the limits of *fluidic dynamism*, our observation might cast its scrutinizing glance into the unseen world."

Homœopathy has a considerable number of adherents in Great Britain, in the United States, and on the continent of Europe. In order to ascertain the esteem accorded to it in the land of its origin, inquiries have been made of neutral and unbiassed authorities, and the general result is that it has no scientific recognition, but that many of the public believe in it, and consult practitioners who profess to practise it. The system has no place in any of the universities of Germany, nor does it seem to have a single school of its own in the entire German empire. It is universally condemned in Germany by men who have anything to do with biological science, and even in the lectures on therapeutics it is not mentioned at all. In Great Britain the Medical Act of 1858 gives power to the Privy Council severely to prohibit attempts by any examining body to impose restrictions as to any theory of medicine or surgery on candidates for examination. There is a homœopathic hospital with 100 beds in London, to which is attached a homœopathic school (see Dr Wyld in *Lancet*, June 2, 1877). Homœopathy is not strong in England. There are said to be 105 homœopathic practitioners in London. In Great Britain and Ireland, with a population of thirty-five millions, there are but 275 homœopathic physicians. Liverpool and Glasgow, each with about half a million of population, have respectively fifteen and five homœopathic doctors. The somewhat weak and failing condition of homœopathy in Britain is thus contrasted by a writer in the monthly *Homœopathic Review* for January 1880 with its condition in America: in four chief American cities there are 462 homœopathic doctors, in four English towns 139; in New York city the homœopathic physicians are to the allopathic as 1 to 6, in London the proportion is 1 to 20. The writer attributes the lower condition of homœopathy in England to the fact "that it has ceased to be a novelty, that it has revolutionized orthodox medicine, and that many of our own men (homœopathic practitioners) abjure the minute doses which served so well in the hands of Hahnemann and many of his earlier disciples." But all these facts or factors must obtain equally in America. It is probable that the different system of medical education and qualification in the two countries has something to do with the difference. In the United States homœopathy has naturally had freer scope than in Europe. Some have estimated the proportion of homœopathic practitioners in the States as being one-eighth of the whole number of legally qualified practitioners. Every State determines for itself the conditions of qualification in medicine; and there is thus a vast number of separate medical schools giving both education and diplomas. Consequently there is a serious inequality in the severity of medical education and examination. In some States, as in that of Michigan, the legislature has engrafted on the university a department for teaching its youth the principles and therapeutics of homœopathy; and very lately the same legislature has provided a hospital for the homœopathic treatment of disease.

In all countries the doctrine of homœopathy is still without broad scientific recognition; and certainly in England its chief representatives are anxious to cease their existence as a distinctive school, and have, by their avowed departure from Hahnemann's law of *Similia*, and his mode of attenuating and administering medicines, brought themselves under the severest condemnation of their master's few faithful followers, amongst whom are still included men of high character. We need not discuss in detail the individual doctrines of Hahnemann, especially those just referred to, as they are scarcely fought for by those who now represent what remains of the homœopathic school. Hahnemann's fundamental views of disease deserve more attention. He despised any deep study of disease, and theorized about it instead. Had he carefully inquired into the nature and natural history of disease as Hippocrates did, or as he himself inquired into the sensations of those who took infinitesimal doses, he would have done more for the world and his own reputation. Hahnemann was easily captivated by theories, and not very sound in his reasoning. But underlying all his system, as we have seen, was the idea that the causes of disease were impalpable, immaterial, spiritual, dynamic. And this great foundation was rotten. Modern medicine is doing some of its best work in showing the material and the visible character of the causes of many of the commonest diseases, and suggests this in many cases where it has not as yet been demonstrated. The cause of many diseases is shown to be a living germ or particle which can be discerned under the microscope, can be carried on a lancet or in a tube, and inserted under the skin so as to produce its peculiar disease. This is true of small-pox, Hahnemann notwithstanding. The germ can be preserved or it can be killed, and thus disease can be propagated or prevented. The close air of workshops, which generates consumption in such amount, can be shown to be full of impurities, chemical or organic. The causes of other diseases are often, not merely visible under a microscope, but coarsely visible. We have been lately told on high authority that to produce certain forms of blood-poisoning one or two ounces at least of septic fluid are necessary. So with other forms of common disease. Alcohol does not destroy a liver or kidney in any dynamic or immaterial form, but in coarse quantities diligently repeated. The lead which paralyses the painter's wrist is not a "spiritual" thing. It is an accumulation of matter in the wrong place, and enters his body in palpable quantities, and, what is more, can be recovered in similar quantities from his body. So with the uric acid or its salts in the blood of a person who has inherited his father's gout, and perhaps his port wine. It is not a "spiritual" affair at all, but can be demonstrated chemically and under the microscope. The itch, to whose mysterious workings Hahnemann attributed two-thirds of the internal diseases of the body, including mania, cancer, gout, &c., is easily demonstrated to be dependent on an ugly crab-like insect, which can be destroyed in a few hours with sulphur, when there is an end both of it and of the itch. We are aware of the euphemistic form which is given to Hahnemann's views of the psoric or itch disease; and we are partly disposed to admit, with the late Professor Henderson, the ablest and wisest of Hahnemann's supporters in England, that Hahnemann was unfortunate in the exposition of his own views of this subject. But Hahnemann's fine but fundamental theories about the spiritual and dynamic origin of disease are all exploded by the revelations of modern pathology, and their demolition only completes that of his therapeutical theories which rested on them.

Still it does not follow that homœopathy has been of no use. Hahnemann deserves the credit of being the first to break decidedly with the old school of medical practice, in which, forgetful of the teachings of Hippocrates, nature was either overlooked or rudely opposed by wrong and ungentle methods. He was so dissatisfied with this system that he gave up practice. We can scarcely now estimate the force of character and of courage which was implied, eighty years back, in abandoning the common lines of medicine. More than this, he and his followers showed results in the treatment of disease which compared very favourably with the results of orthodox practice. But they entirely missed the right conclusion from their experience. Let us take, for example, the statistics of the treatment of inflammation of the lung (pneumonia), adduced, not by Hahnemann,—for it is one of his very weak points that he did not record cases,—but, after his death, by Dr Fleischmann of Vienna. Dr Henderson quotes these and other homœopathic statistics with great satisfaction, and undoubtedly and properly they produced a great effect, showing a mortality of 1 in 21 cases only, which was a much higher percentage of success than under the ordinary treatment. But these statistics have since been entirely eclipsed by the minute and historical record of cases treated in the Edinburgh Infirmary, where the late Dr Hughes Bennett treated 105 cases of acute pneumonia, extending over sixteen years, without one death. Still we must admit that Fleischmann's results were greatly better than the old ones, and that but for the homœopathic practice, which most practitioners regarded as a negation, tantamount to leaving the disease to nature, the emancipation from traditional methods of treatment would have been much slower than it was.

Besides this, homœopathy may be credited with two other services. It has given prominence to the therapeutical side of medicine, and has done much to stimulate the study of the physiological action of drugs. No doubt Hahnemann completely erred in despising nature, and in magnifying medicines in the cure of disease. But his very methods showed, unintentionally on his part, what nature could do;

and his devotion and that of his school to therapeutics has acted as a somewhat deserved rebuke to those physicians who get so absorbed in the study of disease as to forget that the great interest of mankind in it is to have it cured with as little delay as possible. It may be admitted that homœopathy has done some service in directing more special attention to various powerful drugs, such as aconite, nux vomica, belladonna, and to the advantage of giving them in simpler forms than were common before the days of Hahnemann.

Hahnemann's errors were great. His doctrine of specifics was highly retrograde and unscientific, and his disparagement of the principle of *tolle causam* and of those who aimed at discovering the causes of disease (*Organon*, p. 3) was unphilosophical. He was fanciful and theoretical to a very high degree. He led his followers far out of the track of sound views of disease and the methods by which it can best be prevented and cured. But, with all his defects, it must be admitted that he had the great merit of disturbing and discrediting indefensible modes of practice. (J. G. G.)

HONDA, or San Bartolommeo de Honda, a town of the republic of Colombia, in the state of Cundinamarca, on the left bank of the river Magdalena, about 575 miles from the sea, in 5° 11′ 42″ N. lat. and 74° 41′ 6″ W. long. It is regular and well-built, but none of its public edifices—churches, convents, or hospitals—call for special remark. Situated at the spot where the upward navigation of the Magdalena is stopped by a series of rapids, Honda was formerly the seat of a very considerable trade, and it still retains a certain amount of commercial importance. Goods and passengers for Bogotá, the capital of Colombia, are now disembarked at Caracoli about 2 miles further down. The population of Honda is stated at 4000 or 5000. See Colombia, vol. vi. p. 153.

HONDECOETER, Melchior d' (*c.* 1636–1695), painter, was born at Utrecht, it is said, about 1636, and died at Amsterdam, April 3, 1695. Old historians say that, being the grandson of Gillis and son of Gisbert d'Hondecoeter, as well as nephew of J. B. Weenix, he was brought up by the last two to the profession of painting. Of Weenix we know that he married one Josina d'Hondecoeter in 1638. Melchior was, therefore, related to Weenix, who certainly influenced his style. As to Gillis and Gisbert some points still remain obscure, and it is difficult to accept the statement that they stood towards each other in the relation of father and son, since both were registered as painters at Utrecht in 1637. Both it appears had practised art before coming to Utrecht, but where they resided or what they painted is uncertain. Unhappily pictures scarcely help us to clear up the mystery. In the Fürstenberg collection at Donaueschingen there is a Concert of Birds dated 1620, and signed with the monogram G. D. H.; and we may presume that G. D. H. is the man whose Hen and Chickens in a Landscape in the gallery of Rotterdam is inscribed "G. D. Hondecoeter, 1652;" but we ask, Is the first letter of the monogram to stand for Gillis or Gisbert? In the museums of Dresden and Cassel landscapes with sportsmen are catalogued under the name of Gabriel de Heusch (?), one of them dated 1529, and certified with the monogram G. D. H., challenging attention by resemblance to a canvas of the same class inscribed G. D. Hond. in the Berlin Museum. The question here is also whether G. means Gillis or Gisbert. Obviously there are two artists to consider, one of whom paints birds, the other landscapes and sportsmen. Perhaps the first is Gisbert, whose son Melchior also chose birds as his peculiar subject. Weenix too would naturally teach his nephew to study the feathered tribe. Melchior, however, began his career with a different specialty from that by which he is usually known. Mr de Stuers affirms that he produced sea-pieces. One of his earliest works is a Tub with Fish, dated 1655, in the gallery of Brunswick. But Melchior soon abandoned fish for fowl. He acquired celebrity as a painter of birds only, which he represented not exclusively, like Fyt, as the gamekeeper's perquisite after a day's shooting, or stock of a poulterer's shop, but as living beings with passions, joys, fears, and quarrels, to which naturalists will tell us that birds are subject. Without the brilliant tone and high finish of Fyt, his Dutch rival's birds are full of action; and, as Bürger truly says, Hondecoeter displays the maternity of the hen with as much tenderness and feeling as Raphael the maternity of Madonnas. But Fyt was at home in depicting the coat of deer and dogs as well as plumage. Hondecoeter cultivates a narrower field, and seldom goes beyond a cock-fight or a display of mere bird life. Very few of his pictures are dated, though more are signed. Amongst the former we should note the Jackdaw deprived of his Borrowed Plumes (1671), at the Hague, of which Earl Cadogan has a variety; or Game and Poultry and a Spaniel hunting a Partridge (1672), in the gallery of Brussels; or a Park with Poultry (1686) at the Hermitage of St Petersburg. Hondecoeter, in great favour with the magnates of the Netherlands, became a member of the painters' academy at the Hague in 1659. William III. employed him to paint his menagerie at Loo, and the picture, now at the Hague museum, shows that he could at a pinch overcome the difficulty of representing India's cattle, elephants, and gazelles. But he is better in homelier works, with which he adorned the royal chateaus of Bensberg and Oranienstein at different periods of his life (Hague and Amsterdam). In 1488 Hondecoeter took the freedom of the city of Amsterdam, where he resided till his death. His earliest works are more conscientious, lighter, and more transparent than his later ones. At all times he is bold of touch and sure of eye, giving the motion of birds with great spirit and accuracy. His masterpieces are at the Hague and at Amsterdam. But there are fine examples in private collections in England, and in the public galleries of Berlin, Caen, Carlsruhe, Cassel, Cologne, Copenhagen, Dresden, Dublin, Florence, Glasgow, Hanover, London, Lyons Montpellier, Munich, Paris, Rotterdam, Rouen, St Petersburg, Stuttgardt, and Vienna.

HONDURAS

HONDURAS, a republic of Central America, formerly a province of the kingdom of Guatemala, deriving its name from the Spanish *honduras*, depths, in allusion, it is said, to the difficulty experienced by its original explorers in finding anchorage off its coast. See Pla[te] III. vol. xi. It is bounded on the N. and E. by the Bay of Honduras and the Caribbean Sea, extending from the mouth of the Rio Tinto, 15° 45′ N. lat. and 88° 30′ W. long., to the mouth of the Rio Wanks or Segovia, in 14° 59′ N. lat. and 83° 11′ W. long., having a coast-line of about 400 miles. On the S. it is bounded by Nicaragua, the line of division following the Rio Wanks for about two-thirds of its length, thence deflecting to the sources of the Rio Negro, which flows into the Gulf of Fonseca; it has on this gulf a coast line of about 60 miles, embracing also the islands of Tigre, Sacate Grande, and Gueguensi. Upon the W. and S.W. it is bounded by San Salvador and Guatemala; the line of separation there is irregular, commencing on the Gulf of Fonseca, at the mouth of the Rio Goascoran, and ending at the mouth of the Rio Tinto, on the Bay of Honduras. The republic is therefore entirely between 83° 20′ and 89° 30′ W. long. and 13° 10′ and 16° N. lat., and comprises about 40,000 square miles. The large island of Roatan, with Guanaja or Bonacca, Utila, Helena, Barbaretta, and Morat are naturally dependent on Honduras.

Mountains.—The general aspect of the country is mountainous; it is traversed by ranges of mountains and hills radiating from the common base of the Cordilleras. That chain does not, in this republic, approach within 50 or 60 miles of the Pacific; nor does it throughout maintain its general character of an unbroken range, but sometimes turns back on itself, forming interior basins or valleys, within which are collected the headwaters of the streams that traverse the country in the direction of the Atlantic Ocean. Nevertheless, viewed from the Pacific, it presents the appearance of a great natural wall, with a lower range of mountains, bristling with volcanic peaks, intervening between it and the western sea. It would almost seem that at one time the Pacific broke at the foot of the great mountain barrier, and that the subordinate coast range was subsequently thrust up by volcanic forces. The northern and eastern coasts of the republic present several bold groups of mountains, which are the ends of the ranges radiating north and east from the Cordilleras, and which, striking the coast diagonally, and overlapping each other, seem to form an unbroken range, and are sometimes represented as such on the maps. The Cordilleras proper traverse the state in the general direction of north-west and south-east, but it is throughout serpentine, and at one point is interrupted by a great transverse valley or plain, known as the plain of Comayagua, having an extreme length of about 40 miles, with a width of from 5 to 15 miles, from which, extending due north to the Atlantic, is the valley of the river Humuya, and due south, to the Pacific, the valley of the river Goascoran, collectively constituting a great transverse valley reaching from sea to sea, which was pointed out soon after the conquest as an appropriate course for inter-oceanic communication. Topographically the country has great diversity of surface and elevation; broad alluvions, fertile valleys, wide and elevated plains, and mountains terraced to their summits, collectively affording almost every variety of climate, soil, and production, from oranges and pine apples in the valleys to peaches and pears on the table-lands.

Hydrography.—The rivers of Honduras are numerous, and some of them of large size and navigable. The largest is the Ulua, which drains a wide expanse of territory, comprehending nearly one-third of the entire state, and probably discharges a greater amount of water into the sea than any other river of Central America, the Wanks or Segovia, perhaps, excepted. It may be navigated by steamers of light draught for the greater part of its course. The soil on its banks is of extreme fertility. The Rio Aguan or Roman is a large stream falling into the sea near Truxillo, with a total length of about 120 miles. Its largest tributary is the Rio Mangualil, celebrated for its gold washings, and it may be ascended by boats of light draft for 80 miles. Rio Tinto, Negro, or Black River, called also Poyer or Poyas, is a considerable stream, said to have a length of 120 miles; it is navigable by small vessels for from 40 to 60 miles. Some English settlements were made on its banks during the last century. The Poyas Indians have a number of establishments on its upper tributaries. The Rio Wanks or Segovia is the longest, if not the largest, river in Central America, rising within 50 miles of the Bay of Fonseca, and flowing into the Caribbean Sea at Cape Gracias á Dios, constituting for the greater part of its length the boundary between Honduras and Nicaragua, and having a length of 350 miles. For 251 miles above its mouth it flows through an almost unbroken wilderness, among high mountains and over a very broken and rocky bed. It is nevertheless occasionally navigated by canoes to within a few leagues of the town of Ocotal or Nueva Segovia in Nicaragua. Three considerable rivers flow into the Pacific,—the Goascoran, Nacaome, and Choluteca, the last-named having a length of about 150 miles. The Goascoran, which almost interlocks with the Humuya, in the plain of Comayagua, has a length of about 80 miles. The Lake of Yojoa or Taulébe is the only lake of note in Honduras, and is about 25 miles in length, by from 6 to 8 in breadth. Its surface is 2050 feet above the sea. It has two outlets on the south, the rivers Jaitique and Sacapa, which unite about 15 miles from the lake; and it is drained on the north by the Rio Blanco, a narrow, deep stream falling into the Ulua. It has also a feeder on the north, in the form of a subterranean stream of beautiful clear water, which here comes to the surface.

Harbours and Islands.—The Bay of Fonseca or Conchagua, sometimes called Amapala, is one of the finest ports, or "constellation of ports," on the entire Pacific, and on it Honduras has a larger frontage than Nicaragua or San Salvador. It is upwards of 50 miles in greatest length by about 30 miles in average width, with an entrance from the sea about 18 miles wide, between the great volcanoes of Conchagua, 3800 feet high, and Coseguina, 3000 feet high, the lofty islands of Conchaguita and Mianguiri lying between them, with a collection of rocks called "Los Farellones," dividing the entrance into four distinct channels, each of sufficient depth for the largest vessels. A channel called "El Estero Real" extends from the extreme southern point of the bay into Nicaragua for about 50 miles, reaching within 20 or 25 miles of Lake Managua. The principal islands in the bay are Sacate Grande, Tigre, Gueguensi, and Esposescion belonging to Honduras, and Martin Perez, Punta Sacate, Conchaguita, and Mianguiri belonging to San Salvador. Of these Sacate Grande is the largest, being about 7 miles long by 4 broad. The island of Tigre from its position is the most important in the bay, being about 20 miles in circumference, and rising in the form of a cone to the height of 2500 feet. The slope from the water for some distance inland is gentle, admitting of cultivation. Upon the southern and eastern shores the lava forms black rocky barriers to the waves, varying in height from 10 to 80 feet; but on the northward and eastward are a number of playas or coves, with smooth, sandy beaches. Facing one of the most considerable of these is the port of Amapala, with deep water in front, where ships of ordinary size may lie within a cable's length of the shore. This island was a favourite resort of the pirates, and it was here that Drake had his depôt during his operations in the South Sea. It exports hides, indigo, tobacco, bullion, silver and copper ores, and Brazil wood. The bay abounds in fish, oysters, crabs, and cray fish, and water-fowl swarm along its shores. The whole region around it is eminently productive, and adapted to the production of every tropical commodity. The savannas back from the shores are fitted for grazing, while wheat, potatoes, and other products of the temperate zone may be cultivated on the plateaus and slopes of the mountains in the interior, where oaks and pines are abundant. The silver and gold mining districts of Tabanco, Aramacina, San Martyn, and Corpus all lie within from 10 to 40 miles of this bay. Limestone is also found near by, with a fine rose-coloured sandstone. Extensive beds of coal exist in the valley of the river Lempa. Puerto Caballos, on the northern coast, in 15° 49′ N. lat. and 87° 57′ W. long., was selected by Cortes during his expedition into Honduras for the settlement which he founded, with the purpose of making it the entrepôt of New Spain; he called it Natividad. For more than two centuries it was the principal establishment on the coast; but, during the time of the buccaneers, the settlement was removed to Omoa, a few miles to the east, because of the large size of the bay, which could only be adequately defended by the construction of several forts, while a single work, still extant and formidable, was sufficient for Omoa. The port or rather bay is about 9 miles in circumference, with a depth throughout the greater part of its area of from 4 to 12 fathoms, with secure holding ground. Towards the northern shore the depth of water is greatest; there suitable docks have been constructed, and the largest ocean steamers may enter and tie up, the rise and fall of the tide being scarcely perceptible. The prevailing winds are from the north-east, north, and north by west, from all which points the port is perfectly protected. The port of Omoa, in 15° 47′ N. lat. and 88° 3′ W. long., is small but secure, and is defended by a strong work, "El Castillo de San Fernando." The anchorage is good, in from 2 to 6 fathoms. The population in 1876 was about 600, most of the inhabitants having removed to San Pedro, 37 miles inland, where the business of the port is transacted. The exports of these ports consist of bullion, tobacco, indigo, sarsaparilla, hides, &c. A large number of cattle are shipped annually to supply the markets of Cuba and the mahogany establishments of Belize. There is an abundant supply of fish, turtle, and wild fowl from the quays and waters in its vicinity. Puerto Sal is a small harbour a few miles to the eastward of Puerto Caballos. Truxillo is an ancient port, in 15° 55′ N. lat. and 86° W. long., situated on the western shore of a noble bay, formed by the projecting land of Punta Castilla. Its trade is chiefly with Olancho, of which department it may be considered the port. There are some mines of gold in its vicinity. Triunfo de la Cruz is a large bay, commencing at Puerto Sal, bending thence inward and terminating at Cabo Triunfo, with a coastline of upwards of 20 miles. To the northward of Honduras, in the bay of the same name, distant from 30 to 50 miles, is a cluster of islands, sometimes called the Bay Islands, consisting of Roatan, Guanaja or Bonacca, Utila, Barbaretta, Helena, and Morat. They have a good soil, fine climate, and an advantageous position. Roatan, the largest, is about 30 miles long by 9 miles broad, with mountains rising to the height of 900 feet, covered with valuable woods, and abounding with deer and wild hogs. Its trade is chiefly with New Orleans in plantains, cocoa-nuts, pine apples, &c. Guanaja, discovered by Columbus, is 9 miles long by 5 miles broad; it lies 15 miles north-east of Roatan, has interior highlands thickly wooded, with beds of limestone, and, it is said, ores of zinc. Wild hogs are numerous. The other islands are comparatively small, and may be regarded as detached parts of Roatan, with which they are connected by reefs.

Minerals.—In respect to mineral resources, Honduras ranks first among the states of Central America; the working of the mines, however, has been conducted on a very small scale, and in a very rude manner, and as a consequence most of them have been abandoned and have filled with water, and have thus or otherwise been allowed to go to ruin. Silver ores are most abundant and valuable. They are chiefly found on the Pacific ranges or groups of mountains, while the gold washings, if not the gold mines proper, are most numerous on the Atlantic slope. The silver is found in various combinations with iron, lead, and copper, and in a few instances with antimony. Chlorides of silver are not uncommon, and rank among the richest ores in the country. The principal supply of gold is from the washings of Olancho, which are exceedingly productive. There are also rich mines of copper, the ores, in all cases, containing a considerable proportion of silver. Iron ores are common, most of them magnetic, and some so rich that they can be worked without smelting. Antimony, zinc, and tin also exist. Lignite has been discovered in various localities, and large beds exist in the department of Gracias, in which opals are also abundant.

Animals.—The domestic animals of the country are much the same as those of England and the United States. Cattle are everywhere abundant, and form one of the great sources of wealth in the country. Of late great numbers have been taken to Cuba, where there is a large and increasing demand for them. The forests are frequented by the ocelot or American tiger, and the peccary and deer; the tapir is found near the sea, and the manatee in the northern creeks. Monkeys are numerous and of many varieties; the raccoon, squirrel, opossum, ant-eater, and armadillo abound. The alligator is found in all the rivers and lagoons on both coasts. Of lizards there are numberless varieties, including the iguana. Serpents are very rare, and of but two or three varieties, of which one only is venomous. Tortoise and turtle are everywhere numerous, and of several kinds. Oysters of two varieties are plentiful, namely, the bank and mangrove oyster. Vast beds of the first are found in the Bay of Fonseca. Crustaceans of various kinds and sizes, from the largest lobster to the smallest crab, are abundant. The lagoons and creeks of the coast abound in endless varieties of fish, as do also the waters of the interior. Several varieties of honey bees also are found. Mosquitoes are almost unknown in the interior, and are found at but few points on the coast. The woodtick and flea are common everywhere. The insect most dreaded is the "langosta" or "chapulin," which at intervals afflicts the entire country, vast columns passing from one end to the other, darkening the air, and destroying every green thing in their course. The parrot, macaw, and toucan are found everywhere. Hawks, vultures, owls, and sea eagles are among the birds of prey. The crow, blackbird, Mexican jay, ricebird, swallow, rainbird, and humming-bird are common. There is a very great variety of water birds. The wild turkey, quail, and pigeon are numerous in the interior.

Inhabitants.—The inhabitants of Honduras are principally of the Indian or aboriginal type. In the eastern portion of the state, between the Rio Roman and Cape Gracias á Dios and Segovia river, the country is almost exclusively occupied by native Indian tribes, known under the general names of Xicaques and Poyas. Portions of all of these tribes have accepted the Catholic religion, and live in peaceful neighbourhood and good understanding with the white inhabitants. There are, however, considerable numbers who live among the mountains, and still conform closely to the aboriginal modes of life. They all cultivate the soil, and are good and industrious labourers. A small portion of the coast, above Cape Gracias, is occupied by the Sambos, a mixed race of Indians and negroes, which, however, is fast disappearing. Spreading along the entire north coast are the Caribs, a vigorous race, descendants of the Caribs of St Vincent, one of the Windward Islands, who were deported in 1796, by the English, to the number of 5000, and landed on the island of Roatan. They still retain their native language, and are active, industrious, and provident, forming the chief reliance of the mahogany cutters on the coast. A portion of them, who have a mixture of negro blood, are called the Black Caribs. They profess the Catholic religion, but retain many of their native rites and superstitions. In the departments of Gracias, Comayagua, and Choluteca are many purely Indian towns, with industrious, peaceable inhabitants, retaining many of their primitive habits and their ancient language. The aggregate population, in the absence of trustworthy data, can only be estimated approximately. Attempts were made under the crown and subsequently under the republic to effect a complete census, but with very unsatisfactory results, since it has always been found that the ignorant masses of the people, and especially the Indians, avoid a census as in some way connected with military conscription or taxation. The bulk of the Spanish population exists on the Pacific slope of the continent, while on the Atlantic declivity the country is uninhabited or but sparsely occupied by Indian tribes, of which the number is wholly unknown. Nevertheless, from the imperfect data which are accessible, the population of Honduras may fairly be estimated at about 400,000, 6000 to 7000 being whites, and the balance Indians and the mixed races.

Departments.—Honduras is divided politically into seven departments, viz., Comayagua, Gracias, Choluteca, Tegucigalpa, Olancho, Yoro, and Santa Barbara.

That of *Comayagua* lies in the very centre of the state. It contains the capital of the same name (see COMAYAGUA). The trade of the town is small, but the plain around it is very fertile, and capable of sustaining, as formerly, a large and flourishing population. Numerous monuments of antiquity are scattered over the plain, consisting of large, pyramidal, terraced structures, conical mounds of earth, and walls of stone.[1] Pine and oak are abundant on the hills, and mahogany, cedar, and lignum vitæ, as well as other useful woods, are found in the valleys. The nopal, cultivated in Guatemala and Mexico as the food of the cochineal insect, is indigenous.

[1] The most remarkable of these are the ruins of Tenampua, situated on a high hill, 20 miles to the south-east of Comayagua. The hill is of the prevailing soft sandstone, about 1600 feet high. At the accessible points are heavy stone walls, terraced on the inner side for convenience in defence. At various points are traces of towers, and remains of water reservoirs. Most of the mounds occur in groups, arranged with obvious design in respect to each other, from 20 to 30 feet square, and of several stages. The principal enclosure is in the very midst of the ruins, at a point conspicuous from every portion of the hill, and is 300 feet long by 80 feet broad, but now elevated only a few feet above the ground, on which are indications of buildings. Great quantities of fragments of pottery are found here, painted and ornamented. Altogether there are the remains of between 300 and 400 truncated, terraced pyramids of various sizes. The whole served probably for defensive and religious purposes.

Coffee and the other staples of semi-tropical regions also flourish here.

The department of *Gracias* lies in the north-western portion of the state, touching on Guatemala and Salvador, and its territory is in many respects the most interesting in Central America, of which it may be regarded as an epitome. On the north are many beautiful valleys, among them that of Copan, celebrated for its ancient monuments. Among its mountains is found the *quetzal*, the royal and sacred bird of the aborigines. Peaches, apples, and plums flourish here, and the blackberry is indigenous among the hills. The vegetable products, actual and possible, exhaust the list of productions of the tropics and the temperate zones. Wheat, barley, rye, and the potato grow on the mountains, while sugar cane, indigo, cotton, coffee, cocoa, oranges, and plantains flourish in the valleys. Pine covers the hills, and there is much mahogany, cedar, and granadillo, also Brazil wood, &c., for dyeing and manufacture. Copal balsam and liquidambar are among the common gums, while the tobacco has a wide and deserved celebrity. Gold and silver mines are numerous and rich, although but little worked. Bituminous coal, in beds of from 8 to 10 feet in thickness, is found in the plain of Sensenti, and asbestos, cinnabar, and platinum in various localities. Opals are frequent, principally in the vicinty of Erandique, where as many as sixteen mines have been "denounced" in a single year. Amethysts are reported to have been found near Campuca.

Choluteca is the extreme southern department of the state, lying along the Bay of Fonseca. It is extremely diversified in surface. Its alluvions, fronting the bay, are remarkably fertile, and are capable of producing all the staples of the tropics. As the country rises, which it does by a series of terraces, the savannas become broad and numerous, affording vast pastures for herds of cattle, which at present constitute the chief wealth of the department. Apart from its agricultural wealth, it is rich in minerals, chiefly in mines of silver.

Tegucigalpa, to the north of Choluteca, is the smallest but relatively the most populous department. It is a vast interior basin or plateau, with an average elevation of not less than 3000 feet above the sea. Its soil is not so productive as that of some of the other departments, and is essentially a mining district, rich in gold and silver. Tegucigalpa is the largest and finest city of the state, and is at present the capital, alternating with Comayagua as the seat of government.

The department of *Olancho* joins Tegucigalpa on the east, and has an area of about 11,300 square miles. Its people are industrious, and the department is comparatively the richest in the state. Its exports are bullion, cattle, hides and deer skins, sarsaparilla, and tobacco. Next to its herds of cattle, its principal sources of wealth are its gold washings. Nearly all of its streams carry gold of a fine quality in their sands.

The department of *Yoro* comprehends all the northern part of Honduras, with an area of 15,000 square miles, being the largest in size and the smallest in population. The valleys of all the streams abound in precious woods, and comprise the great mahogany district of Central America. The inhabitants are chiefly mahogany cutters by occupation. The mountains of Pija and Sulaco are said to contain great mineral wealth, but they have never been adequately explored.

The department of *Santa Barbara* lies between Gracias and Comayagua and the Bay of Honduras. It is traversed by several large streams. The great plain of Sula is the distinguishing feature of this department, which has a frontage of between 60 and 70 miles on the Bay of Honduras, and reaches inland upwards of 50 miles, comprising an area of not less than 1500 square miles. Its products are cotton, rice, sugar, cocoa, and all the great staples of the tropics.

Administration.—The government is republican in form, based on a constitution promulgated in November 1865. The chief executive consists of a president elected every four years, assisted by a council of state, consisting of two ministers appointed by the president, a senator elected by congress, and a judge of the supreme court. The legislature consists of a senate and chamber of deputies.

Public Debt.—The public debt of the republic in 1876 was $29,950,540, held in London and Paris, having been issued in three different loans in those cities, at high rates of interest and at a low valuation to make them attractive to capitalists. Since that time the accumulated interest, which has never been paid, has considerably swollen the amount. This debt, which is of a very questionable origin, was contracted for the alleged purpose of building the "Honduras Interoceanic Railway" between Port Caballos on the Bay of Honduras and the Gulf of Fonseca on the Pacific, a distance of 148 geographical miles. The road was first proposed by Mr E. G. Squier of New York, in 1854, who made the preliminary survey of the line, finding it perfectly feasible, and had it been built then it no doubt would have proved a financial success, and a great benefit to the commerce of the world. But the breaking out of the American war put a stop to the enterprise for the time, and the completion of the Union Pacific Railway in the United States has done away with the necessity for such a road as a highway for the nations. Still it would be a great benefit to the interior country should it at any time be completed. It is graded, and has a narrow guage track laid to San Pedro, 37 miles from Port Cortez.

Trade.—The total trade of the country for 1876 is given below:—

Exports from the Bay Islands, Truxillo, Omoa, and Puerto Caballos during the year 1876.

To United States	$230,503
To other countries	114,337
Total	344,840
From the port of Amapala, of which $208,646 was gold and silver	250,000
Grand total	$594,840

Imports into the Bay Islands, Truxillo, and Puerto Caballos for 1876.

From the United States	$230,184
From other countries	109,959
Total	340,143
Into the port of Amapala, estimated value	300,000
Total imports for 1876	640,143
Total foreign commerce foi 1876	$1,234,983

A number of small sailing vessels engaged in the fruit trade ply between the Bay Islands and New Orleans: Cocoa-nuts are in demand both in New Orleans and New York, and the inhabitants of the mainland, as well as those of the islands, have planted the fruit extensively, so that the entire north coast will soon be bordered by cocoa-nut plantations.

History.—It was in Honduras that Columbus first planted his feet on the continent of America. In 1502, while on his fourth voyage, he discovered the island of Guanaja or Bonacca, whence he saw the high mountains of the mainland; and on the 14th of August he landed on the continent at a point which he called *Punta de Cassinas*, now Cabo de Honduras, and took possession of the country on behalf of the crown of Spain. He subsequently coasted to the eastward, and after many delays and dangers reached a point where the coast abruptly trends to the southward, forming a cape, to which, in gratitude for his safety, he gave the name of *Cabo Gracias á Dios*, Cape Thanks to God. Less than twenty years afterwards, Hernando Cortes, inspired by accounts of great and populous empires to the southward of the then prostrate empire of the Montezumas, undertook an expedition into Honduras, which for length and difficulties encountered and overcome stands unprecedented in the history of martial adventure. He entered the vast and unbroken wilderness, and after two years of struggle and endurance reached the point where Columbus first landed. Without giving the history of Spanish power in Honduras, suffice it to say that as early as 1540, sixty years before Jamestown in Virginia was founded, and nearly a hundred years before Hudson entered the Bay of New York, Honduras had its large and flourishing cities. After throwing off the Spanish yoke, Honduras in 1823 joined the union of Central America. In 1839 that union was dissolved, but the liberal party in the now independent state made repeated attempts to restore a federative union with the neighbouring republics of Nicaragua and San Salvador. These efforts even led to unsuccessful hostilities with Guatemala, but President Cabaños in 1855 being defeated and exiled, his successor General Guardiola (1856) concluded with Guatemala a treaty of peace. Six years of quiet ensued, when an insurrection broke out in 1862 among the soldiers, which cost Guardiola his life. After passing through some vicissitudes, the republic in November 1865 adopted a new constitution, under which the president is elected every four years.

See *Notes on Central America*, by E. G. Squier, New York, 1855, and *Honduras*, by same author, London, 1870. (E. G. S.)

BRITISH HONDURAS

BRITISH HONDURAS is the name given to the English establishment or colony of Belize, on the eastern shore of the peninsula of Yucatan, fronting the Bay of Honduras. It probably derives its name of Belize or Balize from the French *balise*, a beacon, as no doubt some signal or light was raised here to guide the freebooters, who at one time infested the bay, to some common rendezvous. Its boundaries, as defined by the convention between Great Britain and Carrera, president of Guatemala, in 1859, were fixed as "commencing at the mouth of the river Sarstoon, in the bay of Honduras, ascending that river to the rapids of Gracias á Dios, thence turning to the right in a straight

See Plate III. vol. xi.

line to Garbutt's Rapids in the river Belize, and thence due north to the Mexican frontier." These limits give a territory about 160 miles long by 60 miles wide at its broadest part, with an area of 7562 square miles.

The approach to the coast is through cays and coral reefs, and is both difficult and dangerous. For some miles inland the ground is low and swampy, thickly covered with mangroves and tropical jungle. Next succeeds a narrow belt of rich alluvial land, not exceeding a mile in width, beyond which, and parallel to the rivers, are vast tracts of sandy, arid land, called "pine ridges," from the red pine with which they are covered, and which are favourite resorts of wild animals. Further inland these give place to what are called "cahoon ridges," with a deep, rich soil covered with myriads of palm trees. Next come broad savannas, studded with clumps of trees, through which the streams descending from the mountains wind in every direction. The mountains themselves rise in a succession of ridges parallel to the coast. The first are the Manatee Hills, from 800 to 1000 feet high; and beyond these are the Cockscomb Mountains, which are about 4000 feet high.

No less than sixteen streams, large enough to be called rivers, descend from these mountains and crests to the sea, between the Hondo and Sarstoon. Behind the Cockscomb range there is a succession of valleys and hills, with a varied elevation of from 1200 to 3300 feet above the level of the sea. This tract, of which but little is known, consists of open, grassy lands, with interesting park-like scenery, and could no doubt support a large number of cattle, as all the conditions of climate, &c., are most favourable.

Many aboriginal remains are found, such as fortified hills, crumbling walls, and buildings subsiding into ruins. The ruins of extensive cities, with monoliths, statues, and carved stones of fine finish are said to be hidden among the yet unexplored forests. They are all, however, more or less similar to the remains found in the neighbouring states of Honduras and Yucatan, and doubtless are the work of the same race or races. The mineral resources of the colony have been but little developed. There are, however, among the hills many indications of gold, silver, and coal.

The climate generally is hot and damp, but favourably influenced by the trade winds. The mean temperature for 1878 was 79·75° Fahr.; the rainfall for the same year was 105·49 inches, which, however, was remarkably high. The country is not troubled by hurricanes, nor has it suffered from earthquakes. It has never been afflicted by epidemics, except cholera. Yellow fever occurs, but only sporadically. The climate is superior to that of Jamaica and the other West Indian Islands, and the high grounds of the interior are unquestionably healthy.

The population is mainly negro, introduced originally as slaves, whence has sprung a hybrid race from intermixture with Europeans and Indians. These are engaged in cutting mahogany and dyewoods, and in fishing. As woodmen they are most efficient, and no class or race of men has been able to excel them. A few only cultivate the soil. There are no aboriginal tribes within the limits of Belize, and of the pure Indians there are but few, belonging principally to the tribes of Yucatan. There are some Carib settlements. The scanty white population is engaged in commerce, and on the sugar plantations. The total population in 1871 was 24,710, of which 12,603 were males and 12,107 females, against a total of 25,635 in 1861, showing a decrease of 925, which can be accounted for from the fact that while the political troubles in the adjacent states caused many of their citizens to take refuge here, these, on the troubles being settled, returned to their homes.

The government is in the hands of a lieutenant-governor, with an executive and legislative council; and there are the usual judicial establishment, a lands title registry office, a public hospital, a lunatic asylum, and an alms-house. There is also an agricultural board for distributing information relative to the cultivation of suitable products, &c. The town of Belize, at the mouth of the river of the same name, has ordinarily about 6000 inhabitants; but the number is more than doubled during the Christmas holidays, when the mahogany cutters come in. The dwellings of the wealthy inhabitants are large and commodious. Besides the Government houses, court-house, barracks, and jail, there are several churches, Episcopal, Methodist, Baptist, and Presbyterian. There are also some large and costly fireproof warehouses. The place was formerly important from being the commercial entrepôt and depôt of the neighbouring Spanish states of Yucatan, Guatemala, and Honduras; but this source of prosperity has been mainly dried up, from the opening of direct communication between several of these states and the United States and Europe, and from the diversion of trade on the Pacific to Panama. The principal product of the country is mahogany, of which the export for many years was 20,000 tons annually, but the demand for it is said to be diminishing. Its logwood ranks high, and from 14,000 to 15,000 tons are exported annually. Besides these, it produces rosewood, sapodilla, Santa Maria, and numerous other woods of value. The cahoon or coyol palm is abundant, producing clusters of nuts, from which is extracted a valuable oil. Several varieties of cotton are produced, some of which are of superior quality. Sarsaparilla and vanilla are found in the interior. The animals of the country comprise many fur-bearing species, as ounces, panthers, &c., and the forests abound with various species of monkeys. Manatees and alligators are found in the lagoons and rivers. Among the birds are turkeys, ducks, macaws, parrots, pelicans, and humming-birds. There is also a small black bottle fly, whose bite is most venomous, and which, with the wood-tick, is a source of great annoyance in the forest. There are also several species of venomous snakes and scorpions. Fishes of many varieties are plentiful, as are also turtles, lobsters, and other shell-fish. Cattle and horses are kept in sufficient numbers for all needful purposes. Present statistical information indicates, instead of improvement in the colony, a considerable falling off during the past ten or fifteen years. Its sugar plantations are, however, in a flourishing condition, having increased in their yearly product from 4035 cwt. in 1860 to 38,667 cwt. in 1877. The rate of duty on the principal articles of import is an average of about 10 per cent., principally *ad valorem.* Machinery, coal, and books are imported free. The gross amount of revenue for 1877 was £41,588, against £27,398 in 1863. The public expenditure for the same year was £39,939, and the public debt £5041, the latter showing a decrease of £34,000 in nine years. The total tonnage of all kinds entered and cleared in 1877, exclusive of that employed in the coasting trade, was 73,974 tons, of which 46,168 tons were British. The value of imports, including bullion and specie, for the ten years ending 1877 was £1,781,175, and for that year £165,756, of which £84,540 came from Great Britain. The exports for 1877 amounted to £124,503, of which £94,548 worth of domestic produce went to Great Britain.

History.—"Her Majesty's Settlement in the Bay of Honduras," as the territory was formerly styled in official documents, owes its origin to logwood-cutters who frequented the coast of Yucatan and Central America, after the decline of piracy in the sea of the Antilles. Most of these had been free companions, and were well acquainted with the coast. The district was rich in dyewoods, and became a principal resort of the English cutters. Although thus industriously occupied, they so far retained their old habits as to make frequent descents on the logwood establishments of the

Spaniards, whose attempts to expel them were generally successfully resisted. The most formidable of these was made by the Spaniards in April 1754, when, in consequence of the difficulty of approaching the position from the sea, an expedition, consisting of 1500 men, was organized inland at the town of Peten. As it neared the coast, it was met by 250 English, and completely routed. The logwood-cutters were not again disturbed for a number of years, and their position had become so well established that, in the treaty of 1763, between England and Spain, the former power, while agreeing to demolish "all fortifications which English subjects had erected in the Bay of Honduras," nevertheless insisted on a clause in favour of the cutters of logwood, that "they or their workmen were not to be disturbed or molested, under any pretext whatever, in their said places of cutting and loading logwood; and for this purpose they may build without hindrance and occupy without interruption the houses and magazines necessary for their families and effects." They had also assured to them the full enjoyment of these advantages and powers in the Spanish coasts and territories. To insure the observance of this treaty, the British Government sent out Sir William Burnaby, who not only settled the limits within which the English were to confine their wood-cutting, but also drew up for their government a code of regulations or laws known as the "Burnaby Code." Successful in their contests with the Spaniards, and now strengthened by the recognition of the crown, the British settlers assumed a corresponding high tone, and, it is alleged, made fresh encroachments on the Spanish territory. The Spaniards, alarmed and indignant, and asserting that the settlers not only abused the privileges conceded to them by the treaty, but were engaged in smuggling and other illicit practices, organized a large force, and on September 15, 1779, suddenly attacked and destroyed the establishment, taking the inhabitants prisoners to Merida, and afterwards to Havana, where most of them died. The survivors were liberated in 1782, and allowed to go to Jamaica. For two or three years the establishment seems to have been abandoned, but in 1783 a part of the original settlers, with a considerable body of new adventurers, revisited the place, and were soon actively engaged in cutting woods. On September 3d of that year a new treaty was signed between Great Britain and Spain, in which it was expressly agreed that his Britannic Majesty's subjects should have "the right of cutting, loading, and carrying away logwood in the district lying between the river Wallis or Belize and Rio Hondo, taking the course of these two rivers for unalterable boundaries." These concessions "were not to be considered as derogating from the rights of sovereignty of the king of Spain" over the district in question, and all the English dispersed in the Spanish territories were to concentrate themselves within the district thus defined within eighteen months. Affairs, notwithstanding the explicit stipulations of the treaty, do not seem to have proceeded favourably; for, three years after, a new treaty was made, in which the king of Spain makes an additional grant of territory, embracing the area between the rivers Sibun or Jabon and Belize, so that collectively the grants embraced the entire coast between the river Sibun in lat. 17° 20′ on the south and the Rio Hondo in lat. 18° 30′ on the north, a coast-line of about 90 miles, with the adjacent islands and bays. But these extended limits were coupled with still more rigid restrictions. It is not to be supposed that a population composed of so wayward and lawless a set of men at a distance from England was remarkably exact in its observance of the letter or spirit of the treaty of 1786. They seem to have given great annoyance to their Spanish neighbours, who eagerly availed themselves of the breaking out of war between the two countries in 1796 to concert a formidable attack on Belize, with a view to the complete annihilation of the establishment. They concentrated a force of 2000 men at Campeachy, which, under the command of General O'Neill, set sail in thirteen vessels for Belize, and arrived off that place July 10, 1798. The settlers, in anticipation of their approach, and aided by the English sloop of war "Merlin," had strongly fortified a small island in the harbour, called St George's Cay, whence they maintained a determined and effectual resistance against the Spanish forces, which, after a contest of two days' duration, were obliged to abandon their object and retire to Campeachy. This was the last attempt to dislodge the English. The defeat of the Spanish attempt of 1798 has been adduced as an act of conquest, thereby permanently establishing British sovereignty. But those who take this view overlook the important fact that, in 1814, by a new treaty with Spain, the provisions of that of 1786 were revived. They forget also that until possibly within a few years the British Government never laid claim to any rights acquired in virtue of the successful defence; for so late as 1817–19 the Acts of Parliament relating to Belize always refer to it as "a settlement, for certain purposes, under the protection of his Majesty." After the independence of the Spanish American provinces, Great Britain sought to secure her rights by incorporating the provisions of the treaty of 1786 in all her treaties with the new states. It was, in fact, incorporated in her treaty with Mexico in 1826, in the project of a treaty which she submitted to Señor Zebadua, the representative of the republic of Central America in London in 1831, and also in the project of a treaty with New Grenada in 1825. Great Britain was, therefore, without any rights in Belize beyond those conveyed by the treaties already quoted, which define with the greatest precision the area within which these rights might be exercised. But it appears from a despatch of Sir George Grey, colonial secretary, dated in 1836, that claims had then been set up to an additional wide extent of territory, including the entire coast as far south as the river Sarstoon, and as far inland as the meridian of Garbutt's Falls on the river Belize. This anomalous state of things has no doubt had a prejudicial influence on the prosperity of Belize; but while Great Britain's right of sovereignty might be questioned, it cannot be doubted that the enterprise of her subjects has rescued a desolate coast from the savage dominion of nature, and carried industry and civilization where none existed before, and where, if left to the control of the Spanish race, none would have existed to this day. It was perhaps this consideration that induced Mr Clayton, the American secretary of state, to consent to the exclusion of Belize from the operation of the convention of 1850 between Great Britain and the United States, whereby both powers bound themselves not to occupy, fortify, or colonize any part of Central America.

See *Balize or British Honduras*, by Chief-Justice Temple, read before the Society of Arts, London, January 14, 1847; *Notes on Central America*, by E. G. Squier, New York, 1855; *A Narrative of a Journey across the Unexplored Portion of British Honduras*, by Henry Fowler, Colonial Secretary, Belize, 1879. (E. G. S.)

HONE. Under the name of hones, whetstones, or sharpening stones, a variety of finely siliceous stones are employed for whetting or sharpening edge tools, and for abrading steel and other hard surfaces. They generally are prepared in the form of flat slabs or small pencils or rods of the material, but some are made with the outline of the special instrument they are designed to sharpen. Their abrading action is due to the quartz or silica which is always present in predominating proportion, some kinds consisting of almost pure quartz, while in others the siliceous element is very intimately mixed with aluminous or calcareous matter, forming a uniform compact stone, the extremely fine siliceous particles of which impart a remarkably keen edge to the instruments for the sharpening of which they are applied. Hones are used either dry, with water, or with oil, and generally the object to be sharpened is drawn with hand pressure backward and forward over the surface of the hone; but sometimes the stone is moved over the cutting edge. The coarsest type of stone which can be included among hones is the bat or scythe stone, a porous fine-grained sandstone used for sharpening scythes and cutters of mowing machines, and for other like purposes. Next come the ragstones, which consist of quartzose mica-schist, and give a finer edge than any sandstone. Under the head of oilstones or hones proper the most famous and best-known qualities are the German razor hone, the Turkey oilstone, and the Arkansas stone. The German razor hone, used, as its name implies, chiefly for razors, is obtained from the slate mountains near Ratisbon, where it forms a yellow vein of from 1 to 18 inches in the blue slate. It is sawn into thin slabs, and these are cemented to slabs of slate which serve as a support. Turkey oilstone is a close-grained bluish stone containing from 70 to 75 per cent. of silica in a state of very fine division, intimately blended with about 20 to 25 per cent. of calcite. It is obtained only in small pieces, frequently flawed and not tough, so that the slabs must have a backing of slate or wood. It is one of the most valuable of all whetstones, abrading the hardest steel, and possessing sufficient compactness to resist the pressure required for sharpening gravers. The stone comes from the interior of Asia Minor, whence it is carried to Smyrna. Of Arkansas stones there are two varieties both found in the same district, Garland county, Arkansas, United States. The finer kind, known as Arkansas hone, is obtained in small pieces at the hot springs, and the second quality, distinguished as Washita stone, comes from Washita or Ouachita river. The hones yield on analysis 98 per cent. of silica, with small proportions of alumina, potash, and soda, and mere traces of iron, lime, magnesia, and hydrofluoric acid. They are white in colour, extremely hard and keen in grit, and not easily worn down or broken. Geologically the materials belong to the millstone grit series, and are supposed to be metamorphosed sandstone resulting from the permeation through the mass of heated alkaline siliceous waters. The finer kind is employed for fine cutting instruments, and also for polishing steel pivots of watch-wheels and similar minute work, the second and coarser quality being used for common tools. Both varieties are largely exported from the United States to all quarters in the form of blocks, slips, pencils, rods, and wheels. During the Centennial Exhibition of 1876 the comparative value of hones per lb was thus quoted—Arkansas $1·50, Washita ·35, Turkey 1·00. Among hones of less importance in general use may be noted Charnley Forest stone, a good substitute for Turkey oilstone; Water of Ayr stone, Scotch stone, or snake stone, used for tools and for polishing marble and copperplates; Idwal or Welsh oilstone, used for small articles; and cutlers' greenstone from Snowdon, very hard and close in texture, used for giving the last edge to lancets.

HONE, WILLIAM (1780–1842), a political satirist and a writer on antiquarian and miscellaneous subjects, was born at Bath, June 3, 1780. His father, a man of deep spiritual experience in that time of religious revival, brought up his children in strictness and reverence, but not without the sectarian narrowness that so frequently produces reaction. The parodist of the litany and of the Athanasian creed was taught to read from the Bible only. Hone received no systematic education. His father having removed to London in 1783, he was in 1790 placed in an attorney's office. Becoming connected with the London Corresponding Society, which was given to freethought and to political agitation, he was removed by his father to the office of a solicitor at Chatham, but after two years and a half he returned to London and became clerk to a solicitor in Gray's Inn. Having no liking for the study of the law, and apparently no hope of succeeding in it, Hone, being then married, started in 1800 a book and print shop and a circulating library in Lambeth Walk, and he soon after removed to St Martin's Churchyard, where he brought out his first publication, Shaw's *Gardener*, and suffered much loss from a fire. It was at this time that Hone matured and with a friend endeavoured to realize a plan for the establishment of popular savings banks, and even had an interview on the subject with the Right Hon. George Rose, then president of the Board of Trade. This scheme, however, fell through from lack of support. His partner in the savings bank became next his partner in a bookseller's business; but Hone's habits were not those of a tradesman, and bankruptcy was the result. After several removals, having compiled an index to Lord Berner's translation of Froissart, he was in 1811 chosen by the booksellers as auctioneer to the trade, and had an office in Ivy Lane. Independent investigations carried on by him into the condition of lunatic asylums led again to difficulties and failure, but, struggling bravely under his burdens, he took a small lodging in the Old Bailey, and kept himself and his now large family by contributions to magazines and reviews. He hired a small shop (or rather box) in Fleet Street, but this was on two separate nights broken into, and valuable books lent for show were stolen. In 1815 he started the *Traveller* newspaper, and endeavoured vainly to exculpate Eliza Fenning, a poor girl, apparently quite guiltless, executed on a charge of poisoning. From February 1 to October 25, 1817, he published the *Reformist's Register*, writing in it as the serious critic of the state abuses, to which he soon after applied the lash of satire in those political squibs and parodies that made his name known throughout the land, and that first gave notoriety to George Cruikshank, who was his artistic collaborator. In April 1817 three *ex officio* informations were filed against him by the attorney-general, Sir William Garrow, and he was seized while reading in the street and hurried to the lock-up. Three separate trials took place in the Guildhall before special juries on the 18th, 19th, and 20th of December 1817. The first, for publishing Wilkes's *Catechism of a Ministerial Member*, was before Mr Justice Abbot (afterwards Lord Tenterden); the second, for parodying the litany and libelling the prince regent, and the third, for publishing the *Sinecurist's Creed*, a parody on the Athanasian creed, were before Lord Ellenborough. The prosecuting officials, among whom we must include the judges, took the ground that the prints were calculated to injure public morals, and to bring the prayer-book and even religion itself into contempt. But there can be no doubt that the real motives of the prosecution were political; Hone had ridiculed the habits and exposed the corruption of the prince regent and of other persons in power. He went to the root of the matter when he wished the jury "to understand that, had he been a publisher of ministerial parodies, he would not then have been defending himself on the floor of that court." In spite of illness and exhaustion Hone displayed great courage, ability, dignity, and presence of mind. On each of the three days he spoke on an average seven hours. Notwithstanding the powerful prosecution and the bias of the judges, he was acquitted on each count, and the result on each occasion was received with enthusiastic cheers by immense crowds within and without the court. Soon after the trials a public meeting, in which Alderman Waithman, Sir F. Burdett, and Lord Cochrane took part, was held, and a subscription was begun, by which a large sum was soon collected to enable Hone to get over the difficulties caused by his prosecution.

Hone's most successful political satires were published within a few years after his trial. Among them we may mention *The Political House that Jack built*, *The Queen's Matrimonial Ladder* (in favour of Queen Caroline), *The Man in the Moon*, *The Political Showman*, all illustrated by Cruikshank. Many of his squibs are directed against a certain "Dr Slop," a nickname given by him to Dr (afterwards Sir John) Stoddart, a writer in the *Times*. In researches for his defence he had come upon some curious and at that time little trodden literary ground, and the results were shown by his publication in 1820 of his *Apocryphal New Testament*, and in 1823 of his *Ancient Mysteries Explained*. He proposed in 1820 to write a *History of Parody*, but this never appeared. In 1826 he published the *Every-day Book*, in 1827–8 the *Table-Book*, and in 1829 the *Year-Book*; all three were collections of curious information on manners, antiquities, and various other subjects.[1] These are the works by which Hone is best remembered. In preparing them he had the warm approval of Southey and the assistance of Charles Lamb, but pecuniarily they were not successful, and Hone was lodged in King's Bench prison for debt. Friends, however, again came to his assistance, and he was established in a coffee-house in Gracechurch Street; but this again, like most of his enterprises, ended in failure. Hone's attitude of mind had gradually changed to that of extreme devoutness, and during the latter years of his life he frequently preached in Weigh House Chapel, Eastcheap. In 1830 he edited Strutt's *Sports and Pastimes*, and, on the starting in 1832 of the *Penny Magazine*, he contributed to the first number. He was also for some years sub-editor of the *Patriot*. He died at Tottenham, 8th November 1842.

[1] According to a recent writer in *Notes and Queries* (6th S. i. 171), Hone remarked in conversation that he took the idea of the *Every-day Book* in 1814 from Defoe's *Time's Telescope*.

HONEY (Chin., *mē*; Sansk., *madhu*, mead, honey,—*cf.* A. S., *medo*, *medu*, mead; Greek, *μέλι*, in which *θ* or *δ* is changed into λ; Lat., *mel*; Fr., *miel*; A. S., *hunig*; Germ., *Honig*),[1] a sweet viscid liquid, obtained by bees chiefly from the nectaries of flowers, *i.e.*, those parts of flowers specially constructed for the elaboration of honey (see BOTANY, vol. iv. p. 134), and after transportation to the hive in the proventriculus or crop of the insects, discharged by them into the cells prepared for its reception. Whether the nectar undergoes any alteration within the crop of the bee is a point on which authors have differed. Some wasps, *e.g.*, *Myrapetra scutellaris*[2] and the genus *Nectarina*, collect honey. A honey-like fluid, which consists of a nearly pure solution of uncrystallizable sugar having the formula $C_6H_{14}O_7$ after drying in vacuo, and which is used by the Mexicans in the preparation of a beverage, is yielded by certain inactive individuals of *Myrmecocystus mexicanus*, Wesmael, the honey-ants or pouched ants (*hormigas mieleras* or *mochileras*) of Mexico.[3] The abdomen in these insects, owing to the distensibility of the membrane connecting its segments, becomes converted into a globular thin-walled sac by the accumulation within it of the nectar supplied to them by their working comrades (Wesmael, *Bull. de l'Acad. Roy. de Brux.*, v. 766, 1838). By the Rev. H. C. M'Cook, who discovered the insect in the Garden of the Gods, Colorado, the honey-bearers were found hanging by their feet, in groups of about thirty, to the roofs of special chambers in their underground nests, their large globular abdomens causing them to resemble "bunches of small Delaware grapes" (*Proc. Acad. Nat. Sci. Philad.*, 1879, p. 197). A bladder-like formation on the metathorax of another ant, *Crematogaster inflatus* (F. Smith, *Cat. of Hymenoptera*, pt. vi. pp. 136 and 200, pl. ix. fig. 1), which has a small circular orifice at each posterior lateral angle, appears to possess a function similar to that of the abdomen in the honey-ant.

It is a popular saying that where is the best honey there also is the best wool; and a pastoral district, since it affords a greater profusion of flowers, is superior for the production of honey to one under tillage.[4] Dry warm weather is that most favourable to the secretion of nectar by flowers. This they protect from rain by various internal structures, such as papillæ, cushions of hairs, and spurs, or by virtue of their position (in the raspberry, drooping), or the arrangement of their constituent parts. Dr A. W. Bennett (*How Flowers are Fertilized*, p. 31, 1873) has remarked that the perfume of flowers is generally derived from their nectar; the blossoms of some plants, however, as ivy and holly, though almost scentless, are highly nectariferous. The exudation of a honey-like or saccharine fluid, as has frequently been attested, is not a function exclusively of the flowers in all plants. A sweet material, the manna of pharmacy, *e.g.*, is produced by the leaves and stems of a species of ash, *Fraxinus Ornus*; and honey-secreting glands are to be met with on the leaves, petioles, phyllodes, stipules (as in *Vicia sativa*), or bracteæ (as in the *Marcgraviaceæ*) of a considerable number of different vegetable forms. The origin of the honey-yielding properties manifested specially by flowers among the several parts of plants has been carefully considered by Darwin, who regards the saccharine matter in nectar as a waste product of chemical changes in the sap, which, when it happened to be excreted within the envelopes of flowers, was utilized for the important object of cross-fertilization, and subsequently was much increased in quantity, and stored in various ways (see *Cross and Self Fertilization of Plants*, p. 402 *sq.*, 1876). It has been noted with respect to the nectar of the fuchsia that it is most abundant when the anthers are about to dehisce, and absent in the unexpanded flower.

Pettigrew is of opinion that few bees go more than two miles from home in search of honey. The number of blossoms visited in order to meet the requirements of a single hive of bees must be very great; for it has been found by A. S. Wilson ("On the Nectar of Flowers," *Brit. Assoc. Rep.*, 1878, p. 567) that 125 heads of common red clover, which is a plant comparatively abundant in nectar, yield but one gramme (15·432 grains) of sugar; and as each head contains about 60 florets, 7,500,000 distinct flower-tubes must on this estimate be exhausted for each kilogramme (2·204 lb) of sugar collected. Among the richer sources of honey are reckoned the apple, asparagus, asters, barberry, basswood (*Tilia americana*), and the European lime or linden (*T. europæa*), beans, bonesets (*Eupatorium*), borage, broom, buckwheat, catnip, or catmint (*Nepeta Cataria*), cherry, cleome, clover, cotton, crocus, currant, dandelion, eucalyptus, figwort (*Scrophularia*), furze, golden-rod (*Solidago*), gooseberry, hawthorn, heather, hepatica, horehound, hyacinth, lucerne, maple, mignonette, mint, motherwort (*Leonurus*), mustard, onion, peach, pear, poplar, quince, rape, raspberry, sage, silver maple, snapdragon, sour-wood (*Oxydendron arboreum*, D.C.), strawberry, sycamore, teasel, thyme, tulip-tree (more especially rich in pollen), turnip, violet, and willows, and the "honey-dew" of the leaves of the whitethorn (Bonner), oak, linden, beech, and some other trees.

Honey contains dextroglucose and lævoglucose (the former practically insoluble, the latter soluble in $\frac{1}{8}$ pt. of cold strong alcohol), cane-sugar (according to some), mucilage, water, wax, essential oil, colouring bodies, a minute quantity of mineral matter, and pollen. By a species of fermentation, the cane-sugar is said to be gradually transformed into inverted sugar (lævoglucose with dextroglucose). The pollen, as a source of nitrogen, is of importance to the bees feeding on the honey. It may be obtained for examination as a sediment from a mixture of honey and water. Other substances which have been discovered in honey are mannite (Guibourt), a free acid which precipitates the salts of silver and of lead, and is soluble in water and alcohol (Calloux), and an uncrystallizable sugar, nearly related to inverted sugar (Soubeiran, *Compt. Rend.*, xxviii. 774–75, 1849). Brittany honey contains *couvain*, a ferment which determines its active decomposition (Wurtz, *Dict. de Chem.*, ii. 430). In the honey of *Polybia apicipennis*, a wasp of tropical America, cane-sugar occurs in crystals of large size (Karsten, *Pogg. Ann.*, C. 550). Dr J. Campbell Brown ("On the Composition of Honey," *Analyst*, iii. 267, 1878) is doubtful as to the presence of cane-sugar in any one of nine samples, from various sources, examined by him. The following average percentage numbers are afforded by his analyses:—lævulose, 36·45; dextrose, 36·57; mineral matter, ·15; water expelled at 100° C., 18·5, and at a much higher temperature, with loss, 7·81: the wax, pollen, and insoluble matter vary from a trace to 2·1 per cent. The specific gravity of honey is about 1·41. The rotation of a polarized ray by a solution of 16·26 grammes of crude honey in 100 c.c. of water is generally from $-3·2°$ to $-5°$ at 60° F.; in the case of Greek honey it is nearly $-5·5°$. Almost all pure honey, when exposed for some time to light and cold, becomes more or less granular in consistency. Any liquid portion can be readily separated by straining through linen. Honey sold out of the comb is commonly clarified by heating and skimming; but according to Bonner it is always best in its natural state. The *mel depuratum* of British pharmacy is prepared by heating honey in a water-bath, and straining through flannel previously moistened with warm water.

The term "virgin-honey" (A.-S., *hunigtear*) is applied to the honey of young bees which have never swarmed, or to that which flows spontaneously from honeycomb with or

[1] The term honey in its various forms is peculiar to the Teutonic group of languages, and in the Gothic New Testament is wanting, the Greek word being there translated *melith*.

[2] See A. White, in *Ann. and Mag. Nat. Hist.*, vii. 315, pl. 4.

[3] Wetherill (*Chem. Gaz.*, xi. 72, 1853) calculates that the average weight of the honey is 8·2 times that of the body of the ant, or 0·3942 grammes.

[4] Compare Isa. vii. 15, 22, where curdled milk (A.V., "butter") and honey as exclusive articles of diet are indicative of foreign invasion, which turns rich agricultural districts into pasture lands or uncultivated wastes.

without the application of heat. The honey obtained from old hives, considered inferior to it in quality, is ordinarily darker, thicker, and less pleasant in taste and odour. The yield of honey is less in proportion to weight in old than in young or virgin combs. The far-famed honey of Narbonne is white, very granular, and highly aromatic; and still finer honey is that procured from the Corbières mountains, 6 to 9 miles to the south-west. The honey of Gâtinais is usually white, and is less odorous, and granulates less readily than that of Narbonne. Honey from white clover has a greenish-white, and that from heather a rich golden-yellow hue. What is made from honey-dew is dark in colour, and disagreeable to the palate, and does not candy like good honey. "We have seen aphide honey from sycamores," says F. Cheshire (*Pract. Bee-Keeping*, p. 74), "as deep in tone as walnut liquor, and where much of it is stored the value of the whole crop is practically *nil*." The honey of the stingless bees (*Melipona* and *Trigona*) of Brazil varies greatly in quality according to the species of flowers from which it is collected, some kinds being black and sour, and others excellent (F. Smith, *Trans. Ent. Soc.*, 3d ser., i. pt. vi., 1863). That of *Apis Peronii*, of India and Timor, is yellow, and of very agreeable flavour, and is more liquid than the British sorts. *A. unicolor*, a bee indigenous to Madagascar, and naturalized in Mauritius and the island of Réunion, furnishes a thick and syrupy, peculiarly scented green honey, highly esteemed in Western India. A rose-coloured honey is stated (*Gard. Chron.*, 1870, p. 1698) to have been procured by artificial feeding. The fine aroma of Maltese honey is due to its collection from orange blossoms. Narbonne honey being harvested chiefly from Labiate plants, as rosemary, an imitation of it is sometimes prepared by flavouring ordinary honey with infusion of rosemary flowers.

Adulterations of honey are starch, detectable by the microscope, and by its blue reaction with iodine, also wheaten flour, gelatin, chalk, gypsum, pipe-clay, added water, cane-sugar, and common syrup, and the different varieties of manufactured glucose. Honey sophisticated with glucose containing copperas as an impurity is turned of an inky colour by liquids containing tannin, as tea. Elm leaves have been used in America for the flavouring of imitation honey. Stone jars should be employed in preference to common earthenware for the storage of honey, which acts upon the lead glaze of the latter.

Honey is mildly laxative in properties. Some few kinds are poisonous, as frequently the reddish honey stored by the Brazilian wasp *Nectarina* (*Polistes*, Latr.[1]) *Lecheguana*, Shuck., the effects of which have been vividly described by Aug. de Saint-Hilaire,[2] the spring honey of the wild bees of East Nepaul, said to be rendered noxious by collection from rhododendron flowers (Hooker, *Himalayan Journals*, i. 190, ed. 1855), and the honey of Trebizond, which from its source, the blossoms, it is stated, of *Azalea pontica* and *Rhododendron ponticum* (perhaps to be identified with Pliny's *Ægolethron*), acquires the qualities of an irritant and intoxicant narcotic, as described by Xenophon (*Anab.*, iv. 8). Pliny (*Nat. Hist.*, xxi. 45) describes as noxious a livid-coloured honey found in Persia and Gætulia. Honey obtained from *Kalmia latifolia*, L., the calico bush, mountain laurel, or spoon-wood of the northern United States, and allied species, is reputed deleterious; also that of the sour-wood is by some good authorities considered to possess undeniable griping properties; and G. Bidie (*Madras Quart. Journ. Med. Sci.*, Oct. 1861, p. 399) mentions urtication, headache, extreme prostration and nausea, and intense thirst among the symptoms produced by a small quantity only of a honey from Coorg jungle. A South African species of *Euphorbia*, as was experienced by the missionary Moffat (*Miss. Lab.*, p. 32, 1846), yields a poisonous honey. The nectar of certain flowers is asserted to cause even in bees a fatal kind of vertigo. As a demulcent and flavouring agent, honey is employed in the *oxymel*, *oxymel scillæ*, *mel boracis*, *confectio piperis*, *conf. scammonii*, and *conf. terebinthinæ* of the *British Pharmacopœia*. To the ancients honey was of very great importance as an article of diet, being almost their only available source of sugar. It was valued by them also for its medicinal virtues; and in recipes of the Saxon and later periods it is a common ingredient.[3] Of the eight kinds of honey mentioned by the great Indian surgical writer Susruta, four are not described by recent authors, viz., *argha*, or wild honey, collected by a sort of yellow bee; *chhatra*, made by tawny or yellow wasps; *audálaka*, a bitter and acrid honey-like substance found in the nest of white ants; and *dála*, or unprepared honey occurring on flowers. According to Hindu medical writers, honey when new is laxative, and when more than a year old astringent (U. C. Dutt, *Mat. Med. of the Hindus*, p. 277, 1877). Ceromel, formed by mixing at a gentle heat one part by weight of yellow wax with four of clarified honey, and straining, is used in India and other tropical countries as a mild stimulant for ulcers in the place of animal fats, which there rapidly become rancid and unfit for medicinal purposes. The *Koran*, in the chapter entitled "The Bee," remarks with reference to bees and their honey: "There proceedeth from their bellies a liquor of various colour, wherein is a medicine for men" (Sale's *Koran*, chap. xvi.). Pills prepared with honey as an excipient are said to remain unindurated, however long they may be kept (*Med. Times*, 1857, i. 269). Mead, of yore a favourite beverage in England (vol. iv. p. 264), is made by fermentation of the liquor obtained by boiling in water combs from which the honey has been drained. In the preparation of sack-mead, an ounce of hops is added to each gallon of the liquor, and after the fermentation a small quantity of brandy. Metheglin, or hydromel, is manufactured by fermenting with yeast a solution of honey flavoured with boiled hops (see Cooley, *Cyclop.*). A kind of mead is largely consumed in Abyssinia (vol. i. p. 64), where it is carried on journeys in large horns (Stern, *Wanderings*, p. 317, 1862). In Russia a drink termed *lipetz* is made from the delicious honey of the linden. The *mulsum* of the ancient Romans consisted of honey, wine, and water boiled together. The *clarre*, or *piment*, of Chaucer's time was wine mixed with honey and spices, and strained till clear; a similar drink was *bracket*, made with wort of ale instead of wine. L. Maurial (*L'Insectologie Agricole* for 1868, p. 206) reports unfavourably as to the use of honey for the production of alcohol; he recommends it, however, as superior to sugar for the thickening of liqueurs, and also as a means of sweetening imperfectly ripened vintages. It is occasionally employed for giving strength and flavour to ale. In ancient Egypt it was valued as an embalming material; and in the East, for the preservation of fruit, and the making of cakes, sweatmeats, and other articles of food, it is largely consumed. Grafts, seeds, and birds' eggs, for transmission to great distances, are sometimes packed in honey. In India a mixture of honey and milk, or of equal parts of curds, honey, and clarified butter (Sansk., *madhu-parka*), is a respectful offering to a guest, or to a bridegroom on his arrival at the door of the bride's father; and one of the purificatory ceremonies of the Hindus (Sansk., *madhu-prāsana*) is the placing of a little honey in the mouth of a new-born male infant. Honey is frequently alluded to by the writers of antiquity as food for children; it is not to this, however, as already mentioned,

[1] *Mémoires du Muséum*, xi. 313, 1824.

[2] *Ib.*, xii. 293, pl. xii. fig. B, 1825. The honey, according to Lassaigne (*ib.*, ix. 319), is almost entirely soluble in alcohol.

[3] For a list of fifteen treatises concerning honey, dating from 1625 to 1868, see Waring, *Bibl. Therap.*, ii. 559, New Syd. Soc., 1879. On sundry ancient uses for honey, see Beckmann, *Hist. of Invent.*, i. 287, 1846.

that Isa. vii. 15 refers. Cream or fresh butter together with honey, and with or without bread, is a favourite dish with the Arabs.

Among the observances at the Fandròana, or New Year's Festival, in Madagascar, is the eating of mingled rice and honey by the queen and her guests; in the same country honey is placed in the sacred water of sprinkling used at the blessing of the children previous to circumcision (Sibree, *The Great African Is.*, pp. 219, 314, 1880). Honey was frequently employed in the ancient religious ceremonies of the heathen, but was forbidden as a sacrifice in the Jewish ritual (Lev. ii. 11). With milk or water it was presented by the Greeks as a libation to the dead (*Odyss.*, xi. 27; Eurip., *Orest.*, 115). A honey-cake was the monthly food of the fabled serpent-guardian of the Acropolis (Herod., viii. 41). By the aborigines of Peru honey was offered to the sun.

The Hebrew word translated "honey" in the authorized version of the English Bible is *debash*, practically synonymous with which are *ja'ar* or *ja'arith had-debash* (1 Sam. xix. 25–27; *cf.* Cant. v. 1) and *nopheth* (Ps. xix. 10, &c.), rendered "honey-comb." *Debash* denotes bee-honey (as in Deut. xxxii. 13, and Jud. xiv. 8); the manna of trees, by some writers considered to have been the "wild honey" eaten by John the Baptist (Matt. iii. 4); the syrup of dates or the fruits themselves; and probably in some passages (as Gen. xliii. 11 and Ez. xxvii. 17) the syrupy boiled juice of the grape, resembling thin molasses, in use in Palestine, especially at Hebron, under the name of *dibs* (see Kitto, *Cyclop.*, and E. Robinson, *Bibl. Res.*, ii. 81). Josephus (*B. J.*, iv. 8, 3) speaks highly of a honey produced at Jericho, consisting of the expressed juice of the fruit of palm trees; and Herodotus (iv. 194) mentions a similar preparation made by the Gyzantians in North Africa, where it is still in use. The honey most esteemed by the ancients was that of Mount Hybla in Sicily, and of Mount Hymettus in Attica (vol. iii. p. 59). Mahaffy (*Rambles in Greece*, p. 148, 2d ed., 1878) describes the honey of Hymettus as by no means so good as the produce of other parts of Greece—not to say of the heather hills of Scotland and Ireland. That of Thebes, and more especially that of Corinth, which is made in the thymy hills towards Cleonæ, he found much better (*cf.* vol. xi. p. 88). Honey and wax, still largely obtained in Corsica (vol. vi. p. 440), were in olden times the chief productions of the island. In England, in the 13th and 14th centuries, honey sold at from about 7d. to 1s. 2d. a gallon, and occasionally was disposed of by the swarm or hive, or *ruscha* (Rogers, *Hist. of Agric. and Prices in Eng.*, i. 418). At Wrexham, Denbigh, Wales, two honey fairs are annually held, the one on the Thursday next after the 1st September, and the other, the more recently instituted and by far the larger, on the Thursday following the first Wednesday in October. In Hungary the amounts of honey and of wax are in favourable years respectively about 190,000 and 12,000 cwt., and in unfavourable years, as, *e.g.*, 1874, about 12,000 and 3000 cwt. The hives there in 1870 numbered 617,407 (or 40 per 1000 of the population, against 45 in Austria). Of these 365,711 were in Hungary Proper, and 91,348 (87 per 1000 persons) in the Military Frontier (Keleti, *Uebersicht der Bevölk. Ungarns*, 1871; Schwicker, *Statistik d. K. Ungarn*, 1877). In Poland the system of bee-keeping introduced by Dolinowski has been found to afford an average of 40 lb of honey and wax and two new swarms per hive, the common peasant's hive yielding, with two swarms, only 3 lb of honey and wax. In forests and places remote from villages in Podolia and parts of Volhynia, as many as 1000 hives may be seen in one apiary. In the district of Ostrolenka, in the government of Plock, and in the woody region of Polesia, in Lithuania, a method is practised of rearing bees in excavated trunks of trees (Stanton, "On the Treatment of Bees in Poland," *Technologist*, vi. 45, 1866). When, in August, in the loftier valleys of Bormio, Italy, flowering ceases, the bees in their wooden hives are by means of spring-carts transported at night to lower regions, where they obtain from the buckwheat crops the inferior honey which serves them for winter consumption (*Ib.*, p. 38).

In Palestine, "the land flowing with milk and honey"[1] (Ex. iii. 17; Numb. xiii. 27), wild bees are very numerous, especially in the wilderness of Judæa, and the selling of their produce, obtained from crevices in rocks, hollows in trees, and elsewhere, is with many of the inhabitants a means of subsistence. Commenting on 1 Sam. xiv. 26, J. Roberts (*Oriental Illust.*) remarks that in the East "the forests literally flow with honey; large combs may be seen hanging on the trees, as you pass along, full of honey." In Galilee, and at Bethlehem and other places in Palestine, bee-keeping is extensively carried on. The hives are sun-burnt tubes of mud, about 4 feet in length and 8 inches in diameter, and, with the exception of a small central aperture for the passage of the bees, closed at each end with mud. These are laid together in long rows, or piled pyramidally, and are protected from the sun by a covering of mud and of boughs. The honey is extracted, when the ends have been removed, by means of an iron hook. (See Tristram, *Nat. Hist. of the Bible*, pp. 322 *sq.*, 2d ed., 1868). Apiculture in Turkey is in a very rude condition. The Bali-dagh, or "Honey Mount," in the plain of Troy, is so called on account of the numerous wild bees tenanting the caves in its precipitous rocks to the south. In various regions of Africa, as on the west, near the Gambia, bees abound. Cameron was informed by his guides that the large quantities of honey at the cliffs by the river Makanyazi were under the protection of an evil spirit, and not one of his men could be persuaded to gather any (*Across Africa*, i. 266). On the precipitous slopes of the Teesta valley, in India, the procuring of honey from the pendulous bees'-nests, which are sometimes large enough to be conspicuous features at a mile's distance, is the only means by which the idle poor raise their annual rent (Hooker, *Him. Journ.*, ii. 41).

To reach the large combs of *Apis dorsata* and *A. testacea*, the natives of Timor, by whom both the honey and young bees are esteemed delicacies, ascend the trunks of lofty forest trees by the use of a loop of creeper. Protected from the myriads of angry insects by a small torch only, they detach the combs from the under surface of the branches, and lower them by slender cords to the ground (Wallace, *Journ. Linn. Soc.*, Zool., vol. xi.). For additional facts concerning honey, and a sketch of the processes of apiculture usually adopted in the Old World, see the article BEE, vol. iii. pp. 484–503.

On honey, and bees and bee-keeping in general, see, besides the above-mentioned works, J. Bonner, *A New Plan for speedily increasing the number of Bee-hives in Scotland*, 1795, containing the substance of *The Bee-Master's Companion*, 1789, by the same author; V. Rendu, *Traité pratique sur les Abeilles*, 1838; Munn's *Honey Bee*, ed. by E. Bevan; J. Samuelson, *Humble Creatures*, pt. ii., 1860; H. Taylor, *The Bee-Keeper's Manual*, 6th ed., 1860; F. Cowan, *Curious Facts in the History of Insects*, pp. 174–215, 1865; A. Neighbour, *The Apiary*, 2d ed., 1866; W. E. Shuckard, *British Bees*, 1866; A. Pettigrew, *The Handy Book of Bees*, 1870; G. de Layens, *Élevage des Abeilles par les Procédés Modernes*, 1874; J. de Hidalgo Tablada, *Tratado de las Abejas*, Madr., 1875; A. J. Danyell, *The Italian System of Bee-Keeping*, 1876; and A. H. Hassall, *Food and its Adulterations*, p. 266, 1876. (F. H. B.)

HONEY-FARMING IN AMERICA.—So rapid of late years has been the development of bee-keeping in the United States, that the taking of steps to secure the fullest and most accurate details with respect to that industry has been deemed necessary by the commissioners of agriculture. It has been estimated by several intelligent bee-keepers that there are in the United States 700,000 hives of bees, owned by 35,000 people, of whom at least 30,000 are farmers possessing on an average not more than 3 hives each, the remaining 5000 being professional apiarians. Mr G. M. Doolittle, of Borodino, N.Y., on the Auburn branch of the New York Central Railway, obtained in 1877 an average of 100 lb of honey apiece from his hives, and from one of them the exceptionally large yield of 700 lb. It is not unreasonable to say that the hives in the United States afford each a net supply of about 50 lb of surplus honey, which, selling at 20 cents (10d.) per lb, returns a good profit to the owners. All American honey is classed by the apiculturist according to the plants from which it is derived. It is only in rare cases that pasturage is specially cultivated for the bees. In the States east of the Rocky Mountains there are three chief sources of honey. Those which yield the most delicately flavoured and whitest and therefore most valuable commodity (see above) are, first, the immense forests of basswood, the honey from which has perhaps a slight minty flavour, and, secondly, white clover grass, cultivated throughout the States for hay and stock pasture, which furnishes a honey pronounced by competent judges superior to that of the world-renowned Hymettus. Bees having access to both basswood and white clover frequently store the honey from each in the same cells. The third and often richest source of supply is buckwheat, which blossoms after the basswood and white clover have ceased to yield. The pungent honey obtained therefrom, though by its dark colour rendered unsuitable for the table, is greatly valued for manufacturing purposes, more especially in the brewing of fine beer, since it forms a perfectly clear solution, ferments well, and is richer in saccharine matter than the glucose commonly employed by brewers, which moreover is apt to be contaminated with the acids employed in its preparation. Buckwheat honey is also accounted a good remedy in bronchial affections, and is therefore in request for the making of cough mixtures. The day is probably not far distant when the refining of the large quantities of dark honey which are harvested will be undertaken on an extensive scale.

For the successful prosecution of bee-keeping energy and perseverance, as well as experience and considerable capital, are requisite. There are not more than four bee-keepers in the United States who own so many as 2500 or 3000 hives. The largest apiaries are the property of Mr J. S. Harbison of California. They are six in number, and situated within easy patrol distance from one another

[1] In Sanskrit, *madhu-kulyā*, a stream of honey, is sometimes used to express an overflowing abundance of good things (Monier Williams, *Sansk.-Eng. Dict.*, p. 736, 1872).

in the extreme south-west corner of the United States, in a narrow strip of country known as the "bee-belt" of California, which enjoys the soft and equable climate of the Pacific coast. Timber in this region is confined to the bottoms near running streams, and to the cañons, the valleys and hill-sides being covered with stunted brushwood and an abundant growth of white sage,—an herb similar to the garden sage, and not to be confounded with the sagebrush of Nevada and Utah, which is a species of wormwood,—sumach, and other flowering plants. These bloom nine months in the year, but are most luxuriant in May and June. The white sage affords a honey comparable to that obtained from the basswood of the eastern States. The Californian honey, owing to the innocuous nature of the flowers from which it is procured, is devoid of the colic-producing properties ascribed to some other varieties of honey. Mr Harbison employs fifteen men in his apiaries, and is reaping rich profits from very many thousands of acres useless for ordinary purposes. Active operations begin in February, and in March or April the bees swarm. The taking of the honey commences usually about May 20th. From the early part of August till as late as October the flowers provide no more honey than is just sufficient for the subsistence of the bees. When October has begun, though the air is still mild, the bees cease to work, becoming semi-dormant, except for an hour or two every eight or ten days, when they fly near their hives in the sunshine. The fact that honey until the middle of the 16th century was the only sweet in general use, and that the aggregate annual consumption of sugar is now from 2 to 2½ millions of tons, points to the conclusion that apiculture, if skilfully and extensively conducted, might ere long become productive of results of very high importance to commerce. For further information regarding American honey-farming see *The American Bee Journal*, *The Bee-Keepers' Exchange*, *Gleanings in Bee Culture*, and *The Bee-Keepers' Magazine*.

HONEY-EATER, or HONEY-SUCKER, names applied by many writers in a very loose way to a large number of birds, some of which, perhaps, have no intimate affinity; but here to be used, as before in this work (BIRDS, vol. iii. p. 739), in a more restricted sense for what, in the opinion of a good many recent authorities,[1] should really be deemed the Family *Meliphagidæ*—excluding therefrom the *Nectariniidæ* or SUN-BIRDS (which see) as well as the genera *Promerops* and *Zosterops* with whatever allies they may possess. Even with this restriction, the extent of the Family must be regarded as very indefinite, owing to the absence of materials sufficient for arriving at a satisfactory conclusion, though the existence of such a Family is probably indisputable. Making allowance then for the imperfect light in which they must at present be viewed, what are here called *Meliphagidæ* include some of the most characteristic forms of the ornithology of the great Australian Region—members of the Family inhabiting almost every part of it, and a single species only, *Ptilotis limbata*, being said to occur outside its limits. They all possess, or are supposed to possess, a long protrusible tongue with a brush-like tip, differing, it is believed, in structure from that found in any other bird,—*Promerops* perhaps excepted,—and capable of being formed into a suctorial tube, by means of which honey is absorbed from the nectary of flowers, though it would seem that insects attracted by the honey furnish the chief nourishment of many species, while others undoubtedly feed to a greater or less extent on fruits. The *Meliphagidæ*, as now considered, are for the most part small birds, never exceeding the size of a Mistletoe-Thrush; and they have been divided into more than 20 genera, containing above 200 species, of which only a few can here be particularized. Most of these species have a very confined range, being found perhaps only on a single island or group of islands in the Region, but there are a few which are more widely distributed—such as *Glycyphila rufifrons*, the White-throated[2] Honey-eater, found over the greater part of Australia and Tasmania. In plumage they vary much. Most of the species of *Ptilotis* are characterized by a tuft of white, or in others of yellow, feathers springing from behind the ear. In the greater number of the genus *Myzomela*[3] the males are recognizable by a gorgeous display of crimson or scarlet, which has caused one species, *M. sanguinolenta*, to be known as the Soldier-bird to Australian colonists; but in others no brilliant colour appears, and those of several genera have no special ornamentation, while some have a particularly plain appearance. One of the most curious forms is *Prosthemadera*—the Tui or Parson-bird of New Zealand, so called from the two tufts of white feathers which hang beneath its chin in great contrast to its dark silky plumage, and suggest a likeness to the bands worn by ministers of several religious denominations when officiating.[4] The Bell-bird of the same island, *Anthornis melanura*—whose melody excited the admiration of Cook the morning after he had anchored in Queen Charlotte's Sound—is another member of this Family, and unfortunately seems to be fast becoming extinct. But it would be impossible here to enter much further into detail, though the Wattle-birds, *Anthochæra*, of Australia have at least to be named. Mention, however, must be made of the Friar-birds, *Tropidorhynchus*, of which nearly a score of species, five of them belonging to Australia, have been described. With their stout bills, mostly surmounted by an excrescence, they seem to be the most abnormal forms of the Family, and most of them are besides remarkable for the baldness of some part at least of their head. They assemble in troops, sitting on dead trees, with a loud call, and are very pugnacious, frequently driving away Hawks and Crows. Mr Wallace (*Malay Archipelago*, ii. pp. 150–153) discovered the curious fact that two species of this genus,—*P. bourensis* and *P. subcornutus*,—respectively inhabiting the islands of Bouru and Ceram, were the object of natural "mimicry" on the part of two species of Oriole of the genus *Mimeta*, *M. bourouensis* and *M. forsteni*, inhabiting the same islands, so as to be on a superficial examination identical in appearance,—the Honey-eater and the Oriole of each island presenting exactly the same tints, —the black patch of bare skin round the eyes of the former, for instance, being copied in the latter by a patch of black feathers and even the protuberance on the beak of the *Tropidorhynchus* being imitated by a similar enlargement of the beak of the *Mimeta*. The very reasonable explanation which Mr Wallace offers is that the pugnacity of the former has led the smaller Birds-of-prey to respect it, and it is therefore an advantage for the latter, being weaker and less courageous, to be mistaken for it. (A. N.)

HONEY-GUIDE, a bird so called from its habit or supposed habit of pointing out to man and to the Ratel (*Mellivora capensis*) the nests of bees. Stories to this effect have been often told, and may be found in the narratives of many African travellers, from Bruce to Livingstone. Yet Mr Layard says (*B. South Africa*, p. 242) that the birds will not unfrequently lead any one to a leopard or a snake, and will follow a dog with vociferations,[5] so that at present judgment may perhaps be suspended on the matter, though its noisy cry and antics unquestionably have in

[1] Among them especially Mr Wallace, *Geogr. Distr. Animals*, ii. p. 275.

[2] It may be remarked that the young of this species has the throat yellow.

[3] Mr W. A. Forbes has published a careful monograph of this genus in the *Proceedings of the Zoological Society* for 1879, pp. 256–279.

[4] This bird, according to Mr Buller (*Birds of New Zealand*, p. 88), while uttering its wild notes, indulges in much gesticulation, which adds to the suggested resemblance. It has great power of mimicry, and is a favourite cage-bird both with the natives and colonists. On one occasion, says this gentleman, he had addressed a large meeting of Maories on a matter of considerable political importance, when "immediately on the conclusion of my speech, and before the old chief to whom my arguments were chiefly addressed had time to reply, a Tui, whose netted cage hung to a rafter overhead, responded in a clear emphatic way, 'Tito!' (false). The circumstance naturally caused much merriment among my audience, and quite upset the gravity of the venerable old chief Nepia Taratoa. 'Friend,' said he, laughing, 'your arguments are very good; but my *mokai* is a very wise bird, and he is not yet convinced!'"

[5] This is also a well-known habit with some *Corvidæ*—the Jays and Pies for example.

many cases the effect signified by its English name. If not its first discoverer, Sparrman, in 1777, was the first who described and figured this bird, which he met with in the Cape Colony (*Phil. Transactions*, lxvii. pp. 42-47, pl. i.), giving it the name of *Cuculus indicator*, its zygodactylous feet with the toes placed in pairs—two before and two behind—inducing the belief that it must be referred to that genus. Vieillot in 1816 elevated it to the rank of a genus, *Indicator*; but it was still considered to belong to the Family *Cuculidæ* (its asserted parasitical habits lending force to that belief) by all systematists except Blyth and Jerdon, until it was shewn by Mr Blanford (*Obs. Geol. and Zool. Abyssinia*, pp. 308, 309) and Mr Sclater (*Ibis*, 1870, pp. 176–180) that it was more allied to the Barbets, *Capitonidæ*, and, in consequence, was then made the type of a distinct Family, *Indicatoridæ*. In the meanwhile other species had been discovered, some of them differing sufficiently to warrant Sundevall's foundation of a second genus, *Prodotiscus*, of the group. The Honey-Guides are small birds, the largest hardly exceeding a Lark in size, and of plain plumage, with what appears to be a very Sparrow-like bill. Mr Sharpe, in a revision of the Family published in 1876 (*Orn. Miscellany*, i. pp. 192–209), recognizes ten species of the genus *Indicator*, to which another has since been added by Dr Reichenow (*Journ. für Ornithologie*, 1877, p. 110), and two of *Prodotiscus*. Four species of the former, including *I. sparrmani*, which was the first made known, are found in South Africa, and one of the latter. The rest inhabit other parts of the same continent, except *I. archipelagicus*, which seems to be peculiar to Borneo, and *I. xanthonotus*, which occurs on the Himalayas from the borders of Afghanistan to Bhotan. The interrupted geographical distribution of this genus is a very curious fact, no species having been found in the Indian or Malayan peninsula to connect the outlying forms with those of Africa, which must be regarded as their metropolis. (A. N.)

HONEYSUCKLE (M.E., *honysocle*, *i.e.*, any plant from which honey may be sucked,—*cf.* Ang.-Sax., *huni-suge*, privet; Germ., *Geissblatt*; Fr., Chèvrefeuille), *Lonicerus*, L., a genus of climbing, erect, or prostrate shrubs, of the natural order *Caprifoliaceæ*, so named after the German botanist Adam Lonicer. The British species are *L. Periclymenum*, the woodbine, *L. Caprifolium*, and *L. Xylosteum*. Some of the garden varieties of the woodbine are very beautiful, and are held in high esteem for their delicious fragrance; even the wild plant, with its pale flowers, compensating for its sickly looks "with never-cloying odours." The North American sub-evergreen *L. sempervirens*, with its fine heads of blossoms, commonly called the trumpet honeysuckle, is a distinct and beautiful species producing both scarlet and yellow flowered varieties, and the Japanese *L. brachypoda aureo-reticulata* is esteemed for its charmingly variegated leaves. The fly honeysuckle, *L. Xylosteum*, a hardy shrub of dwarfish erect habit, and *L. tatarica*, of similar habit, both European, are amongst the oldest English garden shrubs, and bear axillary flowers of various colours, occurring two on a peduncle. There are numerous other species, many of them introduced to our gardens, and well worth cultivating in shrubberies or as climbers on walls and bowers, either for their beauty or the fragrance of their blossoms.

Honeysuckle.

In the western counties of England, and generally by agriculturists, the name honeysuckle is applied to the meadow clover, *Trifolium pratense*. Another plant of the same leguminous family, *Hedysarum coronarium*, a very handsome hardy biennial often seen in old-fashioned collections of garden plants, is commonly called the French honeysuckle. The name is moreover applied with various affixes to several other totally different plants. Thus white honeysuckle and false honeysuckle are names for the North American *Azalea viscosa*; Australian or heath honeysuckle is the Australian *Banksia serrata*, Jamaica honeysuckle the *Passiflora laurifolia*, dwarf honeysuckle the widely spread *Cornus suecica*, Virgin Mary's honeysuckle the European *Pulmonaria officinalis*, while West Indian honeysuckle is the *Tecoma capensis*, and is also a name applied to *Desmodium*.

The wood of the fly honeysuckle is extremely hard, and the clear portions between the joints of the stems, when their pith has been removed, are stated by Linnæus to be utilized in Sweden for making tobacco-pipes. The wood is also employed to make teeth for rakes; and, like that of *L. tatarica*, it is a favourite material for walking-sticks.

HONFLEUR, a town of France, at the head of a canton in the arrondissement of Pont l'Évêque in the department of Calvados, is situated on the south side of the estuary of the Seine directly opposite Havre, and about 10 miles to the north of Pont l'Évêque and 37 miles to the north-east of Caen. With the general railway system of northern France it is connected by a line running by Pont l'Évêque to Lisieux; and a concession was granted in 1879 for another line to Pont-Audemer. As a town Honfleur has the typical aspect of a small old-fashioned seaport, equally heedless of symmetry in its plan and cleanliness in its economy. The most noteworthy of its buildings is the church of St Catherine, constructed entirely of timber work and plaster, and consisting of two parallel naves, of which the more ancient is supposed to date from the end of the 15th century. A process of restoration is at present (1880) going on under Government supervision. Within the church are several antique statues and a painting by Jordaens—Jesus in the Garden of Gethsemane. The church tower stands on the other side of a street. St Leonard's dates from the 17th century, with the exception of its fine ogival portal and rose-window belonging to the 16th, and its octagonal tower erected in the 18th. The ruins of a 16th century castle, and several houses of the same period, are the only buildings of antiquarian interest. The town-house, which contains the exchange and the commercial court, is of modern erection. On the rising ground above the town is the chapel of Notre Dame de Grâce, a shrine much resorted to by pilgrim sailors, which was founded in 1034 by Robert the Magnificent of Normandy, and rebuilt in 1606. Honfleur is the seat of a commercial college, a school of hydrography, a chamber of commerce, a custom-house, and various other Government offices, as well as of several consular establishments. The harbour, which consists of three basins, has been greatly improved between 1860 and 1875 by the extension of the pier and the formation of a new channel, which has a depth of 21 feet at neap tides and of 24 to 27 at spring-tides; and a fourth basin, decreed by the Government in 1879, will be completed by 1881. A reservoir of 120 acres in extent affords the means of sluicing the channel. In 1878 the gross returns of the shipping showed 894 vessels, of which 586 were British, 118 Norwegian, and 62 French, the total burthen amounting to 200,939 tons; and there were besides 840 French coasting vessels, with 48,000 tons. The export trade consists almost exclusively of eggs (from 10 to 12 million dozens yearly), poultry, table-fruits, nuts, butter (9 to 12 million lb), and similar produce for the London market; and the principal imports are coals, iron, wheat and oats, cement, wool, and marble, also deals from Norway, Sweden, and Russia, and oak timber from Germany. In 1879 the wheat imported from the United States amounted to 64,000 tons. Shipbuilding was formerly an extensive industry in Honfleur, most of the vessels of from 400 to 1200 tons belonging to the Havre shipowners issuing from its yards; but the number now laid on the stocks is very small. Saw-mills, oil-factories, soap-works, paper-mills, and marble-works are the main industrial establishments. The population of Honfleur, estimated at 8800 shortly before the great Revolution, was 9946 in 1872. In 1876 the census showed 9037 inhabitants in the town and 9425 in the commune.

Honfleur, Latinized as *Honflorium*, dates from the 11th century, and is thus four or five hundred years older than its greater rival Havre. During the English wars it was frequently taken and retaken, the longest English occupation being from 1430 to 1440. In 1562 the Protestant forces got possession of it only after a regular siege of the faubourg St Léonard; and though Henry IV. effected its capture in 1590 he had again to invest it in 1594 after all the rest of Normandy had submitted to his arms. In the earlier years of the 17th century Honfleur colonists founded Quebec, and Honfleur traders under Binot Paulmier established factories in Java and Sumatra. The German troops occupied the town in February 1871. Among the local celebrities are the admirals Doublet, Boitard, and Hamelin.

See A. Labutte, *Essai historique sur Honfleur et l'arrondissement de Pont-l'Évêque*, 1840; P. P. V. Thomas, *Hist. de la ville de Honfleur*, 1840; *Hist. de Honfleur par un enfant de Honfleur*, 1867; Abbé Sauvage, *Études hist. normandes: Honfleur au XIV^e siècle*, 1875.

HONG-KONG, properly HIANG-KIANG (the place of "sweet streams"), an important British island-possession, situated off the south-east coast of China, opposite the province of Kwang-tung, on the east side of the estuary of the Chu-Kiang or Canton river, 38 miles east of Macao and 75 south-east of Canton, between 22° 9′ and 22° 1′ N. lat. and 114° 5′ and 114° 18′ E. long. It is one of a small cluster named by the Portuguese "Ladrones" or Thieves, on account of the notorious habits of their old inhabitants. Extremely irregular in outline, it has an area of 29 square miles, measuring 10½ miles in extreme length from north-east to south-west, and varying in breadth from 2 to 5 miles. From the mainland it is separated by a narrow channel, which at Hong-Kong roads, between Victoria, the island capital, and Kau-lung Point, is about one mile broad, and which narrows at Ly-ce-moon Pass to little over a quarter of a mile. The southern coast in particular is deeply indented; and there two bold peninsulas, extending for several miles into the sea, form two capacious natural harbours, namely, Deep Water Bay, with the village of Stanley to the east, and Tytam Bay, which has a safe, well-protected entrance showing a depth of 10 to 16 fathoms. An in-shore island on the west coast, called Aberdeen or Taplichan, affords protection to the Shekpywan or Aberdeen harbour, an inlet provided with a granite graving dock, the caisson gate of which is 60 feet wide, and the Hope dock, opened in 1867, with a length of 425 feet and a depth of 24 feet. Opposite the same part of the coast, but nearly 2 miles distant, rises the largest of the surrounding islands, the Lamma, whose conspicuous peak, Mount Stenhouse, attains a height of 1140 feet, and is a landmark for local navigation. On the northern shore of Hong-Kong there is a patent slip at East or Matheson Point, which is serviceable during the north-east monsoon, when sailing vessels frequently approach Victoria through the Ly-ce-moon Pass. The ordinary course for such vessels is from the westward, on which side they are sheltered by Green Island and Kellett Bank. There is good anchorage throughout the entire channel separating the island from the mainland, except in the Ly-ce-moon Pass, where the water is deep; the best anchorage is in Hong-Kong roads, in front of Victoria, where, over good holding ground, the depth is 5 to 9 fathoms. The inner anchorage of Victoria Bay, about half a mile off shore and out of the strength of the tide, is 6 to 7 fathoms. Victoria, the seat alike of government and of trade, is the chief centre of population, but in recent years a tract of 4 square miles on the mainland has been covered with public buildings and villa residences. Practically an outlying suburb of Victoria, Kau-lung (Nine Dragons), or as it is commonly called Kowloon, is free from the extreme heat of the capital, being exposed to the south-west monsoon. Numerous villas have also been erected along the beautiful western coast of the island, while Stanley, in the south, has lately been attracting attention by its excellent qualifications as a watering-place.

The island is mountainous throughout, the low granite ridges, parted by bleak, tortuous valleys, leaving in some

Hong-Kong, with adjacent Coast and Islands.

places a narrow stripe of level coast-land, and in others overhanging the sea in lofty precipices. From the sea, and especially from the magnificent harbour which faces the capital, the general aspect of Hong-Kong is one of singular beauty. With something of the rugged grandeur of the western Scottish isles, and a suggestion of Italian softness and grace, it is distinguished by unmistakable traces of a purely tropical character. Inland the prospect is wild, dreary, and monotonous. The hills have a painfully bare appearance from the want of trees. The streams, which are plentiful, are traced through the uplands and glens by a line of straggling brushwood and rank herbage. Nowhere is the eye relieved by the grateful evidences of cultivation or fertility. The mountains, which are mainly composed of granite, serpentine, and syenite, rise in irregular masses to considerable heights, the loftiest point, Victoria Peak, reaching an altitude of 1825 feet. The Peak lies immediately to the south-west of the capital, in the extreme north-west corner of the island, and is used as a station for signalling the approach of vessels. Patches of land, chiefly around the coast, have been laid under rice, sweet potatoes, and yams, but the island is hardly able to raise a home-supply of vegetables. The mango, lichen, pear, and orange are indigenous, and to these the English have added several fruits and esculents. One of the chief products is building-stone, which is quarried by the Chinese. The animals are few, comprising a land tortoise, the armadillo, a species of boa, several poisonous snakes, and some woodcock. The public works suffer from the ravages of white ants. Water everywhere abounds, and is supplied to the shipping by means of tanks. Hong-Kong acquired the name of an extremely unhealthy place at the time of settlement, but it has been found that the mortality is only high in certain seasons. It is not free from a certain malaria which, according to Montgomery Martin, is thrown off by the decomposed rocks that have been baked by a strong sun during the day. The change from the heat and rain of summer (May to October) to the refreshing temperature of the cool season tends to produce disease of the kidneys, &c. During the years 1871–75 the mean temperature was 73° Fahr. in the shade, and the range from 56° to 84°, taking the mean readings for the months. Occasionally the thermometer registers below 40°, and on 26th February 1876, when extreme cold was experienced, water was frozen to the thickness of ¼ of an inch. The annual rainfall was 99·24 inches in 1871 and 83·43 in 1875. The population, which in 1841 was only 5000, had increased to 21,514 in 1848, to 37,058 in 1852, to 123,511 in 1862, and to 139,144 in 1876. According to the census of 1872, there were of Europeans and Americans 5931, of Chinese 115,444, and of natives of India, Goa, Manila, &c., 2623. Victoria was the residence of almost all the Europeans, and of the Chinese 83,487 (14,269 women) resided there, including a boat population of 12,309, while 10,507 resided in Kau-lung and other villages, and 11,400 were scattered along the coast in boats.

Formerly an integral part of China, the island was first ceded to Great Britain in 1841, and the cession was confirmed by the treaty of Nanking in 1842, the charter bearing date 5th April 1843. Kau-lung, temporarily occupied for several years as a military sanatarium, was ceded by a treaty contracted by Lord Elgin in 1861. The colony is under a governor, and an executive council comprising the colonial secretary, the commander of the troops, the attorney-general, and the auditor-general. The legislative council, presided over by the governor, is composed of all these officials (except the commander), with the addition of four unofficial members, nominated by the crown on the recommendation of the governor. The occupation of Hong-Kong was effected at a considerable outlay, but the parliamentary vote on its behalf was reduced from £50,000 in 1845 to £9200 in 1853, and since 1855 the colony has paid its local establishments. In 1868 it extinguished its debt, which had dwindled to £15,625, and it now pays £20,000 a year as military contribution to the imperial exchequer.

The capital, situated at the north-west extremity of the island, is laid out in fine wide streets and terraces. The buildings, mostly of stone and brick, are greatly superior to those of a Chinese city. The merchants' houses are elegant and spacious, with broad verandahs and tasteful gardens. Including the Chinese town, Victoria extends for 3 miles along the bay, towards which it slopes from the base of the hills. It is lighted with gas, and supplied with water from the Pokovfulun reservoir, which impounds 74 million gallons. The main thoroughfare is protected by a massive sea-wall, and the appearance of the town has been greatly improved by the construction of public gardens. Besides several handsome Government buildings, Victoria has a large exchange, a cathedral and bishop's palace, several good hospitals, extensive barracks, and a few higher class schools. A city hall with library and museum was opened in 1876, and the public works completed in that year (the extension of public gardens, construction of many miles of mountain path, and improvement of drainage) involving an outlay of £30,867. The educational provision of the Government in 1876 comprised 54 schools, with an attendance of 3111 pupils, and of these 16 with 1816 pupils were native schools, in which the language is Chinese. At the central school (556 pupils in 1876) there is a Chinese class for Europeans, as there is also in several of the missionary and "grant-in-aid" schools. Hong-Kong publishes, in addition to 5 English newspapers (2 daily), 1 in Chinese every second day and a Portuguese weekly. The streets are guarded by a strong force of Indian sepoys, and the natives are not allowed to go abroad after 8 o'clock at night without a pass; but the general character of the town is orderly, as is attested by the police returns, from which it appears that only 68 persons were convicted before the superior courts in 1875. The common mode of street conveyance is by chairs, which are carried by coolies, while the passage across to Kau-lung is usually effected in sampans or pull-away boats. Victoria has a few slight industries, including sugar-refining, rum-distilling, and ice-making. In 1877 the introduction of a steam laundry broke the monopoly of the dhoby. There are upwards of 500 Chinese hongs of a superior class belonging to ship compradores and to dealers in fancy goods, china ware, articles in gold and silver, opium and other drugs, rice, piece goods, tea, &c.

Although formerly the central point of the great European Chinese trade and still a thriving seat of commerce, Hong-Kong owes its present importance chiefly to its financial prominence as the head-quarters of the banking interest, and to its magnificent harbour, which makes it both the station of the British fleet and an entrepôt for the custom trade of all nations. In 1877 it was the residence of 14 foreign consuls, and had 10 large banking-houses. It still imports opium more largely than any other port, and among other articles of which it is the centre of trade are sugar, flour, salt, china ware, nut-oil, amber, cotton, sandalwood, ivory, betel, live stock, granite, and ship supplies. The principal transactions in tea and silk are controlled by firms residing in Hong-Kong. As it is a free port there are no exact returns of trade, but in 1877 the imports from Great Britain alone amounted to £3,645,068 and the exports thither to £1,895,310. Chief of these exports was tea, the value of which in 1876 was £839,568. In the same year the opium imported amounted to 96,985 piculs, as compared with 69,851 piculs received at all the other treaty ports. Of 3424 chests of Bengal opium imported in February 1876, 1500 passed into the hands of local consumers and 1924 were exported; at the same date there were 4800 chests in stock as compared with 1374 at Shanghai. There is an enormous passenger traffic: between the years 1871 and 1876 there have passed through the port no fewer than 15,000 Chinese coolies, of whom the majority have gone to the United States. In the year 1876 Queensland drafted hence as many as 8325 emigrants. Large steamers go and come almost daily, the ports in regular communication with Hong-Kong including Bombay, Calcutta, Singapore, Canton, San Francisco, Yokohama, and (since 1875) Sydney. The aggregate shipping that entered the port in 1878 amounted to 3,900,891 tons. Of this 45·2 per cent. were junks, 43·7 steamers, and 11·1 European and American built sailing vessels. Exclusive of native craft there entered and cleared (1876) 4,359,616 tons, of which 3,150,952 were in British and 1,208,664 in foreign vessels. The revenue in 1878, derived from land rents, fines, licences to sell opium, and spirits, &c., amounted to £197,424, the expenditure to £189,695; there is usually a surplus of revenue. At the 31st January 1877 the bank-notes in circulation were stated at $3,536,380, and the specie in reserve at $1,295,000. Hong-Kong has a dollar of its own coining (4s. 2d.), but its mint, which entailed a cost of £9,000 a year, has ceased to operate. Other coins in circulation are the Mexican dollar, Chinese taels and cash, the American trade dollar, and Japanese silver yen. A movement is at present on foot to have the last two coins placed on an equality with the Mexican dollar. The standard of value is 1000 Mexican dollars to 717 taels by weight. In spite of the great increase in recent years of the direct trade with the various treaty ports, the progress of Hong-Kong has been steady, and there is every probability of its maintaining its peculiar position of influence in the Chinese trade. In 1871 it was placed in telegraphic communication with England, and in its recent legislative action it has shown vitality and enterprise. The gambling practices which prevailed here, as they still do in many Chinese towns, have been vigorously suppressed, and the difficulties arising from the sudden development of the coolie emigration have been overcome. The presence of Chinese revenue cruisers in Hong-Kong waters has led (February 1880) to a storm of opposition on the part of resident British merchants, who declare that this amounts to a blockade of the island; but British officials uphold the action of China as a necessary check upon the opium and salt smuggling.

Besides the Government papers and *The Hong-Kong Almanac and Directory*, see *A Letter from Hong-Kong, descriptive of that Colony, by a Resident*, 2d ed., Lond., 1845; Bentham, *Flora Hongkongensis*, Lond., 1861; Beach, *Visit of H.R.H. the Duke of Edinburgh to Hong-Kong in* 1869, Hong-Kong, 1869; J. Legge, "The Colony of Hong-Kong," in *The China Review* (edited by Dennys), 1872. (A. M'D.)

HONITON, a municipal borough and market-town of England, county of Devon, is pleasantly situated on a rising ground on the left bank of the Otter and on the London and South-Western Railway, 16 miles E.N.E. of Exeter. It consists of one wide street about a mile in length, crossed by a smaller one at right angles. Along the main street there runs a small stream of water. The only buildings of importance are the old parish church, on an eminence about half a mile from the town, built by Courtenay, bishop of Exeter, about 1482, and possessing a curiously carved screen; the church of St Paul's (now the parish church) in the centre of the town, in the Norman style; the dispensary; the St Margaret's charity, originally erected as a hospital for lepers, but now used as almshouses; the union workhouse, erected in 1836, with accommodation for 250 inmates; the grammar school, the national schools, and the British school opened in 1878. The town is famed for its lace manufacture; and there are also breweries, malting establishments, flour mills, tanneries, brick and tile works, and an iron foundry. The population of the municipal borough in 1871 was 3464.

Honiton is supposed to have originated in a Roman settlement at Hembury fort, about 3 miles from the town, where there are still traces of an extensive camp conjectured to be the *Moridunum* of Antoninus. The town first sent members to parliament in the reign of Edward I., but after the reign of Edward II. the privilege was suspended until 1640. In 1867 its representation was limited to one member, and in 1868 it was disfranchised. It was incorporated as a municipal borough in 1846.

HONOLULU. See HAWAIIAN ISLANDS, vol. xi. p. 531.

HONORIUS, FLAVIUS AUGUSTUS, was emperor of the West from 397 to 425 A.D. His reign of twenty-eight years was one of the most eventful in the Roman annals; the weakness and timidity of the emperor co-operated with the attacks of the Goths and Vandals in promoting the rapid disintegration of the empire. But his influence on the current of events was purely negative, and his reign will be noticed under ROMAN HISTORY.

HONORIUS I., pope from 625 to 638, succeeded Boniface V. The festival of the Elevation of the Cross is said to have been instituted during his pontificate, which was marked also by considerable missionary enterprise. Honorius in his lifetime had favoured the formula proposed by the emperor Heraclius with the design of bringing about a reconciliation between the Monophysites and the Catholics, which bore that Christ had accomplished His work of redemption by one manifestation of His will as the God-man. For this he was, more than forty years after his death, anathematized by name along with the other Monothelite heretics by the council of Constantinople (First Trullan) in 680; and this condemnation was subsequently confirmed by more than one pope, particularly by Leo II., as has been abundantly proved by unimpeachable evidence against the contentions of Baronius and Bellarmine (see Hefele, *Die Irrlehre des Honorius u. das vaticanische Lehre der Unfehlbarkeit*, 1871, who, however, has modified his view in *Conciliengeschichte*, 1877). Honorius I. was succeeded by Severinus.

HONORIUS II.[1] (Lambert of Ostia), pope from 1124 to 1130, succeeded Calixtus II. As papal legate he had been one of the framers of the concordat of Worms (1122). During his pontificate the Præmonstratensian order, and also that of the Knights Templars, received papal sanction. His successor was Innocent II.

HONORIUS III., pope from 1216 to 1227, was the successor of Innocent III., whose uncompromising policy in the struggle between the papacy and the empire he had not firmness and vigour to continue. He consented to crown Frederick II. as Holy Roman emperor in 1220, although the engagements made with his predecessor had not been fulfilled; the promises which he himself had exacted he was somewhat slow to urge, and it was left to his successor Gregory IX. to insist upon their accomplishment. He gave papal sanction to the Dominican order in 1216, and to the Franciscan in 1223; and during his pontificate also many of the tertiary orders first came into existence.

HONORIUS IV. succeeded Martin IV., and was pope for two years (1285–1287). After an uneventful pontificate he was succeeded by Nicholas IV.

[1] This name had been assumed in the previous century (1061–64) by Peter Cadalus; but he never was recognized as a legitimate pope.

HONTHEIM, JOHANN NIKOLAUS VON (1701–1790), a zealous opponent of Ultramontanism, was born at Treves, January 27, 1701. After receiving his early education at the Jesuit college of his native town, he studied jurisprudence both there and at Louvain and Leyden. On obtaining the degree of doctor of laws at Treves in 1724 he took the ecclesiastical habit, and went to Rome in order to make himself acquainted with the forms of the curia. Returning to Treves in 1728, he was appointed ecclesiastical councillor of the consistory, in 1732 professor of law, in 1741 privy councillor of the archbishop, and in 1748 suffragan of the see. In 1750 he published at Treves *Historia Trevirensis diplomatica*, and in 1763, under the pseudonym of Justinus Febronius, *De Statu ecclesiæ et legitima potestate Romani Pontificis liber singularis*, in which he maintained the Gallican theory that the supreme authority of the church was vested not in the pope but in the general council. This work he in perfect simplicity and sincerity dedicated to Pope Clement XIII., who, however, condemned it and caused it to be burned at Rome. When Hontheim was discovered to be the author he was induced to make a retractation, but in his *Febronius abbreviatus et emendatus* (Vienna, 1771) and *Febronii commentarius* (Vienna, 1781) he nevertheless gave further currency to his old views. He died at Montquintin, Luxembourg, September 2, 1790.

HONTHORST, GERARD VAN (born at Utrecht 1590, died at Utrecht 1656), was brought up as a painter at the school of Bloemart, who exchanged the style of the Franckens for that of the pseudo-Italians at the beginning of the 16th century. Infected thus early with a mania which came to be very general in Holland, Honthorst went to Italy, where he copied the naturalism and eccentricities of Michelangelo da Caravaggio. Home again about 1614, after acquiring a considerable practice in Rome, he set up a school at Utrecht which flourished exceedingly; and he soon became so fashionable that Sir Dudley Carleton, then English envoy at the Hague, recommended his works to the earl of Arundel and Lord Dorchester. At the same time the queen of Bohemia, sister of Charles I. and electress palatine, being an exile in Holland, gave him her countenance and asked him to teach her children drawing; and Honthorst, thus approved and courted, became known to Charles I., who invited him to England. There he painted several portraits, and a vast allegory, now at Hampton Court, of Charles and his queen as Diana and Apollo in the clouds receiving the duke of Buckingham as Mercury and guardian of the king of Bohemia's children. Charles I., whose taste was flattered alike by the energy of Rubens and the elegance of Van Dyck, was thus first captivated by the fanciful mediocrity of Honthorst, who though a poor executant had luckily for himself caught, as Lord Arundel said, "much of the manner of Caravaggio's colouring, then so much esteemed at Rome." It was his habit to transmute every subject into a night scene, from the Nativity, for which there was warrant in the example of Correggio, to the penitence of the Magdalen, for which there was no warrant at all. But unhappily this caprice, though "sublime in Allegri and Rembrandt," was but a phantasm in the hands of Honthorst, whose prosaic pencil was not capable of more than vulgar utterances, and art gained little from the repetition of these quaint vagaries. Sandrart gave the measure of Honthorst's popularity at this period when he says that he had as many as twenty apprentices at one time, each of whom paid him a fee of 100 florins a year. In 1623 he was president of his guild at Utrecht. After that he went to England as above stated, returning to settle anew at Utrecht, where he married. His position amongst artists was acknowledged to be important, and in 1626 he received a visit from Rubens, whom he painted as the honest man sought for and found by Diogenes Honthorst. In his home at Utrecht Honthorst succeeded in preserving the support of the English monarch, for whom he finished in 1631 a large picture of the king and queen of Bohemia "and all their children." For Lord Dorchester about the same period he completed some illustrations of the *Odyssey*, one of which survives in the Weld-Blundell collection at Ince; for the king of Denmark he composed incidents of Danish history, of which one example remains in the gallery of Copenhagen. In the course of a large practice he had painted many likenesses—Charles I. and his queen, the duke of Buckingham, and the king and queen of Bohemia. He now became court painter to the princess of Orange, settled (1637) at the Hague, and painted in succession at the Castle of Ryswick and the House in the Wood. The time not consumed in producing pictures was devoted to portraits. Even now his works are very numerous, and amply represented in English and Continental galleries. His most attractive pieces are those in which he cultivates the style of Caravaggio, those, namely which represent taverns, with players, singers, and eaters. He shows great skill in reproducing scenes illuminated by a single candle. But he seems to have studied too much in dark rooms, where the subtleties of flesh colour are lost in the dusky smoothness and uniform redness of tints procurable from farthing dips. Of great interest still, though rather sharp in outline and hard in modelling, are his portraits of the Duke of Buckingham and Family (Hampton Court), the King and Queen of Bohemia (Hanover and Combe Abbey), Mary de Medici (Amsterdam town-hall, 1628), the Stadtholders and their Wives (Amsterdam and Hague), Charles Louis and Rupert, Charles I.'s nephews (Louvre, St Petersburg, Combe Abbey, and Willin), and Lord Craven (National Portrait Gallery). His early form may be judged by a Lute-player (1614) at the Louvre, the Martyrdom of St John in S. M. della Scala at Rome, or the Liberation of Peter in the Berlin Museum; his latest style is that of the House in the Wood (1648), where he appears to disadvantage by the side of Jordaens and others. Honthorst was succeeded by his brother William, born at Utrecht in 1604, who died it is said in 1666. He lived chiefly in his native place, temporarily at Berlin. But he has left little behind except a portrait at Amsterdam, and likenesses in the Berlin Museum of William and Mary of England.

HOOCH, Pieter de, a Dutch painter of note, was born it is thought about 1632, and died it is supposed in 1681 at Haarlem. Public records testify that he was a native of Rotterdam, and wandered early to Delft, where he married in 1654 and practised till 1657. From that time onward his life is obscure; and the only proofs of his existence to which we can point are the dates on his pictures, which range from 1658 to 1670. The registry of "Pieter de Hooge's" death at Haarlem on the 28th of February 1681 is believed to refer to our artist. Though neglected by his contemporaries, De Hooch is one of the kindliest and most charming painters of homely subjects that Holland has produced. He seems to have been born at the same time and taught in the same school as Van der Meer and Maes, but his works are more harmoniously coloured than those of Maes, and more boldly touched than those of Meer. In one respect all three are alike, being disciples of the school of Rembrandt. De Hooch only once painted a canvas of any size, and that unfortunately perished in a fire at Rotterdam in 1864. But his small pieces display perfect finish and great dexterity of hand, combined with that power of discrimination which accomplishes detail whilst avoiding rapidity and smoothness. Though he sometimes paints open-air scenes, these are not his favourite subjects. He is most at home in interiors, and his delight is to contrast in one picture the different atmospheres of rooms illuminated by different lights with the radiance of day as seen through doors and windows. He thus brings together the most delicate varieties of tone, and produces chords that vibrate with harmony. The themes which he illustrates are thoroughly suited to his purpose. Sometimes he chooses the drawing-room where dames and cavaliers dance, or dine, or sing; sometimes—mostly indeed—he likes cottages or courtyards, where housewives tend their children or superintend the labours of the cook. Satin and gold are as familiar to him as camlet and fur, but the latter are his favourites; and there is no article of furniture in a Dutch house of the middle class that he does not paint with pleasure. What distinguishes him most besides subtle suggestiveness is the serenity of his pictures, whether in the open or in confined spaces. One of his most charming arrangements is a canvas in the Ashburton collection, where an old lady with a dish of apples walks with a child along a street bounded by a high wall, above which gables and a church steeple are seen. The dame is busied with the child, whilst a gentleman in a hat and cloak shows his back in the distance. The sun radiates and glitters joyfully over the whole. Fine in another way is the Mug of Beer in the Amsterdam museum, an interior where a woman is seen coming out of a pantry and giving a measure of beer to a little girl. The light flows in here from a small closed window. But through the door to the right we look into a drawing-room, and through the open sash of that room we see the open air. The three lights are managed with supreme cunning. In such masterpieces as these we discern the models familiar to later artists such as Boursse and Koedijk, and a delicate gradation of tints which Maes and Meer might have envied. Beautiful for its lighting again is the Mother peeling Apples, whilst her child looks on supported in leading strings by a nurse, the sun shining through the casement to the left, a gem in the Speck collection at Lütschena near Leipsic. More subtly suggestive, in the museum of Berlin, is the Mother seated near a Cradle, whilst a child totters away into a lobby on the right. The mother looks into the depths of the cradle with a smile, thus betraying to us the presence of the baby which we cannot see. A Card Party, dated 1658, at Buckingham Palace is a good example of De Hooch's drawing-room scenes, counterpart as to date and value of a Woman and Child in the National Gallery, and a Smoking Party belonging to Lord Enfield. Other pictures later onward in the master's career are—the Lady and Child in a Courtyard, of 1665, in the National Gallery, and the Lady receiving a Letter, of 1670, in the Van der Hoop collection at Amsterdam. It is possible to bring together between fifty and sixty examples of De Hooch, but not more. There are eight at St Petersburg alone, three in Buckingham Palace, three in the National Gallery, five, or at least four of undoubted genuineness, in the Hoop collection at Amsterdam, some in the Louvre, at Munich, and Darmstadt; the rest are chiefly in private galleries in England. For England was the first to recognize the merit of De Hooch, who only began to be valued in Holland in the middle of last century. A celebrated picture at Amsterdam, sold for 450 florins in 1765, fetched 4000 in 1817, and now even that price is thought a bagatelle, since the Berlin museum gave £6000 for a De Hooch at the Schneider sale in 1876.

HOO-CHOW-FOO, a city of China, in the province of Che-Keang, lies a little to the south of Lake Tai-hoo, in the midst of the central silk district. According to Chinese authorities, it is 6 miles in circumference, and contains about 100,000 families; but Fortune thinks it is not more than 3 or 4 miles round. A broad stream or canal crosses the city from south to north, and forms the principal highway for boat traffic. The main trade of the place is in raw silk, but some silk fabrics, such as flowered crape (*tchoisha*), are also manufactured. Silk is largely worn even by the lowest classes of the inhabitants.

HOOD, ROBIN. See ROBIN HOOD.

HOOD, THOMAS (1789-1845), humorist and poet, born 23d May 1789, was the son of Mr Hood, bookseller, of the firm of Vernor & Hood, a man of intelligence, and the author of two novels. "Next to being a citizen of the world," writes Thomas Hood in his *Literary Reminiscences*, "it must be the best thing to be born a citizen of the world's greatest city." The best incident of his boyhood was his instruction by a schoolmaster who appreciated his talents, and, as he says, "made him feel it impossible not to take an interest in learning while he seemed so interested in teaching." Under the care of this "decayed dominie," whom he has so affectionately recorded, he earned a few guineas—his first literary fee—by revising for the press a new edition of *Paul and Virginia*. Admitted soon after into the counting-house of a friend of his family, he "turned his stool into a Pegasus on three legs, every foot, of course, being a dactyl or a spondee;" but the uncongenial profession affected his health, which was never strong, and he was transferred to the care of a relation at Dundee. He has graphically described his unconditional rejection by this inhospitable personage, and the circumstances under which he found himself in a strange town without an acquaintance, with the most sympathetic nature, anxious for intellectual and moral culture, but without guidance, instruction, or control. This self-dependence, however, suited the originality of his character: he became a large and indiscriminate reader, and before long contributed humorous and poetical articles to the provincial newspapers and magazines. As a proof of the seriousness with which he regarded the literary vocation, it may be mentioned that he used to write out his poems in printed characters, believing that that process best enabled him to understand his own peculiarities and faults, and probably unconscious that Coleridge had recommended some such method of criticism when he said he thought "print settles it."

His modest judgment of his own abilities, however, deterred him from literature as a profession, and on his return to London he applied himself assiduously to the art of engraving, in which he acquired a skill that in after years became a most valuable assistant to his literary labours, and enabled him to illustrate his various humours and fancies by a profusion of quaint devices, which not only repeated to the eye the impressions of the text, but, by suggesting amusing analogies and contrasts, added considerably to the sense and effect of the work.

In 1821 Mr John Scott, the editor of the *London Magazine*, was killed in a duel, and that periodical passed into the hands of some friends of Hood, who proposed to him to take a part in its publication. His installation into this congenial post at once introduced him to the best literary society of the time; and in becoming the associate of such men as Charles Lamb, Cary, De Quincey, Allan Cunningham, Proctor, Talfourd, Hartley Coleridge, the peasant-poet Clare, and other contributors to that remarkable miscellany, he gradually developed his own intellectual powers, and enjoyed that happy intercourse with superior minds for which his cordial and genial character was so well adapted, and which he has described in his best manner in several chapters of *Hood's Own*. *Odes and Addresses*—his first work—were written about this time, in conjunction with his brother-in-law Mr J. H. Reynolds, the friend of Keats; and it is agreeable to find Sir Walter Scott acknowledging the gift of the work with no formal expressions of gratification, but "wishing the unknown author good health, good fortune, and whatever other good things can best support and encourage his lively vein of inoffensive and humorous satire." *Whims and Oddities*, *National Tales*, *Tylney Hall*, a novel, and *The Plea of the Midsummer Fairies* followed. In these works the humorous faculty not only predominated, but expressed itself with a freshness, originality, and power which the poetical element could not claim. There was much true poetry in the verse, and much sound sense and keen observation in the prose of these works; but the poetical feeling and lyrical facility of the one, and the more solid qualities of the other, seemed best employed when they were subservient to his rapid wit, and to the ingenious coruscations of his fancy. This impression was confirmed by the series of the *Comic Annual*, a kind of publication at that time popular, which Hood undertook and continued, almost unassisted, for several years. Under that somewhat frivolous title he treated all the leading events of the day in a fine spirit of caricature, entirely free from grossness and vulgarity, without a trait of personal malice, and with an under-current of true sympathy and honest purpose that will preserve these papers, like the sketches of Hogarth, long after the events and manners they illustrate have passed from the minds of men. But just as the agreeable jester rose into the earnest satirist, one of the most striking peculiarities of his style became a more manifest defect. The attention of the reader was distracted, and his good taste annoyed, by the incessant play upon words, of which Hood had written in his own vindication—

"However critics may take offence,
A double meaning has double sense."

Now it is true that the critic must be unconscious of some of the subtlest charms and nicest delicacies of language who would exclude from humorous writing all those impressions and surprises which depend on the use of the diverse sense of words. The history, indeed, of many a word lies hid in its equivocal uses; and it in no way derogates from the dignity of the highest poetry to gain strength and variety from the ingenious application of the same sounds to different senses, any more than from the contrivances of rhythm or the accompaniment of imitative sounds. But when this habit becomes the characteristic of any wit, it is impossible to prevent it from degenerating into occasional buffoonery, and from supplying a cheap and ready resource, whenever the true vein of humour becomes thin or rare. Artists have been known to have used the left hand in the hope of checking the fatal facility which practice had conferred on the right; and if Hood had been able to place under some restraint the curious and complex machinery of words and syllables which his fancy was incessantly producing, his style would have been a great gainer, and much real earnestness of object, which now lies confused by the brilliant kaleidoscope of language, would have remained definite and clear. He was probably not unconscious of this danger; for, as he gained experience as a writer, his diction became more simple, and his ludicrous illustrations less frequent. In another annual called the *Gem* appeared the poem on the story of "Eugene Aram," which first manifested the full extent of that poetical vigour which seemed to advance just in proportion as his physical health declined. He started a magazine in his own name, for which he secured the assistance of many literary men of reputation and authority, but which was mainly sustained by his own intellectual activity. From a sick-bed, from which he never rose, he conducted this work with surprising energy, and there composed those poems, too few in number, but immortal in the English language, such as the "Song of the Shirt," the "Bridge of Sighs," and the "Song of the Labourer," which seized the deep human interests of the time, and transported them from the ground of social philosophy into the loftier domain of the imagination. They are no clamorous expressions of anger at the discrepancies and contrasts of humanity, but plain, solemn pictures of conditions of life, which neither the politician nor the moralist can deny to exist, and which they are imperatively called upon to remedy. Woman, in her wasted life, in her hurried death, here stands appealing to the society that degrades her, with a combination of eloquence and poetry, of forms of art at once instantaneous and permanent, and with a metrical energy and variety of which perhaps our language alone is capable. Prolonged illness brought on straitened circumstances; and application was made to Sir Robert Peel to place Hood's name on the pension list with which the British state so moderately rewards the national services of literary men. This was done readily and without delay, and the pension was continued to his wife and family after his death, which occurred on the 3d of May 1845. Nine years after, a monument, raised by public subscription, in the cemetery of Kensal Green, was inaugurated by Mr Monckton Milnes (Lord Houghton) with a concourse of spectators that showed how well the memory of the poet stood the test of time. Artisans came from a great distance to view and honour the image of the popular writer whose best efforts had been dedicated to the cause and the sufferings of the workers of the world; and literary men of all opinions gathered round the grave of one of their brethren whose writings were at once the delight of every boy and the instruction of every man who read them. Happy the humorist whose works and life are an illustration of the great moral truth that the sense of humour is the just balance of all the faculties of man, the best security against the pride of knowledge and the conceits of the imagination, the strongest inducement to submit with a wise and pious patience to the vicissitudes of human existence. This was the lesson that Thomas Hood left behind him, and which his countrymen will not easily forget. (H.)

HOOD, Tom (1835–1874), son of Thomas Hood, and the inheritor of similar though less brilliant literary talents, was born at Lake House, Wanstead, January 19, 1835. After attending University College School and Louth Grammar School he entered Pembroke College, Oxford, where he passed all the examinations for the degree of B.A., but did not graduate. At Oxford he also wrote his first work, *Pen and Pencil Pictures*, which appeared in 1854–55. This was followed in 1861 by *The Daughters of King Daker, and other Poems*, after which he published a number of amusing books for children. His serious novels were not so successful, and are now almost wholly forgotten. He also wielded the pencil with considerable facility, among his illustrations being those of several of his father's comic verses. Having become editor of the comic paper *Fun* in 1865, he succeeded in acquiring for it a wide popularity, principally as a depictor of the humours and eccentricities of middle-class life. Privately his lightsomeness, geniality, and sincere friendliness secured him the affection and esteem of his wide circle of acquaintance. He died 20th November 1874.

HOOD, Samuel Hood, First Viscount (1724–1816), English admiral, was born in 1724 at Butleigh in Somersetshire, where his father was rector. Entering the navy at sixteen years of age, he quickly obtained promotion, becoming lieutenant in 1746 and commander in 1754. In 1757 he captured a French ship of equal size with his own, and in 1759 he repeated the achievement. After holding successively the appointments of chief commander of the Boston naval station and commissioner of the dockyards at Portsmouth, he was in 1780 promoted to the rank of rear-admiral, and sent to co-operate with Sir George Rodney in the West Indies, where he fought some indecisive actions with the Comte de Grasse. In July of the following year he succeeded Rodney in the supreme command, shortly after which the fleet set sail for America. Although in January 1782 Hood failed to hold the island of St Christopher's against the superior forces of the French, he succeeded in very difficult circumstances in preserving his fleet intact until the arrival of Rodney, when he so distinguished himself in the action of the 9th April and the more important one of the 12th, that for his services he was created a peer of Ireland with the title of Baron Hood of Catherington. On Rodney's return home he was again promoted to the chief command, which he held till peace was proclaimed in 1783. In 1784 Lord Hood successfully opposed Charles Fox as parliamentary candidate for Westminster, and, though he lost his seat on being made a lord of the admiralty in 1788, he regained it in 1790. On the outbreak of war with France, after the Revolution, in 1793, he was appointed to the command of the fleet in the Mediterranean, where he received the surrender of Toulon from the French royalists. Before evacuating it to Napoleon on December 18th, Hood burned the arsenal, and destroyed fifteen sail of the line besides carrying off eight. In the following year he succeeded, after a stubborn resistance, in expelling the French from Corsica; and after his return home he was in 1796 appointed governor of Greenwich Hospital and raised to the English peerage with the title of Viscount Hood of Whitley. In 1799 he was promoted to the rank of admiral, and in 1804 he received the grand cross of the bath. He died at Bath 27th June 1816. The achievements of Lord Hood, though not of so brilliant a character as those of a Blake or a Nelson, were the result of thorough seamanship, and of a rare union of courage and decision with coolness and caution.

HOOFT, Pieter Cornelissen (1581–1647), Dutch poet and historian, was born at Amsterdam on the 16th of March 1581. His father was one of the leading citizens of Holland, both in politics and in the patronage of letters, and for some time burgomaster of Amsterdam. As early as 1598 the young man was made a member of the chamber of rhetoric of the Eglantine, and produced before that body his tragedy of *Achilles and Polyxena*, not printed until 1614. In June 1598 he left Holland and proceeded to Paris, where on the 10th of April 1599 he saw the body of Gabrielle d'Estrées lying in state. He went a few months later to Venice, Florence, and Rome. In 1600 he proceeded to Naples, and during all this Italian sojourn he made a deep and fruitful study of the best literature of Italy. In July 1600 he sent home to the Eglantine a very fine letter in verse, which is considered to mark an epoch in the development of Dutch poetry. He returned through Germany, and after an absence of three years and a half found himself in Amsterdam again on the 8th of May 1601. He soon after brought out his second tragedy, the *Ariadne*, in 1602. In 1605 he completed his beautiful pastoral drama *Granida*, not published until 1615. He studied law at Leyden from 1606 to 1609, and in June of the latter year received from the prince of Orange the appointment of steward of Minden, bailiff of Gooiland, and lord of Weesp, a joint office of great emolument. He occupied himself with repairing and adorning the decayed castle of Minden, which was his residence during the remainder of his life. In August 1610 he married the famous botanist, Christina van Erp. In 1612 Hooft produced, and in 1613 printed, his national tragedy of *Geeraerdt van Velsen*, a story of the reign of Count Floris V. In 1614 was performed at Coster's academy Hooft's comedy of *Ware-nar*, an adaptation of the *Aulularia* of Plautus, first printed in 1617. In 1616 he wrote another tragedy, *Baeto, or the Origin of the Dutch*, not printed until 1626. It was in 1618 that he abandoned poetry for history, and in 1626 he published the first of his great prose works, the

History of Henry the Great (Henry IV. of France). His next production was his *Miseries of the Princes of the House of Medici*, printed in 1638. In 1642 he published the masterpiece of his life, his *Dutch History*, a magnificent performance, to the perfecting of which he had given fifteen years of labour. Hooft died on a visit to Prince Frederick Henry at the Hague on the 21st of May 1647, and was buried in the New Church at Amsterdam.

Hooft is one of the most brilliant figures that adorn Dutch literature at its best period. He was the first writer to introduce a modern and European tone into belles lettres, and the first to refresh the sources of native thought from the springs of antique and Renaissance poetry. His lyrics and his pastoral of *Granida* are strongly marked by the influence of Tasso and Sannazaro; his later tragedies belong more exactly to the familiar tone of his native country. But high as Hooft stands among the Dutch poets, he stands higher, he holds perhaps the highest place, among writers of Dutch prose. His historical style has won the warmest eulogy from so temperate a critic as Motley, and his letters are the most charming ever published in the Dutch language. After Vondel, he may on the whole be considered the most considerable author that Holland has produced.

Hooft's poetical and dramatic works were collected in two volumes, 1871, 1875, by P. Leendertz. Many editions exist of his prose works.

HOOGEVEEN (*i.e.*, High Fen or Moor), a village and commune of the Netherlands in the province of Drenthe, about 12 miles north-east of Meppel on the railway opened in 1870 between that town and Groningen. The village contains a Reformed church, erected in 1652 and restored in 1766 and 1801, a small but handsome synagogue, a poorhouse dating from 1810, and a library belonging to the local branch of the society *Tot nut van 't Algemeen*; and among the industrial establishments of the commune are timber yards, sail factories, block factories, tanneries, brick-works, gin distilleries, and breweries. Hoogeveen was founded in 1625 by Baron van Eichten, and in the following year it was erected into a lordship which lasted till 1795. The population of the commune, which was 7339 in 1840, had risen to 10,763 in 1874.

HOOGHLY, or Húglí. The Hooghly river is the most westerly and commercially the most important channel by which the Ganges enters the Bay of Bengal. It takes its distinctive name near the town of Sántipur, about 120 miles from the sea. The stream now known as the Hooghly represents three western deltaic distributaries of the Ganges —viz., (1) the Bhágirathí, (2) the Jalangi, and (3) part of the Mátábhángá. The Bhágirathí and Jalangi unite at Nadiyá, above the point of their junction with the lower waters of the Mátábhángá, which has taken the name of the Churní before the point of junction and thrown out new distributaries of its own These three western distributaries are known as "The Nadiyá Rivers," and are important, not only as great highways for internal traffic, but also as the headwaters of the Hooghly. Like other deltaic distributaries, they are subject to sudden changes in their channels, and to constant silting up. The supervising and keeping open of the Nadiyá rivers has, therefore, formed one of the great tasks of fluvial engineering in Bengal. Proceeding south from Sántipur, with a twist to the east, the Hooghly river divides Murshidábád from Hooghly district, until it touches the district of the Twenty-Four Parganás in 22° 57′ 30″ N. lat. and 88° 27′ 15″ E. long. It then proceeds almost due south to Calcutta, next twists to the south-west, and finally turns south, entering the Bay of Bengal in 21° 41′ N. lat. and 88° E. long.

In the 40 miles of its course that are above Calcutta, the channels of the Hooghly are under no supervision, and the result is that they have silted up and shifted to such an extent as to be no longer navigable for sea-going ships. Yet it was upon this upper section that all the famous ports of Bengal lay in olden times. From Calcutta to the sea (about 80 miles) the river is a record of engineering improvement and success. A minute supervision, with steady dredging and constant readjustment of buoys, now renders it a safe waterway to Calcutta for ships of the largest tonnage. Much attention has also been paid to the port of Calcutta. For its trade, shipping, and administration, see CALCUTTA.

The tide runs rapidly on the Hooghly, and produces a remarkable example of the fluvial phenomenon known as a "bore." This consists of the headwave of the advancing tide, hemmed in where the estuary narrows suddenly into the river, and often exceeds 7 feet in height. It is felt as high up as Calcutta, and frequently sinks small boats or dashes them to pieces on the bank. The difference from the lowest point of low-water in the dry season to the highest point of high-water in the rains is reported at 20 feet 10 inches. The greatest mean rise of tide, about 16 feet, takes place in March, April, or May,—with a declining range during the rainy season to a mean of 10 feet, and a minimum during freshets of 3 feet 6 inches. The scenery on the banks of the Hooghly varies greatly. The sea approach presents nothing to view but sandbanks, succeeded by mean-looking mud formations covered with coarse grass. As the river narrows, however, the country improves. Trees and rice fields and villages are common, and at length a section is reached where the banks are high, and lined with hamlets buried under evergreen groves. Then come long tiers of shipping, with the stately painted mansions of Garden Reach on the margin in the foreground, the fort rising from the great plain on the bank higher up, and the domes, steeples, and noble public buildings of Calcutta beyond,—all gradually unfolding their beauties in a long panorama.

HOOGHLY, a British district in the lieutenant-governorship of Bengal, lying between 22° 13′ 45″ and 23° 13′ 15″ N. lat., and between 87° 47′ and 88° 33′ E. long. The area, including the magistracy of Howrah, amounted in 1878 to 1467 square miles. It forms the south-eastern portion of the Bardwán division, and is bounded N. by the district of Bardwán, E. by the Hooghly river, separating it from the districts of Nadiyá and the Twenty-Four Parganás; S. by the Rúpnáráyan, separating it from Midnapur; and W. by the same river, separating it from Midnapur, and by Bardwán district.

The district is flat, with a gradual ascent to the north and north-west. The scenery along the high-lying bank of the Hooghly has a quiet beauty of its own, presenting the appearance of a connected series of orchards and gardens, interspersed with factories, villages, and temples. The principal rivers are the Hooghly, the Dámodar, and the Rúpnáráyan. The Dámodar is the only large river which intersects the district. As in other deltaic districts, the highest land lies nearest the rivers, and the lowest levels are found midway between two streams. There are in consequence considerable marshes both between the Hooghly and the Damodar and between the latter river and the Rúpnáráyan.

The first regular census of the district (1872) showed a population of 1,488,556 persons, of whom 722,856 were males and 765,700 females. Of these 813 were Non-Asiatics, the great majority of them Europeans, and 557 were of mixed races (Eurasians). The Hindus numbered 1,186,435; Mahometans, 299,025; and the Christian community, 2583. Seven municipalities contain a population of over 5000 each, viz., Howrah, 97,784; Hooghly and Chinsurah given as one town, 34,761; Serampur, 24,448; Baidyabati, 13,332; Bansbáriá, 7861; Bhadreswar, 7417; and Kotrang, 6811. HOWRAH (*q.v.*) is the largest and most important town in the district. Amongst other places of interest are—Tribeni, a place of great sanctity, and the scene of many religious gatherings; Panduah, now a small village, but in ancient times the fortified seat of a Hindu rájá; Tarakeswar, a village containing a large and richly endowed shrine of great holiness, visited at all times of the year by crowds of pilgrims. The total revenue in 1870–71 was £239,452, and the expenditure £84,989. In 1870 there were 16 magisterial and 35 civil and revenue courts, with 8 covenanted English officers. The regular police force of Hooghly and Howrah consisted (1871) of 1140 men, maintained at a cost of £20,726. There was also in 1870 a municipal force (exclusive of Howrah) of 583 men, costing £4475, and a rural police of 7068 men, costing £17,856. The number of Government-aided schools in

1877–78 was 625, attended by 22,666 pupils. The principal educational institution in the district is the Hooghly College, attended in 1872 by 3142 students, on which the expenditure was £5143.

Rice forms the staple crop of the district, occupying about thirteen-sixteenths of the cultivated area; the other cereals are barley, wheat, and Indian corn. The other crops consist of pease, pulses, oil-seeds, vegetables, jute, hemp, cotton, sugar-cane, indigo, mulberry, tobacco, and *pán*. Blights occasionally visit Hooghly and Howrah, but they have not affected any crop throughout the entire district. An exceptional case was that of the "Bombay sugar-cane," which was totally destroyed by blight in 1860. Droughts caused by deficiency of rainfall sometimes occur, but not to any serious extent. Floods are rare. The trade of the district is chiefly carried on by means of permanent markets. The principal exports are—fine rice, silk, indigo, jute, cotton cloth, and vegetables; the chief imports are common rice, English piece goods, lime, timber, &c. The chief manufactures are silk and cotton. In 1870 there were 400 miles of road in Hooghly district, maintained at a cost of £4000. The East Indian Railway has its principal terminus at Howrah, and runs through the district for about 45 miles; there are 10 stations in the district. There are six canals in Hooghly district used for water-carriage, of a total length of 33 miles.

The climate does not differ from that of Lower Bengal generally. The average maximum temperature is 92° F., the minimum 68° F., and the average annual rainfall about 70 inches. The diseases of the district are fever, cholera, dysentery, &c. An epidemic malarious fever has raged at intervals, and is said to have carried off more than half the population and to have almost depopulated certain villages. There are 7 hospitals and dispensaries.

From an historical point of view the district possesses as much interest as any in Bengal, or indeed in India. In the early period of the Mahometan rule Sátgáon was the seat of the governors of Lower Bengal and a mint town. It was also a place of great commercial importance. In consequence of the silting up of the Saraswatí, the river on which Sátgáon was situated, the town became inaccessible to large ships, and the Portuguese moved to Hooghly. In 1632 the latter place, having been taken from the Portuguese by the Mahometans, was made the royal port of Bengal; and all the public offices and records were withdrawn from Sátgáon, which rapidly fell into decay. In 1640 the East India Company established a factory at Hooghly. This was the first English settlement in Lower Bengal. In 1685, a dispute having taken place between the English factors and the nawáb of Bengal, the town was bombarded and burned to the ground. This was not the first time that Hooghly had been the scene of a struggle deciding the fate of a European power in India. In 1629, when held by the Portuguese, it was besieged for three months and a half by a large Mahometan force sent by the emperor Sháh Jahán. The place was carried by storm; more than 1000 Portuguese were killed, upwards of 4000 prisoners taken, and of 300 vessels only 3 escaped. But Hooghly district possesses historical interest for other European nations besides England and Portugal. The Dutch established themselves at Chinsurah in the 17th century, and held the place till 1825, when it was ceded to Great Britain in exchange for the island of Java. The Danes settled at Serampur, where they remained till 1825, when all Danish possessions in India were transferred to the East India Company. Chandarnagar became a French settlement in 1683. The English captured this town twice, but since 1816 it has remained in the possession of the French.

HOOGHLY, the administrative headquarters of the above district, is a town situated on the right or west bank of the Hooghly, 22° 54′ 44″ N. lat. and 88° 26′ 28″ E. long. Hooghly and Chinsurah form one municipality, and the two towns were treated as one in the enumeration of 1872. Population, 34,761, viz., 17,114 males and 17,647 females:—Hindus, 27,429; Mahometans, 6952; Christians, 328; "others," 52. Hooghly is a station on the East Indian Railway, 25 miles from Calcutta. The principal building is a handsome "imámbárá," constructed out of funds which had accumulated from an endowment originally left for the purpose by a wealthy Shiá gentleman, Muhammad Mohsin. The town is said to have been founded by the Portuguese in 1537, on the decay of Sátgáon, the royal port of Bengal. Upon establishing themselves they built a fort at a place called Gholghat (close to the present jail), vestiges of which are still visible in the bed of the river. This fort gradually grew into the town and port of Hooghly. (W. W. H.)

HOOGSTRATEN, SAMUEL DIRKSZ VAN, was born, it is said, in 1627 at the Hague, and died at Dort, October 19, 1678. This artist, who was first a pupil of his father, lived at the Hague and at Dort till about 1640, when on the death of Dirk Hoogstraten he changed his residence to Amsterdam and entered the school of Rembrandt. A short time afterwards he started as a master and painter of portraits, set out on a round of travels which took him (1651) to Vienna, Rome, and London, and finally retired to Dort, where he married in 1656, and held an appointment as "provost of the mint." Hoogstraten's works are scarce; but a sufficient number of them has been preserved to show that he strove to imitate different styles at different times. In a portrait dated 1645 in the Lichtenstein collection at Vienna he imitates Rembrandt; and he continues in this vein as late as 1653, when he produced that wonderful figure of a Jew looking out of a casement, which is one of the most characteristic examples of his manner in the Belvedere at Vienna. A view of the Vienna Hofburg, dated 1652, in the same gallery displays his skill as a painter of architecture, whilst in a piece at the Hague representing a Lady Reading a Letter as she crosses a Courtyard, or a Lady Consulting a Doctor, in the Van der Hoop Museum at Amsterdam, he imitates De Hooch. One of his latest works is a portrait of Mathys van den Brouck, dated 1670, in the gallery of Amsterdam. The scarcity of Hoogstraten's pictures is probably due to his versatility. Besides directing a mint, he devoted some time to literary labours, wrote a book on the theory of painting, and composed sonnets and a tragedy. We are indebted to him for some of the familiar sayings of Rembrandt. He was an etcher too, and some of his plates are still preserved. His portrait engraved by himself at the age of fifty still exists.

HOOK, THEODORE EDWARD (1788–1841), novelist, dramatist, and improvisatore, was born in London 22d September 1788. At Harrow he received but a scant education, and although he subsequently matriculated at Oxford he never actually resided at the university. Indeed he seems to have abandoned all thought of serious study about 1802, on the death of his mother, *née* Madden, a lady of singular beauty and ability. The father, James Hook, a composer of some distinction, took great delight in exhibiting the extraordinary musical and metrical gifts of the stripling, and before many months the precocious Theodore had become "the little pet lion of the green room." At the age of sixteen he scored a dramatic success with *The Soldier's Return*, a comic opera, and this he rapidly followed up with a series of over a dozen sparkling ventures, the instant popularity of which was hardly dependent on the inimitable acting of Liston and Mathews. But an overweening love of society withheld Hook from a lucrative career as a dramatic author, and for some ten of the best years of his life he gave himself up to the pleasures of the town, winning a foremost place in the world of fashion by his matchless powers of improvisation and mimicry, and startling the public by the audacity of his practical jokes. His unique gift of impromptu minstrelsy "mystified" Sheridan, astonished Coleridge, and eventually charmed the Prince Regent into a declaration that "something must be done for Hook." The prince was as good as his word, and the victim of social success was appointed accountant-general and treasurer of the Mauritius with a salary of £2000 a year. For five delightful years Hook was the life and soul of the island, but in 1817, a serious deficiency having been discovered in the treasury accounts, he was arrested and brought to England on a criminal charge. It transpired that a sum of about £12,000 had been abstracted by a deputy official, and for this amount Hook was held responsible.

During the tardy scrutiny of the audit board he lived obscurely and maintained himself by writing for magazines and newspapers. In 1820 he launched the *John Bull*, the champion of high Toryism and the virulent detractor of Queen Caroline. Witty, incisive criticism and pitiless invective secured a large circulation for the newspaper, and from this source alone Hook derived, for the first year at least, an income of £2000. In the midst of his labours, however, he was arrested for the second time on account of his debt to the state, which he made no effort to defray. Confined for eight months in a sponging-house, he issued thence the first series of his lively *Sayings and Doings* (3d series, 1828). On his liberation he continued to work with his pen indefatigably, pouring forth in the remaining twenty-three years of his life no fewer than thirty-eight volumes, besides numberless articles, squibs, and sketches. His novels are not works of enduring interest, but they are saved from mediocrity by frequent passages of racy narrative and vivid portraiture. The best are *Maxwell* (1830), *Love and Pride* (1833), the autobiographic *Gilbert Gurney* (1835), *Jack Brag* (1837), *Gurney Married* (1839), and *Peregrine Bunce* (1841). Incessant work had already begun to tell on his health, when Hook returned to his old social habits, and a prolonged attempt to combine industry and dissipation resulted in the sad confession that he was "done up in purse, in mind, and in body too at last." He died 24th August 1841. His writings in great part are of a purely ephemeral character; the less transient, touched though they be with a sparkling fancy, have long since passed out of favour; while the greatest triumphs of the improvisatore may be said to have been writ in wine. Putting aside, however, his claim to literary greatness, Hook will be remembered as one of the most brilliant, genial, and original figures of Georgian times.

See Lockhart's *Biographic Sketch* (1852), and the Rev. R. H. D. Barham's *Life and Remains* (3d ed., 1877).

HOOK, Walter Farquhar (1798–1875), son of the Rev. Dr James Hook, dean of Worcester, and nephew of the witty Theodore, was born in London, 13th March 1798. Educated at Tiverton and Winchester, he graduated at Oxford (Christ Church) in 1821, and after holding an incumbency in Coventry, 1829–37, and in Leeds, 1837–59, was nominated dean of Chichester by Lord Derby. He had received the degree of D.D. in 1837. His friendship towards the Tractarians exposed him to considerable persecution, but his simple manly character and zealous devotion to parochial work gained him the support of widely divergent classes. Throughout life he held steadily by sober high-church principles, and the earnest, elevated tone of his mind is exemplified in such sermons as "Hear the Church!" which was preached before the court in 1837, and subsequently passed through many large editions. The vigorous practical turn of his Christianity is attested by the erection in the parish of Leeds, during his incumbency, of 21 new churches, 32 parsonages, and over 60 schools, in addition to the rebuilding of the parish church at a cost of £28,000. His literary works, which are numerous, attain the limit of their design in advancing some incidental plea or in contributing to the student's resources. The principal are *An Ecclesiastical Biography, containing the Lives of Ancient Fathers and Modern Divines* (8 vols., 1845–52), *A Church Dictionary* (8th ed., 1859), *The Means of Rendering more Effectual the Education of the People* (10th ed., 1851), *The Cross of Christ* (1873), *The Church and its Ordinances* (sermons, 4 vols., 1876), and *Lives of the Archbishops of Canterbury* (12 vols., 1860–76). He died 20th October 1875. A memorial church has been erected in his honour at Leeds; it is a 13th century Gothic structure, designed by Sir G. G. Scott (cost £25,000), and was consecrated 29th January 1880.

See *Life and Letters of Dean Hook* by his son-in-law, W. R. W. Stephens (2 vols., 1878), and *Parish Sermons* (1879).

HOOKE, Robert (1635–1703), an original and ingenious experimental philosopher, was born at Freshwater, in the Isle of Wight, July 18, 1635. His father, who was minister of the parish, destined him for the church; but his constitutional ill-health precluded study, and threw him instead on the resources afforded by his precocious mechanical genius. From the workshop of Sir Peter Lely, where he was placed after his father's death in 1648, he was transferred to the house of Dr Busby, master of Westminster School; and there his education progressed with surprising rapidity both in its classical and mathematical branches. In 1653 he entered Christ Church, Oxford, as servitor; and ten years later he took his M.A. degree by special recommendation of Lord Clarendon, then chancellor of the university. After 1655 he was employed and patronized by the Hon. Robert Boyle, who turned his skill to account in the construction of his celebrated air-pump. Hooke's inventive faculty exercised itself, between 1657 and 1659, in devising thirty different methods of flying, and more profitably in regulating the movement of watches by the application of the balance spring. In 1675 a lively controversy arose between him and Huygens respecting their rival claims to this ingenious invention. The truth seems to be that the original idea belonged to Hooke, but that the coiled form of the spring, on which its practical utility depends, was due to Huygens. On the 12th of November 1662 Hooke was appointed curator of experiments to the Royal Society, and filled the office with extraordinary diligence and skill during the remainder of his life. In 1664 Sir John Cutler instituted for his benefit a mechanical lectureship of £50 a year, and in the following year he was nominated professor of geometry in Gresham College, where he subsequently resided. After the great fire of 1666 he constructed a model for the rebuilding of the city, which was highly approved, although the design of Wren was preferred. During the progress of the works, however, Hooke acted as surveyor, and accumulated in that lucrative employment a sum of several thousand pounds, discovered after his death in an old iron chest, which had evidently lain unopened for above thirty years. He fulfilled the duties of secretary to the Royal Society during five years after the death of Oldenburg in 1677, publishing in 1681–82 the papers read before that body under the title of *Philosophical Collections*. A protracted controversy with Hevelius, in which Hooke urged the advantages of telescopic over plain sights, brought him little but discredit. His reasons were good; but his offensive style of argument rendered them unpalatable and himself unpopular. Many circumstances concurred to embitter the latter years of his life. The death, in 1687, of his niece, Mrs Grace Hooke, who had lived with him for many years, caused him deep affliction; a law suit with Sir John Cutler about his salary (decided, however, in his favour in 1696) occasioned him prolonged anxiety; and the repeated anticipation of his discoveries inspired him with a morbid jealousy. Marks of public respect were not indeed wanting to him. A degree of M.D. was conferred on him at Doctors' Commons, December 7, 1691, and the Royal Society made him, in 1696, a grant to enable him to complete his philosophical inventions. While engaged on this task he died, worn out with disease and toil, March 3, 1703, and was buried in St Helen's Church, Bishopsgate Street.

In personal appearance Hooke made but a sorry show. His figure was crooked, his limbs shrunken; his hair hung in dishevelled locks over his haggard countenance. His temper was irritable, his habits penurious and solitary. He was, however, blameless in morals, and reverent in religion. His scientific performances would probably have been more striking if they had been less varied. He originated much, but perfected little. His optical investigations led him to adopt in an imperfect form the undulatory theory of light, to anticipate the doctrine of interference, and to observe, independently of though subsequently to Grimaldi, the phenomenon of diffraction. He was the first to state clearly that the motions of the heavenly bodies must be regarded as a mechanical problem, and he approached in a remarkable manner the discovery of universal gravitation. He suggested a method of meteorological forecasting and a system of telescopic signalling, anticipated Chladni's experiment of strewing a vibrating bell with flour, investigated the nature of sounds and the function of the air in respiration and combustion, and originated the idea of using the pendulum as a measure of gravity.

His principal writings are *Micrographia*, 1664; *Lectiones Cutlerianæ*, 1674-79; and *Posthumous Works*, containing a sketch of his "Philosophical Algebra," published by Waller in 1705.

HOOKER, JOSEPH (1814-1879), American general, was born in Old Hadley, Massachusetts, November 13, 1814. He was educated at the Military Academy at West Point, 1833-37, and immediately commissioned second lieutenant in the 1st Artillery. In the war with Mexico (1846-48) he served as aide-de-camp and assistant adjutant-general, and was breveted captain, major, and lieutenant-colonel, and commissioned captain, for meritorious services in the engagements at Monterey, National Bridge, and Chapultepec. He was transferred with his regiment to California in 1849. In 1853 he resigned his commission and bought a large farm near Sonoma, which he managed successfully till 1858, when he was made superintendent of military roads in Oregon. Upon the opening of hostilities in the civil war of 1861-65, he sacrificed his fine estate and offered his sword to the Federal Government. He was commissioned brigadier-general of volunteers, May 17, 1861, and major-general May 5, 1862. At Williamsburg, May 5th, he attacked a strong Confederate position, and for nine hours maintained the fight, inflicting and sustaining heavy loss, and winning the title of "Fighting Joe." He was engaged at Fair Oaks, June 1st, and at Malvern Hill, July 1st, and did signal service at Charles City Cross Roads, June 29th, when his division aided in holding a vital position on the flank of the Union Army, in its noted "change of base." In the campaign of Northern Virginia, under General Pope, August 27 to September 1, 1862, he led his division in the actions at Bristoe Station, Manassas, and Chantilly. In the Maryland campaign, September 6-17 (under General M'Clellan), he commanded the first corps, and gallantly carried the north pass of South Mount, opening the way for the advance of the army. He opened the battle of Antietam on the 14th, and on the following morning was pitted against "Stonewall" Jackson, at the noted "cornfield," where he used his artillery with terrible effect, but received a painful wound, and was borne from the field. He was commissioned brigadier-general in the United States army September 20, 1862, and in the disastrous battle of Fredericksburg, under Burnside, he commanded the centre grand division (3d and 5th corps). He commanded the army of the Potomac January 26th to June 28th, 1863, and, having by a fine strategic movement thrown his army across a turbulent stream in face of the foe, fought a severe battle at Chancellorsville, where he was seriously injured; and, his army being thrown into an unfavourable position by the unexpected giving way of his right wing, he decided to retire. He was relieved at his own request, on the 28th of June, with the thanks of Congress "for skill, energy, and endurance" in the beginning of the Gettysburg campaign. He commanded the 20th corps (11th and 12th corps consolidated) in the Atlanta campaign, winning special distinction in the night battle of Wauhatchie, and at Lookout Mountain, "the battle above the clouds." For a hundred days, and until the capture of Atlanta, the noise of battle scarcely ceased, his corps doing signal service at Mill Creek, Resaca, New Hope Church, Pine Mount, Peach Tree Creek, and the siege of Atlanta. He was commissioned brevet-major-general in the United States army, March 13, 1865, and retired from active service at his own request, October 15, 1868. The last years of his life were passed in the neighbourhood of New York. He died at Garden City, Long Island, October 31, 1879.

HOOKER, RICHARD (1553-1600), author of the *Laws of Ecclesiastical Polity*, was born at Heavitree, near the city of Exeter, about the end of 1553 or beginning of 1554. At school, not only his facility in mastering his tasks, but his intellectual inquisitiveness and his fine moral qualities, attracted the special notice of his teacher, who strongly recommended his parents to educate him for the church. Though well connected, they were, however, somewhat straitened in their worldly circumstances, and Hooker was indebted for admission to the university to his uncle, John Hooker, chamberlain of Exeter, and in his day a man of some literary repute, who, besides giving him an annual pension, induced Bishop Jewel to become his patron and to bestow on him a clerk's place in Corpus College, Oxford. To this Hooker was admitted in 1567. Bishop Jewel died in September 1571, but Dr Cole, president of the college, from the strong interest he felt in the young man, on account at once of his character and his abilities, spontaneously offered to take the bishop's place as his patron; and shortly afterwards Hooker, by his own labours as a tutor, became independent of gratuitous aid. Two of his pupils, and these his favourite ones, were Edwin Sandys, afterwards author of *Europæ Speculum*, and George Cranmer, grand-nephew of the archbishop. Hooker's reputation as a tutor soon became very high, for he had employed his five years at the university to such good purpose as not only to have acquired great proficiency in the learned languages, but to have joined to this a wide and varied culture which had delivered him from the bondage of learned pedantry; in addition to which he is said to have possessed a remarkable talent for communicating knowledge in a clear and interesting manner, and to have exercised a special influence over his pupils' intellectual and moral tendencies. In December 1573 he was elected to a foundation in his college; in July 1577 he proceeded M.A., and in September of the same year he was admitted a fellow. In 1579 he was appointed by the chancellor of the university to read the public Hebrew lecture, a duty which he continued to discharge till he left Oxford. Not long after his admission into holy orders, about 1581, he was appointed to preach at St Paul's Cross; and, according to Walton, he was so kindly entertained by Mrs Churchman, who kept the Shunamite's house where the preachers were boarded, that he permitted her to choose him a wife, "promising upon a fair summons to return to London and accept of her choice." The lady selected by her was "her daughter Joan," who, says the same authority, "found him neither beauty nor portion; and for her conditions they were too like that wife's which is by Solomon compared to a dripping house." It is probable that Walton has exaggerated the simplicity and passiveness of Hooker in the matter, but though, as Keble observes with justice, his writings betray uncommon shrewdness and quickness of observation, as well as a vein of keenest humour, it would appear that either gratitude or some other impulse had on this occasion led his judgment astray. After his marriage he was about the end of 1584 presented to the living of Drayton Beauchamp in Buckinghamshire. In the following year he received a visit from his two pupils Edwin Sandys and George Cranmer, who found him with the *Odes* of Horace in his hand, tending the sheep while the servant was at dinner, after which, when they on the return of the servant accompanied him to his house, "Richard was called to rock the cradle." Finding him so engrossed by worldly and domestic cares, "they stayed but till the next morning," and, greatly grieved at his narrow circumstances and unhappy domestic condition, "left him to the company of his wife Joan."

The visit had, however, results of the highest moment, not only in regard to the career of Hooker, but in regard to English literature and English philosophical thought. Sandys prevailed on his father, the archbishop of York, to recommend Hooker for presentation to the mastership of the Temple, and Hooker, though his "wish was rather to gain a better country living," having agreed after some hesitation to become a candidate, the patent conferring upon him the mastership was granted 17th March 1585. The rival candidate was Walter Travers, a Presbyterian and evening lecturer in the same church. Being continued in the lectureship after the appointment of Hooker, Travers was in the habit of attempting a refutation in the evening of what Hooker had spoken in the morning, Hooker again replying on the following Sunday; so it was said "the forenoon sermon spake Canterbury, the afternoon Geneva." On account of the keen feeling displayed by the partisans of both, Archbishop Whitgift deemed it prudent to prohibit the preaching of Travers, whereupon he presented a petition to the council to have the prohibition recalled. Hooker published an *Answer to the Petition of Mr Travers*, and also printed several sermons bearing on special points of the controversy; but, feeling strongly the unsatisfactory nature of such an isolated and fragmentary discussion of separate points, he resolved to compose an elaborate and exhaustive treatise, exhibiting the fundamental principles by which the question in dispute must be decided. It is probable that the work was begun in the latter half of 1586, and he had made considerable progress with it before, with a view to its completion, he petitioned Whitgift to be removed to a country parsonage, in order that, as he said, "I may keep myself in peace and privacy, and behold God's blessing spring out of my mother earth, and eat my own bread without oppositions." His desire was granted in 1591 by a presentation to the rectory of Boscombe near Salisbury. There he completed the volume containing the first four of the proposed *Eight Books of the Laws of Ecclesiastical Polity*. It was entered at Stationers' Hall, 9th March 1592, but was not published till 1593 or 1594. In July 1595 he was promoted by the crown to the rectory of Bishopsbourne near Canterbury, where he lived to see the completion of the fifth book in 1597. In the passage from London to Gravesend some time in 1600 he caught a severe cold from which he never recovered, but, notwithstanding great weakness and constant suffering, he "was solicitous in his study," his one desire being "to live to finish the three remaining books of *Polity*." His death took place about November of the same year. A volume professing to contain the sixth and eighth books of the *Polity* was published at London in 1648, but the bulk of the sixth book, as has been shown by Keble, is an entire deviation from the subject on which Hooker proposed to treat, and doubtless the genuine copy, known to have been completed, has been lost. The seventh book, which was published in a new edition of the work by Gauden in 1662, and the eighth book, may be regarded as in substance the composition of Hooker; but, as, in addition to wanting his final revision, they have been very unskilfully edited, if they have not been manipulated for theological purposes, their statements in regard to doubtful matters must be received with due reserve, and no reliance can be placed on their testimony where their meaning contradicts that of other portions of the *Polity*.

The conception of Hooker in his later years which we form from the various accessible sources is that of a person of low stature and not immediately impressive appearance, much bent by the influence of sedentary and meditative habits, of quiet and retiring manners, and discoloured in complexion and worn and marked in feature from the hard mental toil which he had expended on his great work. There seems, however, exaggeration in Walton's statement as to the meanness of his dress; and Walton certainly misreads his character when he portrays him as a kind of ascetic mystic. Though he was unworldly and simple in his desires, and engrossed in the purpose to which he had devoted his life,—the "completion of the *Polity*,"—his writings indicate that he possessed a cheerful and healthy disposition, and that he was capable of discovering enjoyment in everyday pleasures, and of appreciating human life and character in a wide variety of aspects. He seems to have had a special delight in outward nature—as he expressed it, he loved "to see God's blessing spring out of his mother earth;" and he spent much of his spare time in visiting his parishioners, his deference towards them, if excessive, being yet mingled with a grave dignity which rendered unwarrantable liberties impossible. As a preacher, though singularly devoid of the qualities which win the applause of the multitude, he always excited the interest of the more intelligent, the breadth and finely balanced wisdom of his thoughts and the fascination of his composition greatly modifying the impression produced by his weak voice and ineffective manner. Partly, doubtless, on account of his dimsightedness, he never removed his eye from his manuscript, and, according to Fuller, "he may be said to have made good music with his fiddle and stick alone, having neither pronunciation nor gesture to grace his matter."

To accede without explanation to the claim put forth for the *Ecclesiastical Polity* of Hooker, that it marks an epoch in English prose literature and English thought, would both be to do some injustice to writers previous to him, and, if not to overestimate his influence, to misinterpret its character. By no means can his excursions in English prose be regarded as chiefly those of a pioneer; and not only is his intellectual position inferior to that of Shakespeare, Spenser, and Bacon,[1] who alone can be properly reckoned as the master spirits of the age, but in reality what effect he may have had upon the thought of his contemporaries was soon disregarded and swept out of sight in the hand-to-hand struggle with Puritanism, and his influence, so far from being immediate and confined to one particular era, has since the reaction against Puritanism been slowly and imperceptibly permeating and colouring English thought down to the present time. His work is, however, the earliest in English prose with enough of the preserving salt of excellence to adapt it to the mental palate of modern readers. Attempts more elaborate than those of the old chroniclers had been made two centuries previously to employ English prose both for narrative and for discussion; and, a few years before him, Roger Ascham, Sir Thomas More, Latimer, Sir Philip Sidney, the compilers of the prayer book, and various translators of the Bible had in widely different departments of literature brought to light many samples of the rich wealth of expression that was latent in the language; but Hooker's is the first independent work in English prose of notable power and genius, and the vigour and grasp of its thought are not more remarkable than the felicity of its literary style. Its more usual and obvious excellences are clearness of expression, notwithstanding occasionally complicated methods; great aptness and conciseness in the formation of individual clauses, and such a fine sense of proportion and rhythm in their arrangement as almost conceals the difficulties of syntax by which he was hampered; finished simplicity, notwithstanding a stateliness too uniform and unbroken; a nice discrimination in the choice of words and phrases, so as both to portray the exact shade of his meaning, and to express each of his thoughts with that degree of emphasis appropriate to its place in his composition. In regard to qualities more relating to the matter than the manner we may note the subtle and partly hidden humour; the strong enthusiasm underlying that seemingly calm and passionless exposition of principles

[1] If Bacon was the author of *The Christian Paradoxes*, his philosophical standpoint in reference to religion was not only less advanced than that of Hooker, but in a sense directly opposed to it.

which continually led him away from the minutiæ of temporary disputes, and has earned for him the somewhat misleading epithet of "judicious"; the solidity of learning, not ostentatiously displayed, but indicated in the character and variety of his illustrations and his comprehensive mastery of all that relates to his subject; the breadth of his conceptions, and the sweep and ease of his movements in the highest regions of thought; the fine poetical descriptions occasionally introduced, in which his eloquence attains a grave, rich, and massive harmony that compares not unfavourably with the finest prose of Milton. His manner is, of course, defective in the flexibility and variety characteristic of the best models of English prose literature after the language had been enriched and perfected by long use, and his sentences, constructed too much according to Latin usages, are often tautological and too protracted into long concatenations of clauses; but if, when regarded superficially, his style presents in some respects a stiff and antiquated aspect, it yet possesses an original and innate charm that has retained its freshness after the lapse of nearly three centuries.

The direct interest in the *Ecclesiastical Polity* is now philosophical and political rather than theological, for what theological importance it possessed was rather in regard to the spirit and method in which theology should be discussed than in regard to the decision of strictly theological points. Hooker bases his reasoning on principles which he discovered in Augustine and Thomas Aquinas, but the intellectual atmosphere of his age was different from that which surrounded them; he was acted upon by new and more various impulses enabling him to imbibe more thoroughly the spirit of Greek thought which was the source of their inspiration, and thus to reach a higher and freer region than scholasticism, and in a sense to inaugurate modern philosophy in England. It may be admitted that his principles are only partially and in some degree capriciously wrought out,—that if he is not under the dominion of intellectual tendencies leading to opposite results there are occasional blanks and gaps in his argument where he seems sometimes to be groping after a meaning which he cannot fully grasp; but he is often charged with obscurity simply because readers of various theological schools, beholding in his principles what seem the outline and justification of their own ideas, are disappointed when they find that these outlines instead of acquiring as they narrowly examine them the full and definite form of their anticipations, widen out into a region beyond their notions and sympathies, and therefore from their point of view enveloped in mist and shade. It is the exposition of philosophical principles in the first and second books of the *Polity*, and not the application of these principles in the remaining books that gives the work its standard place in English literature. It was intended to be an answer to the attacks of the Presbyterians on the Episcopalian polity and customs, but no attempt is made directly to oust Presbyterianism from the place it then held in the Church of England. The work must rather be regarded as a remonstrance against the narrow ground chosen by the Presbyterians for their basis of attack, Hooker's exact position being that "a necessity of polity and regiment may be held in all churches without holding any form to be necessary." The general purpose of his reasoning is to vindicate Episcopacy from objections that had been urged against it, but he attains a result which has other and wider consequences than this. The fundamental principle on which he bases his reasoning is the unity and all-embracing character of law—law "whose seat," he beautifully says, "is the bosom of God, whose voice the harmony of the world." Law—as operative in nature, as regulating each man's individual character and actions, as seen in the formations of societies and governments—is equally a manifestation and development of the divine order according to which God Himself acts, is the expression in various forms of the divine reason. He makes a distinction between natural and positive laws, the one being eternal and immutable, the other varying according to external necessity and expediency; and he includes all the forms of government under laws that are positive and therefore alterable according to circumstances. Their application is to be determined by reason, reason enlightened and strengthened by every variety of knowledge, discipline, and experience. The leading feature in his system is the high place assigned to reason, for, though affirming that certain truths necessary to salvation could be made known only by special divine revelation, he yet elevates reason into the criterion by which these truths are to be judged, and the standard to determine what in revelation is temporal and what eternal. "It is not the word of God itself," he says, "which doth or possibly can assure us that we do well to think it His word." At the same time he saves himself from the dangers of abstract and rash theorizing by a deep and absolute regard for facts, the diligent and accurate study of which he makes of the first importance to the proper use of reason. "The general and perpetual voice of men is," he says, "as the sentence of God Himself. For that which all men have at all times learned, nature herself must needs have taught; and, God being the author of nature, her voice is but His instrument." Applying his principles to man individually, the foundation of morality is, according to Hooker, immutable, and rests "on that law which God from the beginning hath set Himself to do all things by;" this law is to be discovered by reason; and the perfection which reason teaches us to strive after is stated, with characteristic breadth of conception and regard to the facts of human nature, to be "a triple perfection: first a sensual, consisting in those things which very life itself requireth, either as necessary supplements, or as beauties or ornaments thereof; then an intellectual, consisting in those things which none underneath man is either capable of or acquainted with; lastly, a spiritual or divine, consisting in those things whereunto we tend by supernatural means here, but cannot here attain unto them." Applying his principles to man as a member of a community, he assigns practically the same origin and sanctions to ecclesiastical as to civil government. His theory of government forms the basis of the *Treatise on Civil Government* by Locke, although Locke developed the theory in a way that Hooker would not have sanctioned. The force and justification of government Hooker derives from public approbation, either given directly by the parties immediately concerned, or indirectly through inheritance from their ancestors. "Sith men," he says, "naturally have no full and perfect power to command whole politic multitudes of men, therefore utterly without our consent we could in such sort be at no man's commandment living. And to be commanded we do consent, when that society whereof we are part hath at any time before consented, without revoking the same after, by the like universal agreement." His theory as he stated it is in various of its aspects and applications liable to objection; but taken as a whole it is the first philosophical statement of the principles which, though disregarded in the succeeding age, have since regulated political progress in England, and gradually modified its constitution into its present form. One of the corollaries of his principles, his theory of the relation of church and state, according to which, with the qualifications implied in his theory of government, he asserts the royal supremacy in matters of religion, and identifies the church and commonwealth as but different aspects of the same government, has not met with such general approval, but practically it is the theory of the ablest defenders of state churches at the present time.

A life of Hooker by Dr Gauden was published in his edition of Hooker's works, London, 1662. To correct the errors in this life Walton wrote another, which was published in the 2d edition of Hooker's works in 1666. The standard modern edition of Hooker's works is that by Keble, which first appeared in 1836, and has since been several times reprinted. The first book of the *Laws of Ecclesiastical Polity* has been edited for the "Clarendon Press Series," by R. W. Church, M.A. (1868). (T. F. H.)

HOOKER, Sir William Jackson (1785-1865), a distinguished English botanist, was born at Norwich, July 6, 1785. His father, Joseph Hooker of Exeter, a member of the same family as the celebrated Richard Hooker, devoted much of his time to the study of German literature and the cultivation of curious plants. The son was educated at the high school of Norwich, on leaving which his independent means enabled him to travel and to take up as a recreation the study of natural history, especially ornithology and entomology. He subsequently confined his attention to botany, on the recommendation of Sir James E. Smith, whom he had consulted respecting a rare moss picked up in a ramble. His first botanical expedition was made in Iceland, in the summer of 1809, at the suggestion of Sir Joseph Banks; but the natural history specimens which he collected, with his notes and drawings, were lost on the homeward voyage through the burning of the ship, and the young botanist himself had a narrow escape with his life. A good memory, however, aided him to publish an account of the island, and of its inhabitants and flora (*Tour in Iceland*, 1809), privately circulated in 1811, and reprinted in 1813. In 1810-11 he made extensive preparations, and sacrifices which proved financially serious, with a view to accompany Sir R. Brownrigg to Ceylon to explore that teeming though then almost unknown island; but the disturbances created by the king of Candy led to the abandonment of the projected expedition. Hooker immediately fixed his attention, however, on the formation of an herbarium which was destined to become the finest in Europe; and in 1814 he spent nine months in botanizing excursions in France, Switzerland, and Northern Italy, during which he became acquainted with many of the leading Continental botanists. The following year he married the eldest daughter of Mr Dawson Turner, F.R.S., a lady who, during forty years, shared in the labours of his study. Settling at Holes-worth, Suffolk, he continued to increase his herbarium, which became the resort and admiration of British and Continental botanists. In 1816 appeared the *British Jungermanniæ*, his first scientific work, which is even now a model of microscopic dissection and of accurate description and figuring. This was succeeded by a new edition of Curtis's *Flora Londinensis*, for which he wrote the descriptions (1817–28); by a description of the *Plantæ Cryptogamicæ* of A. de Humboldt and A. Bonpland; by the *Muscologia Britannica*, a very complete account of the mosses of Great Britain and Ireland, prepared in conjunction with Dr T. Taylor (1818); and by his *Musci Exotici*, 2 vols. (1818–20), devoted to new foreign mosses and other cryptogamic plants. In 1820 he accepted the regius professorship of botany in Glasgow university, and entered upon a new career of activity, in which he soon became popular as a lecturer, his style being both clear and ready. The following year he brought out the *Flora Scotica*, in which the natural method of arrangement of British plants was given with the artificial. During the twenty years he remained at Glasgow he prepared and took part in many works, the more important being the following:—

The *Botanical Illustrations*; *Exotic Flora*, indicating such of the specimens as are deserving cultivation, 3 vols. 1822–27; *Account of Sabine's Arctic Plants*, 1824; *Catalogue of Plants in the Glasgow Botanic Garden*, 1825; the Botany of *Parry's Third Voyage*, 1826; *The Botanical Magazine*, 1827–65, 38 vols.; *Icones Filicum*, in concert with Dr R. K. Greville, 1829–31, 2 vols.; *British Flora*, of which several editions appeared, undertaken with Dr G. A. W. Arnott, 1830, &c.; *British Flora Cryptogamia* (Fungi), 1833; *Characters of Genera from the British Flora*, 1830; *Flora Boreali-Americana*, 1840, 2 vols., being the botany of British North America collected in Sir J. Franklin's voyage; *The Journal of Botany*, 1830–42, 4 vols.; *Companion to the Botanical Magazine*, 1835–36, 2 vols.; *Icones Plantarum*, 1837–54, 10 vols.; the *Botany of Beechey's Voyage to the Pacific and Behring's Straits* (with Dr Arnott, 1841); the *Genera Filicum*, 1842, from the original coloured drawings of F. Bauer, with additions and descriptive letterpress; *The London Journal of Botany*, 1842–48, 7 vols.; *Notes on the Botany of the Antarctic Voyage of the Erebus and Terror*, 1843; *Species Filicum*, 1846–64, 5 vols., the standard work on this subject; *A Century of Orchideæ*, 1846; *Journal of Botany and Kew Garden Miscellany*, 1849–57, 9 vols. In 1849 he edited the *Niger Flora* of Vogel, and the *Rhododendrons of Sikkim*, *Victoria Regia*, 1851; *Museum of Economic Botany at Kew*, 1855; *Filices Exotici*, 1857–59; *The British Ferns*, 1861–62; *A Century of Ferns*, 1854; *A Second Century of Ferns*, 1860–61. The estimation in which he held his patron the duke of Bedford is shown in the *Letter* on his grace's death printed in 1840, calling attention to the services rendered by him to botany and horticulture.

It was mainly by Hooker's exertions that botanists were appointed to the Government expeditions. While his works were in progress his herbarium received large and valuable additions from all parts of the globe, and his position as a botanist was thus vastly improved. He received the honour of knighthood from William IV. in 1836 in consideration of his meritorious researches in scientific botany; and a few years later, in 1841, he was appointed director of the Royal Botanical Gardens of Kew, on the resignation of Mr Aiton. The attainment of this post had long been the object of his life. The gardens flourished under his administration; the Government had confidence in him; and his numerous friends and correspondents took pride in contributing to the scientific needs of his herbarium. From small beginnings the gardens expanded under his direction to 75 acres, with an arboretum of 270 acres; and three museums, enriched with many thousand examples of vegetable products, have been added, forming together, with the magnificent palm-house and conservatories, the most delightful and beautiful resort that the inhabitants of London possess; while his extensive library of reference and admirably arranged herbarium, the greater part of which was presented by Sir William to the country, form a constant attraction to the botanist. He was engaged on the *Synopsis Filicum* with J. G. Baker when an epidemic at Kew brought his valuable life to a close. He died August 12, 1865, in the eighty-first year of his age.

HOOLE, John (1727–1803), translator and dramatist, was born at Moorfields, London, in December 1727. At the age of seventeen he became a clerk in the accountants' department of the East India House. His leisure hours he devoted to the study of Latin and especially Italian, after obtaining a mastery of which he commenced writing translations of the chief works of the Italian poets. He published the *Jerusalem Delivered* of Tasso in 1763, the *Orlando Furioso* of Ariosto in 1773–1783, the *Dramas* of Metastasio in 1767, and *Rinaldo*, an early work of Tasso, in 1792. He also wrote the following dramas—*Cyrus* (1768), *Timanthes* (1770), and *Cleonia* (1775), none of which achieved success. The verses of Hoole have been praised by Johnson, with whom he was on terms of intimacy, but, though correct, smooth, and flowing, they cannot be commended for any other merit; and the noble poetry of Italy, transmuted through the crucible of his translations, becomes spiritless and commonplace. In 1773 he was promoted to be auditor of Indian accounts, which office he resigned in 1783, and in 1786 he retired to Abinger near Dorking, Surrey, where he died 2d April 1803.

See *Anecdotes of the Life of John Hoole*, by the Rev. Samuel Hoole, London, 1803.

HOOPER, John (*c.* 1495–1555), bishop and martyr, was a native of Somersetshire, and was born about 1495. He was educated at Merton College, Oxford, and after taking his degree of bachelor of arts in 1518 joined the order of Cistercian monks at Gloucester. Subsequently, "while living too much of a court life in the palace of the king," his attention was directed to the writings of Zwingli, and the result of his perusing them was that after a diligent study of the Scriptures he became a zealous advocate of the principles of the Reformation. For a short time he was chaplain to Sir Thomas Arundel, but, being warned of the danger to which his opinions exposed him, he in 1539 made his escape to France. Returning to England shortly afterwards, he found that plots were again being laid for his life, and escaped to Ireland disguised as a sailor. From Ireland he again went to France, passing thence to Germany, where he married, probably in 1546. After his marriage he settled in Zurich till March 1549, when he set out for England. Immediately on arriving in London he began to apply himself to the work of instructing the masses, and so successful were his labours that the churches in which he lectured were crowded by eager audiences, and that the king specially requested him to remain in London to further the progress of the Reformation. In 1550 he was presented to the bishopric of Gloucester; but, refusing it on account of objections to the oath and vestments, he was summoned before the council, and ultimately was imprisoned for some time in the Fleet, till he intimated that his scruples had been removed. The duties of his episcopate he discharged with a diligence, zeal, and self-sacrifice that have been rarely equalled. He preached three or four times a day in the towns and villages of his diocese, and so regardless was he of fatigue that his wife wrote Bullinger to "recommend Master Hooper to be more moderate in his labour," lest his "overabundant exertions should cause a premature decay;" he made minute inquiry into the knowledge, doctrine, conduct, and worldly condition of his clergy, whose impoverished livings he petitioned the council to be allowed to augment out of his own income; and he supplied a free dinner in his hall to the poor of the city daily, sitting down and sharing it with them. In 1552 he was created bishop of Worcester *in commendam*. On the accession of Mary in the following year he was immediately arrested and sent to the Fleet, and after suffering eighteen months' imprisonment he was on January 29, 1555, tried for heresy and condemned to death. The sentence was carried out on February 9th, the martyr enduring the agonies of the stake, which on account of the accidental use of green wood were unusually protracted, with great fortitude. Hooper's opinions were more decidedly anti-Romish than those of Cranmer or Ridley, and very nearly identical with those afterwards promulgated by the Puritans. He was the author of various sermons and controversial treatises.

His *Early Writings*, edited for the Parker Society by the Rev. Samuel Carr, appeared in 1843, and his *Later Writings*, edited for the same society by the Rev. Charles Nevinson, M.A., in 1852. A new edition of his works was published at Oxford in 1855.

HOOPING-COUGH, or Whooping-Cough (syn. *Pertussis*, Chin-Cough), an infectious disease of the respiratory mucous membrane, manifesting itself by frequently recurring paroxysms of convulsive coughing accompanied with peculiar sonorous inspirations. It occurs for the most part among children, and only once in a lifetime.

The specific cause of hooping-cough is unknown, but the view which ascribes it to some atmospheric condition appears to derive support from the frequency of this disease as an epidemic; whether, however, that be the presence of a peculiar form of germ, as is held by some, remains as yet undetermined. Although specially a disease of childhood, hooping-cough is by no means limited to that period, but may occur at any time of life, even to old age, should there have been no previous attack. It is most common between the ages of one and four, and is rare after ten. Dr Edward Smith's statistics showed that it was the most fatal of all diseases of children under one year, that 68 per cent. of the deaths from hooping-cough occurred under the age of two, and that only 6 per cent. of the deaths were recorded after five years. It has been occasionally observed in newly-born infants. It is more common in female than in male children. Hooping-cough is highly contagious during any stage of its progress, but apparently more so in its commencement. It is not only communicated by the breath, but may, as has been clearly proved, be conveyed by the medium of clothing and by persons who have been in contact with those affected. It is said to be favoured by cold and damp weather, and to prevail mostly in spring and autumn, doubtless owing to these seasons increasing the predisposition to affections of the respiratory passages. Epidemics of hooping-cough have often been noticed to succeed or even to accompany those of measles or scarlet fever, although no causal connexion between these diseases can be admitted.

With respect to the symptoms of hooping-cough, three stages of the disease are recognized, viz., (1) the catarrhal stage, (2) the spasmodic stage, (3) the stage of decline.

The *first stage* is characterized by the ordinary phenomena of a catarrh, with sneezing, watering of the eyes, irritation of the throat, feverishness and cough, but in general there is nothing in the symptoms to indicate that they are to develop into hooping-cough. The catarrhal stage usually lasts from ten to fourteen days. The *second stage* is marked by the abatement of the catarrhal symptoms, but at the same time by increase in the cough, which now occurs in irregular paroxysms both by day and by night. Each paroxysm consists in a series of violent and rapid expiratory coughs, succeeded by a loud sonorous or crowing inspiration—the "whoop." During the coughing efforts the air is driven with great force out of the lungs, and as none can enter the chest the symptoms of impending asphyxia appear. The patient grows deep-red or livid in the face, the eyes appear as if they would burst from their sockets, and suffocation seems imminent till relief is brought by the "whoop"—the louder and more vigorous the better. Occasionally blood bursts from the nose, mouth, and ears, or is extravasated into the conjunctiva of the eyes. A single fit rarely lasts beyond from half to three-quarters of a minute, but after the "whoop" another recurs, and of these a number may come and go for several minutes. The paroxysm ends by the coughing or vomiting up of a viscid tenacious secretion, and usually after this the patient seems comparatively well, or, it may be, somewhat wearied and fretful. The frequency of the paroxysms varies according to the severity of the case, being in some instances only to the extent of one or two in the whole day, while in others there may be several in the course of a single hour. Slight causes serve to bring on the fits of coughing, such as the acts of swallowing, talking, laughing, crying, &c., or they may occur without any apparent exciting cause. In general children come to recognize an impending attack by a feeling of tickling in the throat, and they cling with dread to their mothers or nurses, or take hold of some object near them for support during the paroxysm; but although exhausted by the severe fit of coughing they soon resume their play, apparently little the worse. The attacks are on the whole most severe at night. This stage of the disease usually continues for thirty to fifty days, but it may be shorter or longer. It is during this time that complications are apt to arise which may become a source of danger greater even than the malady itself. The chief of these are inflammatory affections of the bronchi and lungs, and convulsions, any of which may prove fatal. When, however, the disease progresses favourably, as it usually does, the *third* or *terminal stage* is announced by the less frequent paroxysms of the cough, which generally loses in great measure its "whooping" character. The patient's condition altogether undergoes amendment, and the symptoms disappear in from one to three weeks. It is to be observed, however, that for a long period afterwards in any simple catarrh from which the patient suffers the cough often assumes a spasmodic character, which may suggest the erroneous notion that a relapse of the hooping-cough has occurred.

In severe cases it occasionally happens that the disease leaves behind it such structural changes in the lungs (emphysema, &c.), as entail permanent shortness of breathing or a liability to attacks of asthma. Further, hooping-cough is well known to be one of those diseases of early life which are apt to give rise to a weakened and vulnerable state of the general health, or to call into activity any inherited morbid tendency, such as that towards consumption.

As regards the treatment of hooping-cough in mild cases, little is necessary beyond keeping the patient warm and carefully attending to the general health. The remedies applicable in the case of catarrh or the milder forms of bronchitis are of service here, while gentle counter-irritation to the chest by stimulating liniments may be employed all through the attack. In mild weather the patient may be in the open air. In the more severe forms efforts have to be employed to modify the severity of the paroxysms. Numerous remedies are recommended, the chief of which are the bromides of ammonium or potassium, hydrocyanic acid, chloral, chloric ether, &c. These can only be safely administered under medical advice, and with due regard to the symptoms in individual cases. During convalescence, where the cough still continues to be troublesome, a change of air will often effect its removal. (J. O. A.)

HOOPOE (French *Huppe*, Latin *Upupa*, Greek ἔποψ—all names bestowed apparently from its cry), a bird long celebrated in literature, and conspicuous by its variegated plumage and its large erectile crest,[1] the *Upupa epops* of naturalists, which is the type of the very peculiar Family *Upupidæ*, placed by Prof. Huxley in his group *Coccygomorphæ*,

[1] Hence the secondary meaning of the French word *huppe*—a crest or tuft (*cf.* Littré, *Dict. Française*, i. 2067).

but considered by Dr Murie (*Ibis*, 1873, p. 208) to deserve separate rank as *Epopomorphæ*. This species has an exceedingly wide range in the Old World, being a regular summer-visitant to the whole of Europe, in some parts of which it is abundant, as well as to Siberia, mostly retiring southwards in autumn to winter in equatorial Africa and India, though it would seem to be resident throughout the year in North-Eastern Africa and in China. Its power of wing ordinarily seems to be feeble; but it is capable of very extended flight, as is testified by its wandering habits (for it occasionally makes its appearance in places very far removed from its usual haunts), and also by the fact that when pursued by a Falcon it will rapidly mount to an extreme height and frequently effect its escape from the enemy. About the size of a Thrush, with a long, pointed, and slightly arched bill, its head and neck are of a golden-buff—the former adorned by the crest already mentioned, which begins to rise from the forehead and consists of broad feathers, gradually increasing in length, tipped with black, and having a subterminal bar of yellowish-white. The upper part of the back is of a vinous-grey, and the scapulars

Hoopoe.

and flight-feathers are black, broadly barred with white tinged in the former with buff. The tail is black with a white chevron, marking off about the distal third part of its length. The legs and feet are as well adapted for running or walking as for perching, and the scutellations are continued round the whole of the tarsi. Chiefly on account of this character, which is also possessed by the Larks, Sundevall (*Tentamen*, pp. 53–55) united the *Upupidæ* and *Alaudidæ* in the same "cohors" *Holaspideæ*. Comparative anatomy, however, forbids its being taken to signify any real affinity between these groups, and the resemblance on this point, which is by no means so striking as that displayed by the form of the bill and the coloration in certain Larks (of the genus *Certhilauda*, for instance), must be ascribed to analogy merely, though at present no explanation of the why and the wherefore can be offered.

Pleasing as is the appearance of the Hoopoe as it fearlessly parades its showy plumage, its habits are much the reverse. All observers agree in stating that it delights to find its food among filth of the most abominable description, and this especially in its winter-quarters. But where it breeds, its nest, usually in the hole of a tree or of a wall, is not only partly composed of the foulest material, but its condition becomes worse as incubation proceeds, for the hen scarcely ever leaves her eggs, being assiduously fed by the cock as she sits; and when the young are hatched, their fæces are not removed by their parents,[1] as is the case with most birds, but are discharged in the immediate neighbourhood of the nest, the unsanitary condition of which can readily be imagined. Worms, grubs, and insects generally, form the Hoopoes' food, and upon it they get so fat in autumn that they are esteemed a delicate morsel in some of the countries of Southern Europe, and especially by the Christian population of Constantinople.[2]

Not a year passes but the Hoopoe makes its appearance in some part or other of the British Islands, most often in spring, and if unmolested would doubtless stop to breed in them, and a few instances are known in which it has done so. But its remarkable plumage always attracts attention, and it is generally shot down so soon as it is seen, and before it has time to begin a nest, which there is reason to think would not in a temperate climate become so offensive a nuisance as it is in more southern latitudes. Eight or nine so-called species of the genus have been described, but of them the existence of five only has been recognized by the writers who have most lately investigated them—Messrs Sharpe and Dresser (*Birds of Europe*, pt. vii.). Besides the *Upupa epops* above treated, these are *U. indica*, resident in India and Ceylon; *U. longirostris*, which seems to be the form of the Indo-Chinese countries; *U. marginata*, peculiar to Madagascar; and *U. africana* or *U. minor* of some writers, which inhabits South Africa to the Zambesi on the east and Benguela on the west coast. In habits and appearance they all resemble the best-known and most widely-spread species, and their particular differences cannot, for want of space, be here pointed out.[3] (A. N.)

HOORN, a town of Holland, at the head of an arrondissement in the province of North Holland, 20 miles N.N.E. of Amsterdam and 10 miles S.W. of Enkhuizen, with which it is connected by the road called De Streek, or The Stroke. The Hoornerhop, a bay of the Zuyder Zee, forms a good outer harbour, and the inner harbour is shut in by a sluice which can be opened only when the water within and without has nearly the same level. Of the massive walls by which Hoorn was formerly surrounded few indications are left except in the shape of promenades and gardens; but two of the old gateways, the East Gate and the Cow Gate, and a few towers still remain. The West Gate is gone, with its monument to the filial piety of Lambert Meliszoon, a young man who by heroic exertions managed to bring his aged mother to refuge within the town when the country around was overrun by the Spaniards in 1579. Most of the ordinary houses are old-fashioned, and interesting from the sculptures or carvings with which they are decorated; but the public buildings have little to boast of in the way of architectural excellence or peculiarity. It is enough to mention the town-house (formerly the state college), the weigh-house, the old admiralty-house or princes' court, the house of correction (formerly the admiralty magazine), the old mint, occupied as barracks, the new infirmary, the orphanage, and the old women's hospital. Of the eight churches the principal is the Groote Kerk, occupying the site of the famous 14th century edifice of the same name, which perished by fire in 1838. A communal high school, a Latin school, a medical and chemical society, and a branch of the society *Tot nut van 't Algemeen* are the main

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[1] This indeed is denied by Naumann, but by him alone; and the statement in the text is confirmed by many eye-witnesses.

[2] Under the name of *Dukipath*, in the authorized version of the Bible translated "Lapwing" (Lev. xi. 19, Deut. xiv. 18), the Hoopoe was accounted unclean by the "Jewish law." Arabs have a great reverence for the bird, imparting to it marvellous medicinal and other qualities, and making use of its head in all their charms (*cf.* Tristram, *Nat. Hist. of the Bible*, pp. 208, 209).

[3] The genera *Rhinopomastus* and *Irrisor* are generally placed in the Family *Upupidæ*, but Dr Murie (*l.c.*), after an exhaustive examination of their osteology, regards them as forming a group of equal value.

educational institutions. The extensive foreign commerce which Hoorn enjoyed in the 16th and 17th centuries has almost entirely vanished; but there is still a good trade with other parts of the Netherlands, especially in cheese and cattle. The annual export of cheese is about 23,000 tons. Saw-mills and boat-building yards are the chief industrial establishments. The population was 8780 in 1870, and 9763 in 1876. Of the 9391 inhabitants in the commune in 1870, 5112 belonged to the Dutch Reformed Church, 2954 were Roman Catholics, and 386 were Jews.

Hoorn, Latinized as Horna or Hornum, has existed at least from the first part of the 14th century, as it is mentioned in a document of the year 1311, five years earlier than the date usually assigned for its foundation. It was at Hoorn in 1416 that the first great net was made for the herring fishery, an industry which long proved an abundant source of wealth to the town. During the 15th century Hoorn shared in the troubles occasioned by the different factions; in 1518 it was molested by Groote Pier, and in 1566 and 1567 by Henry of Brederode. The Spanish forces entered the town in 1569; but in 1572 it cast in its lot with the States of the Netherlands, and four years later it assisted in defeating the duke of Alva's admiral, Count de Bossu, who remained for some time a prisoner within its walls. The riot against the burgomaster Langewagen in 1672 was a matter of purely local interest. A company of commerce and navigation was formed at Hoorn in 1720; but on the other hand, in 1795, the admiralty offices and storehouses were removed to Medemblik. The English under Abercromby took possession of the town in 1799, and in 1811 it suffered severely from the French. Among the celebrities of Hoorn are William Schouten, who discovered in 1616 the passage round Cape Horn or Hoorn, as he called it in honour of his birthplace; Abel Janszoon Tasman, whose fame is associated with Tasmania; and Jan Pieters Koen, the founder of Batavia.

HOP (German, *Hopfen*; French, *houblon*), *Humulus Lupulus*, L., the sole representative of its genus, an herbaceous twining plant, belonging to the natural order *Cannabinaceæ*, which is by some botanists included in the larger group called *Urticaceæ* by Endlicher. It is of common occurrence in hedges and thickets in the southern counties of England, but is believed not to be native in Scotland. On the Continent it is distributed from Greece to Scandinavia, and extends through the Caucasus and Central Asia to the Altai Mountains. It is common, but doubtfully indigenous, in the northern and western States of North America, and has been introduced into Brazil, Australia, and the Himalayas.

It is a diœcious perennial plant, producing annually several long twining roughish striated stems, which twist from left to right, are often 15 to 20 feet long, and climb freely over hedges and bushes. The leaves are stalked, opposite, 3–5 lobed, and coarsely serrate, and bear a general resemblance to those of the vine, but are, as well as the whole plant, rough to the touch; the upper leaves are sometimes scarcely divided, or quite entire. The stipules are interpetiolar, each consisting of two lateral ones united, or rarely with the tips free. The male inflorescence (fig. 1, A) forms a panicle; the flowers consist of a small greenish five-parted perianth (*a*) enclosing five stamens, whose anthers (*b*) open by terminal slits. The female inflorescence (fig. 1, B) is less conspicuous in the young state. The catkin or strobile consists of a number of small acute bracts, with two sessile ovaries at their base, each subtended by a rounded bractlet (*c*). Both the bracts and bractlets enlarge greatly during the development of the ovary, and form, when fully grown, the membranous scales of the strobile (fig. 2, *a*). The bracts can then only be distinguished from the bractlets by being rather more acute and more strongly veined. The perianth (fig. 1, *d*) is short, cup-shaped, undivided, and closely applied to the ovary, which it ultimately encloses. In the young strobile the two purple hairy styles (*e*) of each ovary project beyond the bracts. The ovary contains a single exalbuminous seed, containing a spirally-coiled embryo (fig. 2, *b*).

The ovary and the base of the bracts are covered with a yellowish powder, consisting of minute sessile grains (see vol. iv. p. 91, fig. 48) called lupulin or lupulinic glands (see vol. i. p. 381). These glands (fig. 2, *c*) are stated by Stoddart to be from $\frac{1}{200}$ to $\frac{1}{140}$ inch in diameter, like flattened subovate little saucers in shape, and attached to a short pedicel; by the expansion of the central portion during growth their apex ultimately becomes convex instead of concave. The upper or hemispherical portion consists of a delicate continuous membrane, and the lower part of tabular polyhedric cells. The stalk is not perceptible in the gland as found in commerce. When fresh the gland

Fig. 1.—Male (A) and Female (B) Inflorescence of the Hop.

is seen to be filled with a yellowish or dark brown liquid; this on drying contracts in bulk and forms a central mass. The contents of these glands, according to Lermer, are chiefly wax (myricylic palmitate) and resins, one of which is crystalline and unites with bases; with these the bitter acid of hops is present in small proportion. It is to these lupulinic glands that the medicinal properties of the hop are chiefly due. By careful sifting, about 1 oz. may be obtained from 1 lb of hops, but the East Kent variety is said to yield more than the Sussex hops.

In hop gardens a few male plants, usually three or four to an acre, are sometimes planted, that number being deemed sufficient to fertilize the female flowers. It is stated, however, that the female plant produces sufficient male flowers for self-fertilization (Royle). The blossoms are produced in August, and the strobiles are fit for gathering from the beginning of September to the middle of October, according to the weather.

The cultivation of hops for use in the manufacture of beer dates from an early period. In the 8th and 9th centuries hop gardens, called "humularia" or "humuleta," existed in France and Germany. In the herbarium of Apuleius (1050 A.D.), the hop ("hymele") is said to have been put in the usual drinks of England on account of its good qualities. Until the 16th century, however, hops appear to have been grown in a very fitful manner, and to a limited extent, generally only for private consumption; but after the commencement of the 17th century the cultivation increased rapidly. At the present time England produces a larger quantity than any other country in Europe. Formerly several plants were used as well as hops to season ale, hence the name "alehoof" for *Nepeta Glechoma*, and "alecost" for *Balsamita vulgaris*. The sweet gale, *Myrica Gale*, and the sage, *Salvia officinalis*, were also similarly employed. Various hop substitutes, in the form of powder, have been offered in commerce of late years, most of which appear to have quassia as a chief ingredient.

The young tender tops of the hop are in Belgium cut off in spring and eaten like asparagus, and are forced from December to February. They are not only considered a delicacy, but valuable as a diet for anæmic, scrofulous, and rachitic persons.

Fig. 2.—Fruit of Hop.

Hops are extensively cultivated in parts of New England, New York, and Michigan, and most of the hops consumed in the United States are supplied by those districts. Although the hop was introduced into America nearly 250 years ago, and its cultivation encouraged by legislative enactments in 1657, it is only about seventy-five years since its culture was commenced on an extensive scale; but from that time the progress has been rapid, and hops have been grown in nearly every State in the Union. The amount produced in the United States was estimated in 1840 at 6196 bales, in 1850 at 17,485, in 1860 at 54,960, and in 1870 at 127,283. As in England, the hop is subject to disease and blight, and in consequence the crop is variable; thus, in 1869, 69,463 bales were exported from New York and none imported, and in 1873 only 315 bales were exported and 20,885 imported. The English cluster and grape hops seem to be most generally cultivated in New York and Wisconsin. Hops are also grown largely in Belgium, Prussia, France, Würtemberg, and central Germany. In 1879 only 7153 cwts. of hops were exported from England chiefly to Australia and other British possessions, while 262,765 cwts. were imported, of which 108,306 cwts. were derived from the United States, 63,485 cwts. from Belgium, 50,567 from Germany, 26,796 from Holland, and smaller quantities from France and British North America. The first packages of hops collected in England often fetch an extravagant price, and are sometimes disposed of with remarkable celerity. The first pocket of hops gathered in 1879 is said to have been picked, dried, sent to London, sold by auction, subjected to hydraulic pressure, packed and banded with iron, covered with three coats of paint, and despatched to an Indian mail steamer—all within twenty-four hours. The better qualities are usually packed in fine and the inferior in coarse sacking. In Germany two varieties of the hop are distinguished, the August and the autumn hop, the former being preferred.

The stem of the hop abounds in fibre similar to that of hemp and flax, and has been used in Sweden in the production of a strong durable white cloth. Hitherto it has been usual to steep the stem in water during the whole winter in order to separate the fibre easily. A much quicker process has, however, been patented, by which the fibre can be speedily extracted. This process consists in boiling the stems first for three quarters of an hour in alkaline lye, and then, after rinsing in water, for the same time in acetic acid; the fibre is thus obtained in a state fit for bleaching. The leaves, stem, and root possess also an astringent property, and their use for tanning purposes was hence at one time patented in England. The leaves have also been recommended as fodder in the fresh state, mixed with other materials, and are said to increase the quantity and improve the quality of milk yielded by cows. The stems or "bine" are usually burned in the hop garden. The spent hops from breweries form excellent manure for light soils, and together with the leaves should be returned to the hop-gardens, the materials absorbed from the ground by the hop plant being thus in some measure restored to it.

By distillation with water, hops yield 0·9 per cent. of a volatile oil, of a greenish colour if from fresh, but reddish-brown if from old hops. Exposed to the air it resinifies. This oil, according to Personne, contains *valerol*, $C_6H_{10}O$, which soon passes into valerianic acid, 0·1 to 0·17 of this acid having been found by Méhu in the lupulinic glands. The unpleasant odour of old hops is due to this change, which may be prevented or retarded by exposure to the action of sulphurous acid gas. For medicinal use fresh hops which have neither undergone this change nor been treated with sulphurous acid should be used. For brewing purposes, according to Liebig, the use of sulphured hops is not objectionable. The bitter acid principle, $C_{32}H_{50}O_7$, to which hops probably owe their tonic properties, although noticed by Payen, was first obtained in the pure state by Lermer in 1863. It crystallizes in large rhombic prisms, and is soluble in ether. It has been variously called lupulin, lupuline, lupulite, and humulin. Griessmayer (1874) has shown that hops contain also in small proportion a liquid volatile alkaloid, not yet analysed, which has the odour of conia; to this alkaloid its narcotic property is perhaps due. The same chemist found trimethylamine in hops. Etti (1876–78) has found in the scales of the hop strobiles an astringent principle, *humulotannic acid*, $C_{50}H_{48}O_{26}$, which is incapable of precipitating gelatin, but which, when boiled in alcohol or water or heated to 130° C., changes to a red substance, *phlobaphen*, $C_{50}H_{46}O_{25}$, whose solution in alcohol possesses that property. Etti likewise obtained a crystalline white and an amorphous brown resin,[1] also malate,

[1] Issleib (*Archiv der Pharmacie*, May 1880) has further elucidated the chemical relationship of the constituents of the resin, essential oil, and bitter principle.

citrate, nitrate, phosphate, and sulphate of potassium, and pectic acid.

The use of hops in medicine dates from a very early period. Coles, in his *History of Plants* (1657), says—"They are good to cleanse the kidneys of gravel and provoke urine; they likewise open obstructions of the liver and spleen, and cleanse the blood and loosen the belly; and as they cleanse the blood, so consequently they help to cure eruptions of the skin." Brooke's *Dispensatory* (1753) recommends them also as an alterative, and as a remedy for hypochondriasis. Hops are, however, but little used in medicine at the present day, although official in the British and United States Pharmacopœias. According to Bartholow hops increase the action of the heart, excite the cutaneous circulation, and cause diaphoresis. A slight cerebral excitement is first produced, soon followed by a disposition to sleep. Hops also possess some anaphrodisiac properties. The preparations used are the tincture, infusion, and extract, the oleoresin, and the lupulinic glands. The drug is generally employed either as a stomachic in dyspepsia, or to allay nervous irritability or cerebral excitement in delirium tremens, where the use of opium is inadmissible. A combination of the tinctures of lupulin and capsicum is said to be one of the best substitutes for alcoholic stimulants when their habitual use is to be discontinued. A pillow stuffed with hops forms a well-known domestic remedy for sleeplessness, and a bag of hops dipped in hot water is often used as an external application to relieve pain or inflammation, especially of the abdominal organs.

See Flückiger and Hanbury, *Pharmacographia*, 2d ed., p. 551; Bentley and Trimen, *Med. Plants*, No. 230; Griessmayer, *Amer. Journ. Pharm.*, Aug. 1876, p. 360; Etti, in Dingler's *Polyt. Journ.* ccxxvii. p. 491; ccxxviii. pp. 354, 357; Bartholow, *Mat. Med.*, p. 362; Watson, *Rural Encyclopædia*, ii. pp. 686-699; Darwin, *Climbing Plants*, p. 2; Scot, *Perfite Platforme of a Hoppe Garden*, 1576; Freake, *Humulus Lupulus in Gout*, 1806; *La Belgique Horticole*, 1851, t. i. 311; Perin, *Culture du Houblon*, Strasburg, 1874; and for details as to the cultivation and varieties and the picking and preparation of hops, and their employment in the making of beer, see AGRICULTURE, vol. i. p. 381, and BREWING, vol. iv. pp. 272-273. (E. M. H.)

HOPE, THOMAS (*c.* 1770–1831), the author of *Anastasius*, born at London about 1770, was descended from a branch of an old Scotch family who for several generations were extensive merchants in London and Amsterdam. About the age of eighteen he started on a tour through various parts of Europe, Asia, and Africa, where he interested himself especially in architecture and sculpture, making a large collection of the principal objects which attracted his attention. On his return to London he purchased a house in Duchess Street, which he fitted up in a very ornamental and elaborate style, from drawings made by himself. In 1805 he published sketches of his furniture, accompanied by letterpress, in a folio volume, entitled *Household Furniture and Decoration*, which had considerable influence in effecting a change in the upholstery and interior decoration of houses. In 1809 he published the *Costumes of the Ancients*, and in 1812 *Designs of Modern Costumes*, works which display a large amount of special antiquarian research. He was also a munificent patron of the highest forms of art, and both at his London house and his country seat at Deepdene near Dorking he formed large collections of paintings, sculpture, and antiques. Thorwaldsen, the Danish sculptor, was indebted to him for the early recognition of his talents, and he also gave frequent employment to Chantrey and Flaxman. In 1819 he published anonymously his novel *Anastasius, or Memoirs of a Modern Greek, written at the close of the 18th century*, a work which, chiefly on account of the novel character of its subject, caused a great sensation. It was generally attributed to Lord Byron, but, though remarkable for the acquaintance it displays with Eastern life, and distinguished by considerable imaginative vigour and much graphic and picturesque description, its paradoxes are not so striking as those in which Lord Byron indulged; and, notwithstanding some eloquent and forcible passages, the only reason which warranted its ascription to him was the general type of character to which its hero belonged. Hope died February 3, 1831. He was the author of two works published posthumously,—the *Origin and Prospects of Man*, 1831, in which he indulged in speculations diverging widely from the usual orthodox opinions, and an *Historical Essay on Architecture*, 1835, an elaborate description of the architecture of the Middle Ages, illustrated by drawings made by himself in Italy and Germany.

HÔPITAL. See L'HÔPITAL.

HOPKINS, EZEKIEL (1633–1690), bishop of Londonderry, and a Calvinistic divine of some repute, was born at Stanford, Devon (where his father was curate), in 1633, was educated at Magdalen College, Oxford, where he identified himself with the Presbyterian party, and about 1660 became assistant to Dr W. Spurstow of Hackney, the W.S. [UU.S.] of "Smectymnuus." He was subsequently presented to the living of St Mary Woolnoth, London, which at the outbreak of the plague he exchanged for that of St Mary's, Exeter. Having married a daughter of Lord Robartes, who in 1669 became lord-lieutenant of Ireland, he was soon afterwards promoted to the deanery of Raphoe, and in 1671 he was raised to the bishopric of that diocese. Translated to the see of Londonderry in 1681, he continued to discharge his episcopal functions until the period of the famous siege, when, after having vainly sought to inculcate the doctrine of passive resistance, he withdrew to London, where in 1689 he accepted the living of St Mary Aldermanbury. He died in June 1690.

His works, consisting chiefly of discourses, but including *A practical Exposition of the Lord's Prayer* and *An Exposition of the Ten Commandments*, were first published in a complete and uniform edition in 1701; they were reprinted in 4 vols. in 1809, with a *Life* prefixed, by Pratt, and again, in 2 vols., in 1841-44. Though marked by "strength of thought, originality of illustration, and felicity of style," they are now but seldom read.

HOPKINS, SAMUEL (1721–1803), the theologian from whom the Hopkinsians or Hopkinsian Calvinists take their name, was born at Waterbury, Connecticut, on September 17, 1721. About his fifteenth year he entered Yale College, where he graduated in 1741; he afterwards studied divinity at Northampton with Jonathan Edwards; and in 1743 he was ordained pastor of the church at Housatonnuc (now Great Barrington), Massachusetts. There in the midst of a small settlement of only thirty families he laboured for six and twenty years, preaching, studying, and writing, until in 1769 he was dismissed from his office on the alleged ground of want of funds for his support. He next began to preach in Newport, Rhode Island, where, in 1770, he was settled as pastor of a small congregation, and where, with an interval from 1776 to 1780, caused by the occupation of the British, he continued to labour until about the close of the century. In 1799 he had an attack of paralysis, from which he never wholly recovered; but he continued to preach occasionally, and with unimpaired mental vigour, almost until his death, which occurred on December 20, 1803.

While in vigour of intellect and in strength and purity of moral tone hardly inferior to Jonathan Edwards, Hopkins considerably excelled his master in force and energy of character. To him belongs the honour of having been one of the first to stir up and organize political action against slavery; and to his persistent though bitterly opposed efforts are chiefly to be attributed the law of 1774, which forbade the importation of negroes into New England, as also that of 1784, which declared that all children of slaves born after the following March should be free. He was the author of numerous pamphlets, addresses, and sermons; and he also published lives of Jonathan Edwards, Susannah Anthony, and Mrs Osborn. But his distinctive theological tenets are chiefly to be sought in his important work, the *System of Theology*, which, published in 1791, has had an influence hardly inferior to that exercised by the writings of Edwards himself. They may be summed up as follows:—(1) God is the efficient cause of all the volitions of the human heart, whether these be good or evil; (2) the guilt of Adam's first sin lies upon Adam alone; moral corruption consists exclusively in the opposition offered by the human heart to the doing of that which it is really and fully capable of doing; (3) all virtue or true holiness consists in disinterested benevolence; (4) all sin consists in selfishness; (5) reconciliation and redemption are fundamentally distinct; the former opens the gate of mercy, the latter applies to individuals Christ's saving benefits; (6) effectual calling consists in a willingness to allow himself to be saved, produced in the heart of the sinner by God; (7) although the righteousness of Christ is the sole ground of the sinner's justification, yet is that righteousness not imputed; (8) repentance is prior in point of time to the exercise of faith in Christ.

The works of Hopkins, first published in two volumes at Boston in 1791, appeared in a 2d edition in 1811. The latest and best edition is that of 1852, in three volumes, also published at Boston; to it there is prefixed a biographical sketch by Professor Park of Andover.

HOPKINSON, Francis (1737–1791), an American author, and one of the signers of the Declaration of Independence, was born at Philadelphia in 1737. He studied at the college of Philadelphia, and after graduating in 1763, resolved to prepare himself for the legal profession. After being admitted to the bar in 1765, he spent two years in England, and on his return in 1768 he obtained a lucrative public appointment in New Jersey. In 1776–77 he represented that State in Congress. In 1779 he was appointed judge of admiralty for Pennsylvania, and in 1790 district judge for the same state. He died at Philadelphia 9th May 1791. Hopkinson was the author of several songs to which he wrote popular airs, and of various political poems, pamphlets, and *jeux d'esprit*, which from their humorous satire had a wide circulation, and powerfully assisted in arousing and fostering the spirit of political independence that issued in the American Revolution.

His principal writings are *The Pretty Story*, 1774; *The Prophecy*, 1776; *The Political Catechism*, 1777. Among his songs may be mentioned *The Treaty*, *The Battle of the Kegs*, and *The New Roof, a Song for Federal Mechanics*; and the best known of his satirical pieces are *Typographical Method of conducting a Quarrel*, *Essay on White Washing*, and *Modern Learning*. His *Miscellaneous Essays and Occasional Writings* were published at Philadelphia in 3 vols., 1792.

HOPPNER, John (1758–1810), English portrait-painter, was born, it is said, on April 4, 1758, at Whitechapel. His father was of German extraction, and his mother was one of the German attendants at the royal palace. Hoppner was consequently brought early under the notice and received the patronage of George III., whose regard for him gave rise to unfounded scandal. As a boy he was a chorister at the royal chapel, but showing strong inclination for art, he in 1775 entered as a student at the Royal Academy. In 1778 he took a silver medal for drawing from the life, and in 1782 the Academy's highest award, the gold medal for historical painting, his subject being King Lear. He first exhibited at the Royal Academy in 1780. His earliest love was for landscape, but necessity obliged him to turn to the more lucrative business of portrait-painting. At once successful, he had, throughout life, the most fashionable and wealthy sitters, and was the greatest rival of the growing attraction of Lawrence. Ideal subjects were very rarely attempted by Hoppner, though a Sleeping Venus, Belisarius, Jupiter and Io, a Bacchante, and Cupid and Psyche are mentioned among his works. The prince of Wales especially patronized him, and many of his finest portraits are in the state apartments at St James's Palace, the best perhaps being those of the prince, of the duke and duchess of York, of Lord Rodney, and of Lord Nelson. Among his other sitters we may mention Sir Walter Scott, Wellington, Frere, and Sir George Beaumont. Competent judges have deemed his most successful works to be his portraits of women and children. A *Series of Portraits of Ladies* was published by him in 1803, and a volume of translations of Eastern tales into English verse in 1805. The verse is of but mediocre quality. In his later years Hoppner suffered from a chronic disease of the liver; he died January 23, 1810. He was confessedly an imitator of Reynolds. When first painted, his works were much admired for the brilliancy and harmony of their colouring, but they have been much injured by lapse of time. His drawing is faulty, but his touch has qualities of breadth and freedom that give to his paintings a faint reflexion of the charm of Reynolds. Hoppner was a man of great social power, and had the knowledge and accomplishments of a man of the world.

HOR, Mount (הֹר הָהָר, Ὢρ τὸ ὄρος), a lofty and conspicuous double-topped mountain in Arabia Petræa, forming part of the great Jurassic chain of Shera or Seir. It stands on the eastern edge of the great valley of the Arabah, which extends from the head of the Gulf of Akabah to the valley of the Jordan, and it is referred to in Scripture as "on the border" or "at the edge" of the land of Edom (Numb. xx. 23, xxxiii. 37). According to the most recent measurements, its height is 4800 feet above the level of the sea. Mount Hor was the first halting-place of the Israelites after they had turned from Kadesh on their way southwards towards Zalmonah and the Red Sea, in order to encompass the land of Edom; and it was while the host was encamped at Kadesh that Aaron ascended this mountain to die. This last event is commemorated in the modern name of the mountain, Djebel Nebi Harûn, "the hill of the prophet Aaron," whose "tomb," a small square Saracenic structure, now occupies one of the summits. Another Mount Hor (τὸ ὄρος τὸ ὄρος, LXX.) is mentioned in Scripture in the passage which (Numb. xxxiv. 7, 8) defines the northern boundary of the prospective conquests of the Israelites. It is probably to be identified with Lebanon.

HORACE (65–8 b.c.). No ancient writer has been at once so familiarly known and so generally appreciated in modern times as Quintus Horatius Flaccus. We seem to know his tastes and habits, and almost to catch the tones of his conversation, from his own works, as we know the character and manner of Dr Johnson from the pages of Boswell. His twofold function of a satiric moralist and a lyric poet give a peculiar value both to his self-portraiture and to the impressions which he has left of his age. From his *Satires*, which deal chiefly with the manners and outward lives of men, we know him in his relations to society and his ordinary moods; from his *Epistles*, which deal more with the inner life, we best understand his deepest convictions and the practical side of his philosophy; while his *Odes* have perpetuated the finest pleasure which he derived from art, nature, and the intercourse of life, have idealized some of the graver as well as the lighter aspects of his reflexion, and given an elevated expression to his sympathy with the national ideas and movement of his time.

His own writings afford much the fullest and most trustworthy materials for his biography and for the estimate of his character. But a few facts, in addition to those recorded by the poet himself, are known from the short life originally contained in the work of Suetonius, *De Viris Illustribus*.

Horace was born on the 8th of December 65 b.c., in the consulship of L. Manlius Torquatus and L. Aurelius Cotta (*Ode* iii. 21, 1; *Epode* 13, 6). His birthplace was the town of Venusia on the borders of Lucania and Apulia, whence he describes himself as "Lucanus an Apulus anceps" (*Sat.* ii. 1, 34). In his "Journey to Brundusium" (*Sat.* i. 5) he marks his recognition of the familiar shapes of the Apulian hills—

> "Incipit ex illo montes Apulia notos
> Ostentare mihi;"

and in one of his finest odes he speaks of Mount Vulturnus as the scene of an adventure of his childhood, which marked him out as a special object of divine protection and as appointed to a poetic destiny. The descriptive touches in that passage, such as "celsæ nidum Acherontiæ," show that the scenery by which he was surrounded in his early years had imprinted itself vividly on his mind. As he connects his native mountains with the dawn of his poetic inspiration, so he associates the name of the "far-sounding Aufidus," the river familiar to his early recollection, in more than one passage of his *Odes* (iii. 30, 10; iv. 9, 2) with his hopes of poetic immortality. He dwells fondly on the virtues of the people belonging to his native district, as in that picture of family happiness and innocence which he paints in the second *Epode*—

> "Quod si pudica mulier in partem juvet
> Domum atque dulces liberos,
> Sabina qualis, aut perusta solibus
> Perniciis uxor Apuli;"

and elsewhere he recalls with pride the old martial glory of the race amongst whom his first years were passed (*Ode* i. 22, 14; iii. 5, 9). Like Virgil he regards the Sabellian stock as that branch of the Italian people which had contributed most to the virtue of Rome as well as to her greatness in war. In the Ofella of the *Satires* we meet with a still surviving type of that primitive virtue. The Servius Oppidius, whose dying directions to his sons are recorded in *Sat.* ii. 3, 168, &c., seems to have been another representative of "the wisdom unborrowed from the schools," who must have been known to Horace through the tie of neighbourhood. We note also, as a trace of the influence of early impressions on his later tastes, that the name of the "Bandusian fountain," which he has made as immortal as the names of Castalia or Aganippe, seems to have been transferred by him from a spring in his native district to one on his Sabine farm, which charmed and inspired him in the meridian of his poetical power. We may thus trace some of the germs of his poetical inspiration, as well as of his moral sympathies, to the early years which he spent on the farm near Venusia. But the most important moral influence of his youth was the training and example of his father, of whose worth, affectionate solicitude, and homely wisdom Horace has given a most pleasing and life-like picture (*Sat.* i. 6, 70, &c.). He was a freedman by position; and it is supposed that he had been originally a slave of the town of Venusia, and on his emancipation had received the gentile name of Horatius from the Horatian tribe in which the inhabitants of Venusia were enrolled. After his emancipation he acquired by the occupation of "coactor" (a collector of the payments made at public auctions, or, according to another interpretation, a collector of taxes) sufficient means to enable him to buy a small farm ("macro pauper agello," *Sat.* i. 6, 71), to make sufficient provision for the future of his son (*Sat.* i. 4, 108), and to take him to Rome to give him the advantage of the best education there. To his care Horace attributes, not only the intellectual training which enabled him in later life to take his place among the best men of Rome, but also his immunity from the baser forms of moral evil (*Sat.* i. 6, 68, &c.). To his practical teaching he attributes also his tendency to moralize and to observe character (*Sat.* i. 4, 105, &c.)—the tendency which enabled him to become the most truthful painter of social life and manners which the ancient world produced. If Horace drew some of his poetical sensibility from the influences of his native district, we may believe that he derived his moral health and practical sagacity from a father who combined with the intelligence and prudence which raised him above his original position the serious spirit and respect for the morality handed down from their forefathers—

> ("mi satis est si
> Traditum ab antiquis morem servare," &c.)—

which formed the basis of the old Italian character.[1]

In one of his latest writings (*Epist.* ii. 2, 42, &c.) Horace gives a further account of his education; but we hear no more of his father, nor is there any allusion in his writings to the existence of any other member of his family or any other relative. After the ordinary grammatical and literary training at Rome, he went to Athens, the most famous school of philosophy, as Rhodes was of oratory; and he describes himself while there as "searching after truth among the groves of the Academy" as well as advancing in literary accomplishment. His pleasant residence there was interrupted by the breaking out of the civil war. Following the example of his young associates, he attached himself to the cause of Brutus, whom he seems to have accompanied to Asia, probably as a member of his staff; and he served at the battle of Philippi in the post of military tribune. He shared in the rout which followed the battle, and in an ode addressed to his old comrade Pompeius Grosphus he alludes, in imitation of a similar confession of Alcæus, to the inglorious casting away of his shield. In interpreting such passages in the works of Horace, we have always to bear in mind the irony habitual to him, and the reserve imposed on him by his subsequent relations to the chiefs of the victorious party. The enthusiasm which he had felt for the republican cause, though necessarily repressed, still betrays itself in some expressions of that ode, and in that addressed to Asinius Pollio (ii. 1, 21, &c.); and though he describes himself as

> "Imbellis et firmus parum,"

and as more fitted to treat of the light warfare of love than of the themes of actual war, yet both the martial and the patriotic feeling expressed in many of his later *Odes* enables us to understand the motives which induced him to quit the placid haunts of art and literature for the harsher experience of the campaign and battlefield.

He returned to Rome shortly after the battle, stripped of his property, which formed part of the land confiscated for the benefit of the soldiers of Octavianus and Antony. It may have been at this time that he encountered the danger of shipwreck, which he mentions among the perils from which his life had been protected by supernatural aid (*Ode* iii. 4, 28). He procured in some way the post of a clerkship in the quæstor's office, and about three years after the battle of Philippi, he was introduced by Virgil and Varius to Mæcenas. This was the turning-point of his fortunes. He owed his friendship with the greatest of literary patrons to his personal merits rather than to his poetic fame; for, though some of his shorter and less important pieces may have been known to a small circle of friends before the date of this introduction, his first published work (book i. of the *Satires*) shows that the relations of intimacy and mutual confidence which were never afterwards disturbed had been established between the statesman and poet some time before this book was given to the world. He tells us in one of his *Satires* (i. 10, 31) that his earliest ambition was to write Greek verses. In giving this direction to his ambition, he was probably influenced by his admiration of the old iambic and lyrical poets whom he has made the models of his own *Epodes* and *Odes*. A parallel to this may be found in the early Latin verse of Milton and Gray, in whom, as in Horace, the gift of expression has been brought to the highest perfection. His common sense as well as his national feeling fortunately saved him from becoming a second-rate Greek versifier in an age when poetic inspiration had passed from Greece to Italy, and the

[1] *Cf.* the line of Ennius, which Cicero compares to the voice of an oracle—

> "Moribus antiquis stat res Romana virisque."

living language of Rome was a more fitting vehicle for the new feelings and interests of men than the echoes of the old Ionian or Æolian melodies. His earliest Latin compositions were, as he tells us, written under the instigation of poverty; and they alone betray any trace of the bitterness of spirit which the defeat of his hopes and the hardships which he had to encounter on his first return to Rome may have temporarily produced on him. Some of the *Epodes*, of the nature of personal and licentious lampoons, and the second *Satire* of book i., in which there is some trace of an angry republican feeling, belong to these early compositions. But by the time the first book of *Satires* was completed and published (35 B.C.) his temper had recovered its natural serenity, and, though he had not yet attained to the height of his fortunes, his personal position was one of comfort and security, and his intimate relation with the leading men in literature and social rank was firmly established.

About a year after the publication of this first book of *Satires* Mæcenas presented him with a farm among the Sabine hills, in the valley crowned by Mount Lucretilis and watered by the stream Digentia, which joins the main valley of the Anio near the modern Vico Varo (the "Varia" mentioned in the *Epistles*), and about 8 miles above the modern Tivoli. No kind of gift could have added more to the poet's happiness or exercised a more salutary influence on his genius. It made him independent in point of fortune; it satisfied the love of nature which had been implanted in him during the early years spent on the Venusian farm; and it afforded him a welcome escape from the distractions of city life and the dangers of a Roman autumn. The lines (*Epist.* i. 16, 15, &c.)—

> "Hæ latebræ dulces, etiam, si credis, amœnæ,
> Incolumem tibi me præstant Septembribus horis"—

express with simple and sincere feeling the charm of peace and outward beauty as well as the restorative influence which this retreat in the Sabine highlands afforded him. Many passages in the *Satires*, *Odes*, and *Epistles*, which recur to the memory of every reader of his poems, express the happiness and pride with which the thought of his own valley filled him, and the interest which he took in the simple and homely ways of his country neighbours. The inspiration of the *Satires* came from the heart of Rome; the feeling of many of the *Odes* comes direct from the Sabine hills; and even the meditative spirit of the later *Epistles* tells of the leisure and peace of quiet days spent among books, or in the open air, at a distance from "the smoke, wealth, and tumult" of the great metropolis.

The second book of *Satires* was published in 29 B.C.; the *Epodes* apparently about a year earlier, though many of them are, as regards the date of their composition, to be ranked among the earliest extant writings of Horace. Horace speaks of them under the name of "iambi." In one of his *Epistles* (i. 19, 25) he rests his first claim to originality on his having introduced into Latium the metres and spirit of Archilochus—

> "Parios ego primus iambos
> Ostendi Latio, numeros animosque secutus
> Archilochi."

Yet, whatever technical claim he may have to have naturalized some special combination of metre employed by the poet of Paros, Catullus, Calvus, and Bibaculus had in the preceding generation employed the iambic metre in the spirit of Archilochus more effectively than Horace. His personal lampoons are the least successful of his works; and those of the *Epodes* which treat of other subjects in a poetical spirit are inferior in metrical effect, and in truth and freshness of feeling, both to the lighter lyrics of Catullus and to his own later and more carefully meditated *Odes*. The *Epodes* are chiefly interesting as a record of the personal feelings of Horace during the years which immediately followed his return to Rome, and as a prelude to the higher art and inspiration of the first three books of the *Odes*, which were published together about the end of 24 or the beginning of 23 B.C.[1] The composition of these *Odes* extended over several years, but all the most important among them belong to the years between the battle of Actium and 24 B.C., at which time the poet was between the age of thirty-five and forty. His lyrical poetry is thus, not, like that of Catullus, the ardent utterance of his youth, but the mature and finished workmanship of his manhood. The state of public affairs was more favourable than it had been since the outbreak of the civil war between Cæsar and Pompey for the appearance of lyrical poetry. Peace, order, and national unity had been secured by the triumph of Augustus, and the enthusiasm in favour of the new government had not yet been chilled by experience of its repressing influence. The poet's circumstances were, at the same time, most favourable for the exercise of his lyrical gift during these years. He lived partly at Rome, partly at his Sabine farm, varying his residence occasionally by visits to Tibur, Præneste, or Baiæ. His intimacy with Mæcenas was strengthened. He was no longer one among a favoured band of poets, but he had become the familiar friend of the great minister. He was treated with distinction by Augustus, and by the foremost men in Roman society. He complains occasionally that the pleasures of his youth are passing from him, but he does so in the spirit of a temperate Epicurean, who found new enjoyments in life as the zest for the old enjoyments decayed, and who considered the wisdom and meditative spirit,—"the philosophic mind that years had brought,"—an ample compensation for the extinct fires of his youth. The sobering influence of time is acknowledged by him in such lines as

> "Lenit albescens animos capillus;"

or in the still finer expression of the *Epistles* (ii. 2, 211),

> "Lenior et melior fis accedente senecta?"

About four years after the publication of the three books of *Odes*, the first book of the *Epistles* appeared, introduced, as his *Epodes*, *Satires*, and *Odes* had been, by a special address to Mæcenas. From these *Epistles*, as compared with the *Satires*, we gather that he had gradually adopted a more retired and meditative life, and had become fonder of the country and of study, and that, while owing allegiance to no school or sect of philosophy, he was framing for himself a scheme of life, was endeavouring to conform to it, and was bent on inculcating it on others. He maintained his old friendships, and continued to form new intimacies, especially with younger men engaged in public affairs or animated by literary ambition. After the death of Virgil he was recognized as pre-eminently the greatest living poet, and was accordingly called upon by Augustus to compose the sacred hymn for the celebration of the secular games in 17 B.C. About four years later he published the fourth book of *Odes*, having been called upon to do so by the emperor, in order that the victories of his stepsons Drusus and Tiberius over the Rhæti and Vindelici might be worthily celebrated. He lived about five years longer, and during these years published the second book of *Epistles*, and the *Epistle to the Pisos*, more generally known as the "*Ars Poetica*." These later *Epistles* are mainly devoted to literary criticism, with the especial object of vindicating the poetic claims of his own age over those of the age of Ennius and the other early poets of Rome. He might have been expected, as a great critic and lawgiver on literature, to have exercised a beneficial influence on the future poetry

[1] The date is determined by the poem on the death of Quintilius Varus (who died 24 B.C.), and by the reference in *Ode* i. 12 to the young Marcellus (died in autumn 23 B.C.) as still alive. *Cf.* Wickham's Introduction to the *Odes*.

of his country, and to have applied as much wisdom to the theory of his own art as to that of a right life. But his critical *Epistles* are chiefly devoted to a controversial attack on the older writers and to the exposition of the laws of dramatic poetry, on which his own powers had never been exercised, and for which either the genius or circumstances of the Romans were unsuited. The same subordination of imagination and enthusiasm to good sense and sober judgment characterizes his opinions on poetry as on morals.

He died somewhat suddenly in the November of the year 8 B.C., within a few weeks of the death of Mæcenas, thus strangely confirming the declaration made by him in one of his *Odes* (ii. 17). Though not an old man, he had reached the full maturity of his faculties, and fully accomplished the work he was fitted to do in the world. He lived longer than any of the illustrious poets immediately contemporary with him or belonging to the preceding generation; and his works show a mature character and a mellow wisdom in striking contrast to the tone of the only other great lyrical poet of Rome, "the young Catullus."

Horace is one of the few writers, ancient or modern, who have written a great deal about themselves without laying themselves open to the charge of weakness or egotism. His chief claim to literary originality is not that on which he himself rested his hopes of immortality,—that of being the first to adapt certain lyrical metres to the Latin tongue,—but rather that of being the first of those whose works have reached us who establishes a personal relation with his reader, speaks to him as a familiar friend, gives him good advice, tells him the story of his life, and shares with him his private tastes and pleasures,—and all this without any loss of self-respect, any want of modesty or breach of good manners, and in a style so lively and natural that each new generation of readers might fancy that he was addressing them personally and speaking to them on subjects of everyday modern interest. In his self-portraiture, so far from wishing to make himself out better or greater than he was, he seems to write under the influence of an ironical restraint which checks him in the utterance of his highest moral teaching and of his poetical enthusiasm. He affords us some indications of his personal appearance, as where he speaks of the "nigros angusta fronte capillos" of his youth, and describes himself after he had completed his forty-fourth December as of small stature, prematurely grey, and fond of basking in the sun (*Epist.* i. 20, 24).

In his later years his health became weaker or more uncertain, and this caused a considerable change in his habits, tastes, and places of residence. It inclined him more to a life of retirement and simplicity, and also it stimulated his tendency to self-introspection and self-culture. In his more vigorous years, when he lived much in Roman society, he claims to have acted in all his relations to others in accordance with the standard recognized among men of honour in every age, to have been charitably indulgent to the weakness of his friends, and to have been exempt from petty jealousies and the spirit of detraction. If ever he deviates from his ordinary vein of irony and quiet sense into earnest indignation, it is in denouning conduct involving treachery or malice in the relations of friends—as in the lines (*Sat.* i. 4, 81, &c.)—

> "Absentem qui rodit amicum,
> Qui non defendit alio culpante, solutos
> Qui captat risus hominum famamque dicacis,
> Fingere qui non visa potest, commissa tacere
> Qui nequit, hic niger est, hunc tu, Romane, caveto."[1]

[1] "He who maligns an absent friend's fair fame,
Who says no word for him when others blame,
Who courts a reckless laugh by random hits,
Just for the sake of ranking among wits,
Who feigns what he ne'er saw, a secret blabs,
Beware him, Roman! that man steals or stabs."
—*Conington.*

He claims to be and evidently aims at being independent of fortune, superior to luxury, exempt both from the sordid cares of avarice and the coarser forms of profligacy. At the same time he makes a frank confession of indolence and of occasional failure in the pursuit of his ideal self-mastery. He admits his irascibility, his love of pleasure, his sensitiveness to opinion, and some touch of vanity or at least of gratified ambition arising out of the favour which through all his life he had enjoyed from those much above him in social station, "Me primis urbis belli placuisse domique" (*Epist.* i. 20, 23). Yet there appears no trace of any unworthy deference in Horace's feelings to the great. Even towards Augustus he maintained his attitude of independence, by declining the office of private secretary which the emperor wished to force upon him; and he did so with such tact as neither to give offence nor to forfeit the regard of his superior. His feeling towards Mæcenas is more like that which Pope entertained to Bolingbroke than that which a client in ancient or modern times entertains towards his patron. He felt pride in his protection and in the intellectual sympathy which united him with one whose personal qualities had enabled him to play so prominent and beneficent a part in public affairs. Their friendship was slowly formed, but when once established continued unshaken through their lives. Many passages in the *Odes* and the *Epistles* show how perfect the confidence was between them, how completely Horace remained his own master, how certainly the bond that united them was one of mutual affection and esteem, not of vanity and interest.

There is indeed nothing more remarkable in Horace than the independence, or rather the self-dependence, of his character. This saved him from the danger to which his genial qualities exposed him of becoming, like Moore or Burns, the slave of society or the slave of passion. The enjoyment which he drew from his Sabine farm consisted partly in the refreshment to his spirit from the familiar beauty of the place, partly in the "otia liberrima" from the claims of business and society which it afforded him. His love poems, when compared with those of Catullus, Tibullus, and Propertius, show that he never, in his mature years at least, allowed his peace of mind to be at the mercy of any one. They are the expressions of a fine and subtle and often a humorous observation rather than of ardent feeling. There is perhaps a touch of pathos in his reference in the *Odes* to the early death of Cinara, but the epithet he applies to her in the *Epistles*,

> "Quem scis immunem Cinaræ placuisse rapaci,"

shows that the pain of thinking of her could not have been very heart-felt. Even when the *Odes* addressed to real or imaginary beauties are most genuine in feeling, they are more the artistic rekindling of extinct fires than the utterance of recent passion. In his friendships he had not the self-forgetful devotion which is the most attractive side of the character of Catullus; but he studied how to gain and keep the regard of those whose society he valued, and he repaid this regard by a fine courtesy and by a delicate appreciation of their higher gifts and qualities, whether proved in literature, or war, or affairs of state, or the ordinary dealings of men. He made life more pleasant to himself and others by restraining the propensities which give pain to others, as well as by active good offices and the expression of kindly feelings. He enjoyed the great world, and it treated him well; but he resolutely maintained his personal independence and the equipoise of his feelings and judgment. The mention of Virgil and Mæcenas elicits from him warmer expressions of affection and appreciation than that of any of the other famous men of the time; but there is no strain of exaggeration in the language which he applies even to them. If it is thought that in attributing a divine function to Augustus he has gone beyond the bounds of a sincere and temperate admiration, a comparison of the *Odes* in which this occurs with the first *Epistle* of the second book shows that he certainly recognized in the emperor a great and successful administrator on whom depended the peace, order, and prosperity of the world, and that the language which at first sight offends our modern sensibilities is to be regarded rather as the artistic expression of the prevailing national sentiment than as the tribute of an insincere adulation.

The aim of Horace's philosophy was to "be master of oneself"—

"Ille potens sui
Lætusque deget," &c.;

to retain the "mens æqua" in all circumstances—

"Quod petis hic est,
Est Ulubris, animus si te non deficit æquus;"

to use the gifts of fortune while they remained, and to be prepared to part with them with equanimity; to make the most of life, and to contemplate its inevitable end without anxiety. Self-reliance and resignation are the lessons which he constantly inculcates. His philosophy is thus a mode of practical Epicureanism combined with other elements which have more affinity with Stoicism. In his early life he professed his adherence to the former system, and several expressions in his first published work show the influences of the study of Lucretius. At the time when the first book of the *Epistles* was published he professes to assume the position of an eclectic rather than that of an adherent of either school (*Epist.* i. 1, 13–19). We note in the passage here referred to, as in other passages, that he mentions Aristippus, the chief of the Cyrenaic school which anticipated the doctrines of Epicurus, rather than Epicurus himself, as the master under whose influence he from time to time insensibly lapsed. Yet the dominant tone of his teaching is that of a refined Epicureanism, not so elevated or purely contemplative as that preached by Lucretius, but yet more within the reach of a society which, though luxurious and pleasure-loving, had not yet become thoroughly frivolous and enervated. His advice is to make the most of the present which alone is within our power—

"Quod adest memento
Componere æquus;"

to enjoy the pleasures of youth in their season, but to choose some more serious object as life goes on—

"Nec lusisse pudet, sed non incidere ludum;"

to subdue all violent emotion of fear or desire; to estimate all things calmly—"nil admirari;" to choose the mean between a high and low estate; and to find one's happiness in plain living rather than in luxurious indulgence. His social and friendly qualities, his enjoyment of refined and simple pleasures, the attitude which he assumed of a critical spectator rather than of an active participator in the various modes of human activity, were all in harmony with the practice and the teaching of Epicurus. Still there was in Horace a robuster fibre, inherited from the old Italian race, which moved him to value the dignity and nobleness of life more highly than its ease and enjoyment. This is perhaps the secret cause of that weariness and dissatisfaction with the comfortable routine of existence which occasionally betrays itself in some of his later writings. But in some of the stronger utterances of his *Odes*, where he expresses sympathy with the manlier qualities of character, whether manifested in the persons of the ancient national heroes or in the civic dress of his own day, we recognize the resistent attitude of Stoicism rather than the passive acquiescence of Epicureanism. The concluding stanzas of the address to Lollius (*Ode* iv. 9) exhibit the Epicurean and Stoical view of life so combined as to be more worthy of human dignity than the genial worldly wisdom of the former school, more in harmony with human experience than the formal precepts of the latter:—

"Non possidentem multa vocaveris
Recte beatum; rectius occupat
Nomen beati, qui deorum
Muneribus sapienter uti
Duramque callet pauperiem pati,
Pejusque leto flagitium timet;
Non ille pro caris amicis
Aut patria timidus perire."

It is interesting to trace the growth of Horace in elevation of sentiment and serious conviction from his first ridicule of the paradoxes of Stoicism in the two books of the *Satires* to the appeal which he makes in some of the *Odes* of the third book to the strongest Roman instincts of fortitude and self-sacrifice. A similar modification of his religious and political attitude may be noticed between his early declaration of Epicurean unbelief—

"Namque deos didici securum agere ævum"—

and the sympathy which he shows with the religious reaction fostered by Augustus; and again between the Epicurean indifference to national affairs expressed in the words

"Quid Tiridatem terreat unice
Securus"

and the strong support which he gives to the national policy of the emperor in the first six *Odes* of the third book, and in the fifth and fifteenth of the fourth book. In his whole religious attitude he seems to stand midway between the consistent denial of Lucretius and Virgil's pious endeavour to reconcile ancient faith with the conclusions of philosophy. His introduction into some of his *Odes* of the gods of mythology must be regarded as merely artistic or symbolical. Yet in such lines as

"Di me tuentur, dis pietas mea
Et musa cordi est,"
"Dis te minorem quod geris, imperas,"
"Immunis aram si tetigit manus," &c.,

we recognize the expression of a natural piety, thankful for the blessing bestowed on purity and simplicity of life, and acknowledging a higher and more majestic law, governing nations through their voluntary obedience. On the other hand, his allusions to a future life, as in the "domus exilis Plutonia," and the "furvæ regna Proserpinæ," are shadowy and artificial. The image of death is constantly obtruded in his poems to enhance the sense of present enjoyment. In the true spirit of paganism he associates all thoughts of love and wine, of the meeting of friends, or of the changes of the seasons with the recollection of the transitoriness of our pleasures—

"Nos, ubi decidimus
Quo pius Æneas, quo dives Tullus et Ancus,
Pulvis et umbra sumus."

Horace is so much of a moralist in all his writings that, in order to enter into the spirit both of his familiar and of his lyrical poetry, it is essential that we should realize to ourselves what were his views of life and the influences under which they were formed. He is, though in a different sense from Lucretius, eminently a philosophical and reflective poet. He is also, like all the other poets of the Augustan age, a poet in whose composition culture and criticism were as conspicuous elements as spontaneous inspiration. In the judgment he passes on the older poetry of Rome and on that of his contemporaries, he seems to attach more importance to the critical and artistic than to the creative and inventive functions of genius. It is on the labour and judgment with which he has cultivated his gift—

"Spiritum Graiæ tenuem Camenæ"—

that he rests his hopes of fame. The whole poetry of the Augustan age was based on the works of older poets, Roman as well as Greek. Its aim was to perfect the more immature workmanship of the former, and to adapt the forms, manners, and metres of the latter to subjects of immediate and national interest. As Virgil performed for his generation the same kind of office which Ennius performed for an older generation, so Horace in his *Satires*, and to a more limited extent in his *Epistles*, brought to perfection for the amusement and instruction of his contemporaries the rude but vigorous designs of Lucilius. Notwithstanding great differences in their intellectual tastes and culture, and the great differences between a time of republican freedom and one of imperial restraint, in which their respective lots were cast, there was a real affinity of temper and disposition between the first and the second in the line of the great Roman satirists. Horace seems to have made Lucilius to some extent his model, in his manner of life as well as in the form and substance of his satire. We find in the fragments of Lucilius expressions of a love of freedom and independence, of indifference to wealth or public employment, of joy at escaping from the storms of life into a quiet haven, of contentment with his own lot, of the superiority of plain living to luxury, identical in spirit and often similar in manner to those that are almost the common-places of Horace.

It was the example of Lucilius which induced Horace to commit all his private thoughts, feelings, and experience "to his books as to trusty companions," and also to comment freely on the characters and lives of other men. Many of the subjects of particular satires of Horace were immediately suggested by those treated by Lucilius. Thus the "Journey to Brundusium" reproduced the outlines of Lucilius's "Journey to the Sicilian Straits." The discourse of Ofella on luxury was founded on a similar discourse of Lælius on gluttony, and the "Banquet of Nasidienus" may have been suggested by the description by the older poet of a rustic entertainment. The same kinds of excess are satirized by both, especially the restless passion of money-making and the sordid anxieties of money-saving, and the opposite extreme of profuse and ostentatious expenditure. There was more of moral censure and personal aggressiveness in the satire of the older poet. The ironical temper of Horace induced him to treat the follies of society in the spirit of a humorist and man of the world, rather than to assail vice with the severity of a censor; and the greater urbanity of his age or of his disposition restrained in him the direct personality of satire. The names introduced by him to mark types of character, such as Nomentanus, Mænius, Pantolabus, &c., are reproduced from the writings of the older poet. Horace also followed Lucilius in the variety of forms which his satire assumes, and especially in the frequent adoption of the form of dialogue, derived from the "dramatic medley" which was the original character of the Roman *Satura*. This form suited the spirit in which Horace regarded the world, and also the dramatic quality of his genius, just as the direct denunciation and elaborate painting of character suited the "sæva indignatio" and the oratorical genius of Juvenal.

Horace's satire is accordingly to a great extent a reproduction in form, manner, substance, and tone of the satire of Lucilius; or rather it is a casting in the mould of Lucilius of his own observation and experience. There is little trace of the influence of his Greek studies either in the matter or the manner of this thoroughly Roman work; though he mentions in one passage that, as aids to composition, he had carried with him to the country the works of Archilochus, and of the comic poets Eupolis, Plato, and Menander. But a comparison of the fragments of Lucilius with the finished compositions of Horace brings out in the strongest light the artistic originality and skill of the latter poet in his management of metre and style. Nothing can be rougher and harsher than the hexameters of Lucilius, or cruder than his expression. In his management of the more natural trochaic metre, he has shown much greater ease and simplicity. It is one great triumph of Horace's genius that he was the first and indeed the only Latin writer who could bend the stately hexameter to the uses of natural and easy, and, at the same time, terse and happy conversational style. Catullus, in his hendecasyllabics, had shown the vivacity with which that light and graceful metre could be employed in telling some short story or describing some trivial situation dramatically. But no one before Horace had succeeded in applying the metre of heroic verse to the uses of common life. But he had one great native model in the mastery of a terse, refined, ironical, and natural conversational style, Terence; and the *Satires* show, not only in allusions to incidents and personages, but in many happy turns of expression very frequent traces of Horace's familiarity with the works of the Roman Menander.

The *Epistles* are more original in form, more philosophic in spirit, more finished in style than the *Satires*. The form of composition may have been suggested by that of some of the satires of Lucilius, which were composed as letters to his personal friends. But letter-writing in prose, and occasionally also in verse, had been common among the Romans from the time of the siege of Corinth; and a practice originating in the wants and convenience of friends temporarily separated from one another by the public service was ultimately cultivated as a literary accomplishment. It was a happy idea of Horace to adopt this form for his didactic writings on life and literature. It suited him as an eclectic and not a systematic thinker, and as a friendly counsellor rather than a formal teacher of his age. It suited his circumstances in the latter years of his life, when his tastes inclined him more to retirement and study, while he yet wished to retain his hold on society and to extend his relations with younger men who were rising into eminence. It suited the class who cared for literature,—a limited circle of educated men, intimate with one another, and sharing the same tastes and pursuits. While giving expression to lessons applicable to all men, he in this way seems to address each reader individually, "admissus circum præcordia ludit," with a subtle power of sympathy and of inspiring sympathy, which respects both himself and his reader. In spirit the *Epistles* are more ethical and meditative than the *Satires*. Like the *Odes* they exhibit the twofold aspects of his philosophy, that of temperate Epicureanism and that of more serious and elevated conviction. In the actual maxims which he lays down, in his apparent belief in the efficacy of addressing philosophical texts to the mind, he exemplifies the triteness and limitation of all Roman thought. But the spirit and sentiment of his practical philosophy is quite genuine and original. The individuality of the great Roman moralists, such as Lucretius and Horace, appears not in any difference in the results at which they have arrived, but in the difference of spirit with which they regard the spectacle of human life. In reading Lucretius we are impressed by his earnestness, his pathos, his elevation of feeling; in Horace we are charmed by the serenity of his temper and the flavour of a delicate and subtle wisdom. We note also in the *Epistles* the presence of a more philosophic spirit, not only in the expression of his personal convictions and aims, but also in his comments on society. In the *Satires* he paints the outward effects of the passions of the age. He shows us prominent types of character—the miser, the parasite, the legacy-hunter, the parvenu, &c., but he does not try to trace these different manifestations of life to their source. In the *Epistles* he finds the secret spring of the social vices of the age in the desire, as marked in other times as in those of Horace, to become rich too fast, and in the tendency to value men according to their wealth, and to sacrifice the ends of life to a superfluous care for the means of living. In the *Satires* he dwells on the discontent of men with their actual condition as he noticed the outward manifestation of this spirit in the various callings of life; in his *Epistles* he lays his finger on the real evil from which society was suffering. The cause of all this aimless restlessness and unreasonable desire is summed up in the words "Strenua nos exercet inertia." In point of style the *Epistles* occupy a middle position between the "sermo pedestris" of the *Satires*, and the studied grace or the grave majesty of the *Odes*. It is the perfection of that kind of style which conceals much thought, insight, and character under a quiet and unpretending exterior. It combines two great excellences of manner both in writing and in conduct, self-restraint with sincerity and simplicity.

In his *Satires* and *Epistles* Horace shows himself a genuine moralist, a subtle observer and true painter of life, and an admirable writer. But for both of these works he himself disclaims the title of poetry. He rests his claims as a poet on his *Odes*. They reveal an entirely different aspect of his genius, his spirit, and his culture. He is one among the few great writers of the world who have attained high excellence in two widely separated provinces of literature. If this division of his powers has been unfavourable to the intensity and spontaneity of his lyrical poetry, it has made him more interesting as a man, and more complete as a representative of his age. Through all his life he was probably conscious of the "ingeni benigna vena," which in his youth made him the sympathetic student and imitator of the older lyrical poetry of Greece, and directed his latest efforts to poetic criticism. But it was in the years that intervened between the publication of his *Satires* and *Epistles* that his lyrical genius asserted itself as his predominant faculty. At that time he had outlived the coarser pleasures and risen above the harassing cares of his earlier career; a fresh source of happiness and inspiration had been opened up to him in his beautiful Sabine retreat; he had become not only reconciled to the rule of Augustus, but a thoroughly convinced and, so far as his temperament admitted of enthusiasm, an enthusiastic believer in its beneficence. But it was only after much labour that his original vein of genius obtained a free and abundant outlet. He lays no claim to the "profuse strains of unpremeditated art," with which other great lyrical poets of ancient and modern times have charmed the world. He recognizes with modest and truthful self-appreciation the source of his power in the lines in which he contrasts his genius with that of Pindar:—

> "Ego, apis Matinæ
> More modoque,
> Grata carpentis thyma per laborem
> Plurimum, circa nemus uvidique
> Tiburis ripas, operosa parvus
> Carmina fingo."

His first efforts were apparently imitative, and were directed to the attainment of perfect mastery over form, metre, and rhythm. The first nine *Odes* of the first book are experiments in different kinds of metre. They and all the other metres employed by him are based on those employed by the older poets of Greece,—Alcæus, Sappho, Archilochus, Alcman, &c. He has built the structure of his lighter *Odes* also on their model, while in some of those in which the matter is more weighty, as in that in which he calls on Calliope "to dictate a long continuous strain," he has endeavoured to reproduce something of the intricate movement, the abrupt transitions, the interpenetration of narrative and reflexion, which characterize the art of Pindar. He frequently reproduces the language and some of the thoughts of his masters, but he gives to them new application, or stamps them with the impress of his own experience. He brought the metres which he has employed to such perfection that the art perished with him. A great proof of his mastery over rhythm is the skill with which he has varied his metres according to the sentiment which he wishes to express. He has impressed the stamp of his own individuality or of his race upon all of them. Thus his great metre, the Alcaic, has a character of stateliness and majesty in addition to the energy and impetus originally imparted to it by Alcæus. The Sapphic metre he employs with a peculiar lightness and vivacity which harmonize admirably with his gayer moods. In his combinations of the Asclepiadean we note the grave and thoughtful temperance of tone which pervades those in which the three Asclepiadean line are combined with one Glyconic as in the "Quis desiderio, &c.," "Inclusam Danaen," &c., the "Divis orte bonis," &c., and the peculiar simplicity and grace, of a graver character than that of the Sapphic, in those *Odes* in which two Asclepiadean lines are combined with one Pherecratean and one Glyconic, as in the

> "Quis multa gracilis te puer in rosa,"

or the

> "O fons Bandusiæ, splendidior vitro."

Again in regard to his diction, if Horace has learned his subtlety and moderation from his Greek masters, he has tempered those qualities with the masculine characteristics of his race. No writer is more Roman in the stateliness and dignity, the terseness, occasionally even in the sobriety and bare literalness, of his diction. The individuality of the man is equally marked in his vivid and graphic condensation of phrase, whether employed in description of outward scenery or in moral portraiture, in the latent fervour or ironical reserve employed in the indication of personal feeling, and in the generalizing maxims which transmute the experience of some special occasion into a universal experience.

While it is mainly owing to the extreme care which Horace gave to form, rhythm, and diction that his own prophecy

> "Usque ego postera
> Crescam laude recens"

has been so amply fulfilled, yet no greater injustice could be done to him than to rank him either as poet or critic with those who consider form everything in literature. Had he been a writer of that stamp he would probably have attached himself to the school of Alexandrian imitators; and such excellence as he might have obtained would have been appreciated only by limited coteries, whose opinion and tastes do not long influence either the educated or uneducated world. With Horace the mastery over the vehicle of expression was merely an essential preliminary to making a worthy and serious use of that vehicle. He may have erred, in theory at least, rather in the other extreme of exaggerating the didactic office of poetry. If an explanation is to be sought for his disparaging reference to the lyrical art of his predecessor, Catullus, it is not necessary to find that explanation in jealousy, nor in any insensibility to a power of expression of which he has shown the sincerest admiration by attempting to imitate it. It is more likely that he was repelled by the purely personal and, as he may have thought, trivial subjects, whether of love or hate, to which the art of his predecessor was almost exclusively limited. The poet, from Horace's point of view, was intended not merely to give refined pleasure to a few, but, above all things, to be "utilis urbi." Yet he is saved, in his practice, from the abuse of this theory by his admirable sense, his ironical humour, his intolerance of pretension and pedantry. Opinions will differ as to whether he or Catullus is to be regarded as the greater lyrical poet. Those who assign the palm to Horace will do so, certainly not because they recognize in him richer or equally rich gifts of feeling, conception, and expression, but because the subjects to which his art has been devoted have a fuller, more varied, more mature, and permanent interest for the world.

For the most complete and exact account of the MSS. and the various editions of Horace, readers are referred to the Introduction to the admirable edition of Mr E. C. Wickham, of which only the first volume, containing the *Odes* and *Epodes*, has appeared. For English readers the translation of the *Odes* and *Satires* by Sir Theodore Martin, and of the *Odes*, *Satires*, and *Epistles* by the late Professor Conington, and the *Life of Horace* by the late Dean Milman, may be especially recommended. (W. Y. S.)

HORATII, three brothers born at one birth, who were the champions of Rome in the war against Alba Longa. Three Alban brothers, named the Curiatii, likewise born at one birth, were opposed to them. The mothers were also twin sisters, who had been married at the same time, and had given birth to their sons on one day. When the Alban army under their king Cluilius lay encamped some miles from Rome, Tullus Hostilius the Roman king agreed with them that the issue should depend on the combat between the two families. Two of the Horatii were soon slain; the third brother feigned flight, and when the Curiatii who were all wounded pursued him without concert he turned and slew them one by one. Now the sister of the Horatii was engaged to one of the Curiatii, and had made for him a beautiful mantle. When the victor, adorned with this trophy, was entering Rome in triumph, his sister came to greet him by the Porta Capena; but when the fatal mantle, which he wore as a trophy, showed her that her lover had fallen by her brother's hand, she invoked a curse on him. Enraged at her reproaches, he slew her on the spot; and the body of her that preferred her lover to her country lay unburied till passers by covered it with stones. Horatius was condemned by *duumviri*, specially appointed as his judges, to be scourged to death; but his father justified his action, and on appeal the people spared his life, condemning him in penalty to walk with veiled head below the *sororium tigillum.* Horatius was afterwards sent to destroy Alba Longa and transport all the inhabitants to Rome. Monuments of the tragic tale were shown by the Romans in the time of Livy:—the *pila Horatia* in the forum, where the victor hung his spoils; the beam under which the brother passed, and which stood across a narrow street near the site of the later Flavian Amphitheatre; the sister's grave outside the gate; the grave of the two Horatii, and those of the three Curiatii where each had fallen; the *fossa Cluilia* dug by the Albans to defend their camp.

The mythical character of many of these details is evident; and indeed it was even doubtful which of the two sets of brothers belonged to Rome and which to Alba. Under the tale lie historical facts known on other evidence —the close relationship and the final internecine strife between the two cities. Alba, the ancient city on the Alban mount, was the mother of all the Latin cities, and of Rome itself; but the ancient city on the Alban hill had gradually given way to the younger cities in the plain, and was finally destroyed by them, while the inhabitants were transported to Rome and various other Latin cities. With the tale that formed round this fact were connected various monuments on the road that led from the Roman forum to Alba Longa. According to Schwegler, the *fossa Cluilia* (*clueo*, to purify) was probably an attempt to drain the country; and the *sororium tigillum* was perhaps the memorial of the substitution of judicial trial for the older patriarchal jurisdiction in case of murder. Dyer, *Kings of Rome*, maintains the historical character of the tale.

HORDE, a manufacturing town of Westphalia, Prussia, circle of Dortmund, government district of Arnsberg, is situated on the railway from Dortmund to Soest, 2 miles south-east from Dortmund. It has one Roman Catholic and two Evangelical churches. Its industry is almost wholly connected with iron, and it possesses a large smelting-work, foundries, puddling-works, rolling mills, and manufactures of iron and plated wares. In the neighbourhood there are large iron and coal-pits. The population in 1875 was 12,837.

HOREB. See SINAI.

HOREHOUND (Ang.-Sax., *harhune*; Germ., *Andorn*; Fr., *Marrube*), *Marrubium*, L., a genus of perennial, usually cottony or woolly herbs, of the natural order *Labiatæ*, and tribe *Stachydeæ.* Common or white horehound, *M. vulgare*, L., has a short and stout rootstock, and thick stems, about a foot in height, which, as well as their numerous branches, are coated with a white or hoary felt—whence the popular name of the plant. The leaves have long petioles, and are roundish, or rhombic-ovate, crenate-serrate, much wrinkled, white and woolly below, and pale green and downy above; the flowers are sessile, in dense whorls or clusters, small, and dull-white, with calyx 10-toothed, and the upper lobe of the corolla long and bifid. The plant occurs in Europe, North Africa, and North Asia to North-West India, and has been naturalized in parts of America. In Britain, where it is found generally on sandy or dry chalky ground, it is far from common. White horehound contains a volatile oil, resin, a crystallizable bitter principle termed *marrubiin*, and other substances, and has a not unpleasant aromatic odour, and a persistent bitter taste. It possesses expectorant, tonic, and carminative properties, and in large doses is diuretic and laxative. Formerly it was official in British pharmacopœias; and the infusion, syrup, or confection of horehound has long been in repute for the treatment of coughs and asthma, and has been recommended also in phthisis, chronic rheumatism, hepatic and uterine disorders, hysteria, and chlorosis. For medicinal purposes the plant should be gathered when in flower, and is preferable in the fresh condition. Black horehound, *Ballota nigra*, L., is a hairy perennial labiate plant, of fœtid odour; is 2 to 3 feet in height; has petiolate, roundish-ovate, serrate leaves, and numerous flowers, in dense axillary clusters, with a green or purplish calyx, and a pale red-purple corolla; and occurs in Europe, North Africa, and Russian Asia, and in Britain, except in northern Scotland, and has been introduced into North America. Water horehound is the *Lycopus europæus* of Linnæus.

Horehound.

See Bentham, *Handb. Brit. Fl.*, ii., 1865; Syme, *Sowerby's Eng. Bot.*, vii. 50, 51, 1867; J. D. Hooker, *Student's Fl.*, 2d. ed., 1878; Bentley and Trimen, *Med. Pl.*, pt. 14, fig. 210; and Stillé and Maisch, *The National Dispensatory*, p. 901, 1879.

HORGEN, a village in the Swiss canton of Zurich, capital of the district of Horgen, is situated on the left bank of the Zurich Lake, 1500 feet above sea-level, and 9 miles south of Zurich. It is surrounded by meadows and vineyards, and possesses many handsome houses, and a beautiful church with frescos by Barzaghi. The town is one of the centres of the Zurich silk industry and vine culture, and the meeting-place of the boats which ply on the north and south banks of the lake. The population in 1870 was 5199, of whom 4744 were Protestants.

HORITZ (Bohemian *Hořice*), a town of Bohemia, Austria, government district of Königgrätz, is situated on the right bank of the Bistritz, 10 miles N.E. from Bidschow. Among the principal buildings are the district court of justice, the castle, the synagogue, the town-house, the poor-house, and the infirmary. It possesses woollen and linen manufactories, a brewery, flour-mills, and saw-mills. Flax and fruit are grown in the vicinity. The population in 1869 was 5659.

HORMAYR, JOSEPH, BARON VON, German statesman and historian, was born at Innsbruck, January 20th 1781, and died at Munich, November 5th, 1848. After studying law for several years (1794–1797) in his native town, and attaining the rank of major in the Tyrol landwehr, the young man, who had the advantage of being the grandson of Joseph von Hormayr (1705–1781), chancellor of Tyrol, obtained a post in the foreign office at Vienna (1801), from which he rose in 1803 to be court secretary and director of the secret archives of the kingdom and court. During the insurrection by which in 1809 the Tyrolese sought to throw off the Bavarian supremacy confirmed by the treaty of Pressburg, Hormayr was the mainstay of the Austrian party, and assumed the administration of everything save the military arrangements; but, returning home without the prestige and protection of success, he fell into disfavour both with the emperor Francis I. and the prime minister Metternich, and at length in 1813 he was arrested and imprisoned. In 1816 some amends were made to him by his appointment as historiographer royal; but so little was he satisfied with the general policy and conduct of the Austrian court that in 1828 he accepted an invitation to the Bavarian capital, where he became ministerial councillor in the department of foreign affairs. In 1832 he was appointed Bavarian minister at Hanover, and from 1839 to 1846 he held the same position at Bremen. The last two years of his life were spent at Munich as superintendent of the national archives. Hormayr's literary activity was closely conditioned by the circumstances of his political career: while the access which he enjoyed to original documents gave value to his treatment of the past, his record or criticism of contemporary events received authority and interest from the character of his personal experience. In his later writings he is a keen opponent of the policy of the court of Vienna.

The following are among Hormayr's more important works:—*Kritisch-diplomatische Beiträge zur Geschichte Tirols im Mittelalter*, Innsb., 1802-3; *Gesch. der gefürst. Grafschaft Tirol*, Tüb., 1806-8; *Österreichischer Plutarch*, 20 vols., Vienna, 1807-20; *Archiv für Gesch. Stat. Lit. und Kunst*, 20 vols., 1809-28; *Wien, seine Gesch. und Denkwürdigkeiten*, Vienna, 1823-25; *Lebensbilder aus dem Befreiungskriege*, Jena, 1841-44; *Die goldene Chronik von Hohenschwangau*, Munich, 1842; *Anemonen aus dem Tagebuch eines alten Pilgermanns*, Jena, 1845-47. Along with Mednyanski (1784-1844) he founded *Taschenbuch für die Vaterländ. Gesch.*, Vienna, 1811-48.

HORMISDAS, pope from 514-523, in succession to Symmachus, was a native of Campania. Although on his election overtures were at once made by Anastasius I., emperor of the East, for the reunion of the Eastern and Western Churches, which had been separated since the excommunication of Acacius in 484, the zeal or intolerance of the pope delayed it till he was able to procure it on his own terms, in 519, from the orthodox emperor Justin. Hormisdas paid much attention to the instruction of his clergy in psalmody. He was succeeded in 523 by John I. Eighty of his letters are preserved in Labbe's *Sacrosancta Concilia*, vol. v. (1728), and are also to be found in vol. lxiii. of Migne's *Patrologiæ Cursus Completus* (Latin series).

HORN. The weapons which project from the heads of various species of animals, constituting what are known as horns, embrace substances which are, in their anatomical structure and chemical composition, quite distinct from each other; and although in commerce also they are known indiscriminately as horn, their uses are altogether dissimilar. These differences in structure and properties are thus indicated by Professor Owen:—"The weapons to which the term horn is properly or technically applied consist of very different substances, and belong to two organic systems, as distinct from each other as both are from the teeth. Thus the horns of deer consist of bone, and are processes of the frontal bone; those of the giraffe are independent bones or 'epiphyses' covered by hairy skin; those of oxen, sheep, and antelopes are 'apophyses' of the frontal bone, covered by the corium and by a sheath of true horny material; those of the prong-horned antelope consist at their basis of bony processes covered by hairy skin, and are covered by horny sheaths in the rest of their extent. They thus combine the character of those of the giraffe and ordinary antelope, together with the expanded and branched form of the antlers of deers. Only the horns of the rhinoceros are composed wholly of horny matter, and this is disposed in longitudinal fibres, so that the horns seem rather to consist of coarse bristles compactly matted together in the form of a more or less elongated sub-compressed cone." True horny matter is really a modified form of epidermic tissue, and consists of an albuminoid principle termed "keratin." It forms, not only the horns of the ox tribe, but also the hoofs, claws, or nails of animals generally, the carapace of the tortoises and the armadilloes, the scales of the pangolin, porcupine quills, and birds' feathers, &c. The principal application of horns is for the manufacture of combs, and under the heading COMB, vol. vi. pp. 177–78, that industry is described. The other uses to which horn is now devoted, among which may be noted the pressing of buttons, the making of handles for walking-sticks, umbrellas, and knives, the manufacture of drinking-cups, spoons of various kinds, and snuff-boxes, do not here require extended notice. The parings and refuse of horn are valuable for the manufacture of prussiate of potash and as manure; and the ash of the cores of horn makes excellent cupels for the assay of precious metals. In former times horn was applied to several uses for which it is no longer required, although such applications have left their traces in our language. Thus the musical instruments and fog signals known as horns indicate their descent from earlier and simpler forms of apparatus made from horn. In the same way powder-horns were spoken of long after they ceased to be made of that substance; to a small extent lanterns still continue to be "glazed" with thin transparent plates of horn, a practice which a century ago was universal. Horn-books consisted of spelling-books with their leaves protected by thin plates of horn, and it was in former times customary to protect the titles of valuable MSS. in the same way. Deer-horn is almost exclusively used for handles by cutlers and walking-stick and umbrella makers. The largest supply is obtained from the East Indies, and consists principally of the antlers of the axis, *Axis maculata*, and the Rusa deer, *Rusa Aristotelis*.

HORN, or FRENCH HORN, a wind instrument made at various times of various materials such as wood, ivory, and several metals, but belonging in its modern significance to the class of brass instruments. In how far the instruments of similar type or character used by the Jews and other Eastern nations, by the Romans, and by mediæval knights may have been related to the modern horn it is needless to investigate here. The instrument as we know it dates at least from the 16th century, for a picture of the circular horn is found in Virdung's *Musica* (1511). But ruder representations of similarly-shaped instruments occur in armorial bearings of a much remoter period. The horn in its earlier form served exclusively the various purposes of the hunt, whence its name in the different languages: Italian, corno di caccia; French, cor de chasse; German, Waldhorn. Originally there seems to have been only a single ring, but a second semicircle occurs at an early date. The capabilities of the primitive instrument were as limited as its purpose, the latter being chiefly that of announcing by signals the various stages and incidents of the hunt, such as the *Reveille*, the *Hallali*, and the *Mort*. Simple tunes, however, were within its range, for Mersenne mentions a "concert à quatre" for horns as early as 1637. The demands on the horn were naturally much enlarged when it was introduced into the orchestra as an exponent of artistic and complicated music. As to the date of this event opinions differ considerably. It has been asserted that Gossec was the first to make use of the horn in an important orchestral part in 1759. But this is true, if true at all, of France only. In Germany and England the instrument was in common use at a much earlier period. From 1712–1740 two hornists were members of the imperial chapel in Vienna at the not inconsiderable salary of 360 florins. Moreover, both Handel (in his *Water Music*, 1715, and elsewhere) and Bach assign important parts to the horn. The notes natural to the horn and produced by the action of the lips alone are the so-called harmonics or partial tones of the bottom note between the extreme limits of the C below the staff in the bass clef to the E in alt. Some of these notes are, however, not used in practice. In order to supply the notes not in the scale of natural harmonics various methods have been used. The simplest is the insertion of the hand in the bell of the instrument, accidentally discovered by a German hornplayer towards the end of the last century. The effect is to lower the note by a semitone or a whole tone, according to the extent that the orifice is closed. The drawback attaching to this system is that the "closed" or "stopped" (*étouffé*) notes differ in character from the open ones, and are in part dull. It is true that a good composer may produce certain effects by this means. In the modern horn a mechanical contrivance generally takes the place of the hand. This is the valve or ventil, an apparatus for lowering the note by means of the pressure of the fingers. There are three valves attached to the ventil-horn, lowering the note by one, two, and three semitones respectively. Most modern composers write for the ventil-horn exclusively; others use it in combination with natural or hand horns. Another important appliance of the horn is the crook, which may best be described as a transposing machine. The crooks can be removed at will, their effect (by altering the length of the tube) being to transpose the notes produced by the lips into anything that is required. The player therefore plays as it were in one and the same key, and the difficulty of transposing his part mentally is saved to him. In consequence the horn part in a score is always written in the key of C, which may be changed into E flat or F or E by merely inserting the crook intended for that key. In this way not only the diatonic scale, but all kinds of chromatic progressions can be produced on the horn. Of these opportunities modern composers have largely availed themselves, frequently tasking the capabilities of the players to the utmost degree. The passage for three horns in the great scena of Fidelio in Beethoven's opera of that name is celebrated for its effectiveness as well as for its difficulty. With Wagner also the horns are favourite instruments. In the economy of the orchestra the horns form the transition from the wood winds to the trumpets, trombones, and other loud brass instruments; they share the softness of the former with the power of the latter, and may be used with equal effect both in filling up the harmony and in emphasizing the melody. In works of a romantic character, such as Mendelssohn's overture to *A Midsummer Night's Dream*, or Weber's *Der Freischütz*, they are invaluable for the purpose of local colouring. There are also many solo pieces written for the horn, amongst which Mozart's three concerti for horn and orchestra, Schumann's concerto for 4 horns and orchestra (op. 86), Beethoven's horn sonata (op. 17), and Brahms's trio for pianoforte, violin, and horn (op. 40) may be cited.

HORNBEAM, *Carpinus*, Tournef., a small genus of trees of the natural order *Cupuliferæ* and sub-order *Corylcæ*. The Latin name *Carpinus* has been thought to be derived from the Celtic *car*, wood, and *pin* or *pen*, head, the wood of hornbeams having been used for yokes of cattle (see Loudon, *Ency. of Pl.*, p. 792, new ed., 1855, and Littré, *Dict.*, ii. 556). The common hornbeam, or yoke-elm, *Carpinus Betulus*, L. (Gr., probably ζυγία; Germ., *Hornbaum* and *Hornbuche*; Fr., *charme*), is indigenous in the temperate parts of western Asia and of Asia Minor, and in Europe, where it ranges as high as 55° and 56° N. lat. It is common in woods and hedges in parts of Wales and of the south of England. The trunk is usually flattened, and twisted as though composed of several stems united; the bark is smooth, and light grey; and the leaves are sub-distichous, 2 to 3 inches long, elliptic-ovate, doubly serrate, pointed, numerously ribbed, hairy below, and opaque, and not glossy as in the beech, have large stipules and short petioles, and when young are plaited. The flowers appear with the leaves in April and May. The male catkins are about 1½ inches long, and have pale yellow anthers, bearing tufts of hairs at the apex; the female attain a length of 2 to 4 inches, with bracts 1 to 1½ inches long. The green and angular fruit or "nut" ripens in October; it is about ¼ inch in length, is in shape like a small chestnut, and is enclosed in leafy, 3-lobed bracts. The hornbeam thrives well on stiff, clayey, moist soils, into which its roots penetrate deeply; on chalk or gravel it does not flourish. Raised from seed it may become a tree 40 to as much as 70 feet in height, greatly resembling the beech, except in its rounder and closer head. It is, however, rarely grown as a timber-tree, its chief employment being for hedges. "In the single row," says Evelyn (*Sylva*, p. 29, 1664), "it makes the noblest and the stateliest *hedges* for long Walks in *Gardens* or *Parks*, of any Tree whatsoever whose leaves are *deciduous*." As it bears clipping well, it was formerly much used in geometric gardening. The branches should not be lopped in spring, on account of their tendency to bleed at that season.

The wood of the hornbeam is white and close-grained, and polishes ill, is of considerable tenacity and little flexibility, and is extremely tough and hard to work—whence, according to Gerard, the name of the tree. It has been found to lose about 8 per cent. of its weight by drying. As a fuel it is excellent; and its charcoal is much esteemed for making gunpowder. The bark of the hornbeam has tonic properties, and the inner part is stated by Linnæus to afford a yellow dye. In France the leaves serve as fodder. The tree is a favourite with hares and rabbits, and the seedlings are apt to be destroyed by mice. Pliny (*Nat. Hist.*, xxvi. 26), who describes its wood as red and easily split, classes the hornbeam with maples. The American hornbeam, blue or water beech, or iron-wood, is *Carpinus americana*, Mich.; the common hop-hornbeam, a native of the south of Europe, is *Ostrya vulgaris*, Willd., and the American, *O. virginica*, Willd.

See Gilpin, *For. Scenery*, i., ed. Lauder, 1834; Loudon, *Arboretum*, iii. 2004, 1838; Selby, *Forest Trees*, p. 337, 1842; Bentham, *Handb. of Brit. Flora*, ii. 753, 1865; Syme, *Sowerby's Eng. Bot.*, viii. 176, 1868; J. D. Hooker, *Student's Flora*, p. 365, 2d ed., 1878; and ARBORICULTURE, vol. ii. p. 317.

HORNBILL, the English name for a long while generally given to all the birds of the Family *Bucerotidæ* of modern ornithologists, from the extraordinary horn-like excrescence (*epithema*) developed on the bill of most of the species, though to which of them it was first applied seems doubtful. Among classical authors Pliny had heard of such animals, and mentions them (*Hist. Nat.*, lib. x. cap. lxx.) under the name of *Tragopan*; but he deemed their existence fabulous, comparing them with *Pegasi* and *Gryphones*—in the words of Holland, his translator (vol. i. p. 296)—"I thinke the same of the Tragopanades, which many men affirme to bee greater than the Ægle; having crooked hornes like a Ram on either side of the head, of the colour of yron, and the head onely red." Yet this is but an exaggerated description of some of the species with which doubtless his informants had an imperfect acquaintance. Mediæval writers found Pliny's bird to be no fable, for specimens of the beak of one species or another seem occasionally to have been brought to Europe, where they were preserved in the cabinets of the curious, and thus Aldrovandus was able to describe pretty fairly and to figure (*Ornithologia*, lib. xii. cap. xx. tab. x. fig. 7) one of them under the name of "*Rhinoceros Avis*," though the rest of the bird was wholly unknown to him. When the exploration of the East Indies had extended further, more examples reached Europe, and the "*Corvus Indicus cornutus*" of Bontius became fully recognized by Willughby and Ray, under the title of the "Horned Indian Raven or *Topau* called the Rhinocerot Bird." Since the time of those excellent ornithologists our knowledge of the Hornbills has been steadily increasing, but it must be confessed that in regard to many points there is still great lack of precise information, and accordingly the completion of Mr Elliot's "*Monograph of the Bucerotidæ*" (now in course of publication) is most earnestly to be desired, for therein it is to be hoped that all questions respecting their history and classification may be fully treated. At present great diversity of opinion prevails as to how many real genera the Family comprises, or how many species. The group, though no doubt ought to be entertained as to its limits,[1] has not attracted sufficient notice from ornithologists, and therefore, apart from the merest superficial characters, the difference of the several sections which it includes has never been properly explained, nor have their distinctions been placed on a firm basis. Some authors appear to have despaired of dividing it satisfactorily, and have left all the described species in the Linnæan genus *Buceros*, as for example, Professor Schlegel (*Cat. du Mus. des Pays Bas*, Buceros); others have split that genus into more than a score—a number which seems to be quite unnecessary. Sundevall (*Tentamen*, pp. 96, 97), with his usual caution, has restrained himself to the recognition of three genera, but it is unquestionable that more should reasonably be admitted, though the present writer is not prepared to state how many are required.

The first genus admitted by Sundevall is *Rhinoplax*, which seems properly to contain but one species, the *Buceros vigil*, *B. scutatus*, or *B. galeatus* of authors, commonly known as the Helmet-Hornbill, a native of Sumatra and Borneo. This is easily distinguished by having the front of its nearly vertical and slightly convex *epithema* composed of a solid mass of horn[2] instead of a thin coating of the light and cellular structure found in the others. So dense and hard is this portion of the "helmet" that Chinese and Malay artists carve figures on its surface, or cut it transversely into plates, which from their agreeable colouring, bright yellow with a scarlet rim, are worn as brooches or other ornaments. This bird, which is larger than a Raven, is also remarkable for its long graduated tail, having the two middle feathers nearly twice the length of the rest. Nothing is known of its habits. Its head was figured by Edwards more than a century ago, but little else had been seen of it until 1801, when Latham described the plumage from a specimen in the British Museum, and the first figure of the whole bird from an example in the Museum at Calcutta was published by Hardwicke in 1823 (*Trans. Linn. Society*, xiv. pl. 23). Yet more than twenty years elapsed before French naturalists became acquainted with it. Under *Rhinoplax* Sundevall places the *Buceros cornutus* of Raffles; but this would seem to be a wrong position for that species, the type of Bonaparte's genus *Berenicornis*, since it does not appear to possess a frontlet of solid horn.

Sundevall divides the genus *Buceros* into three sections, of which one, *Buceros* proper, contains the species having the *epithema* developed to its greatest extent, such as *B. rhinoceros*, *B. hydrocorax*, *B. bicornis*, and others, while the remaining sections have little or no *epithema*, and one of them has the throat feathered. This last includes the African forms which seem to belong to the genus *Toccus* of Lesson, while the other comprises the Oriental species exemplified by Mr Hodgson's genus *Aceros*; but the arrangement cannot be deemed wholly satisfactory, and must be regarded only as an approach to a better. The presence or absence of the *epithema* may indeed be considered in distinguishing genera; but among those that possess it, seeing that its development is to a great degree dependent upon age and perhaps sex (this last being uncertain), its size and shape hardly afford good generic characters, and, though the group assigned by Sundevall to *Buceros* proper doubtless requires further separation, some less superficial distinctions must be pointed out than those which have been taken as sufficient to establish many of the "genera" of this family suggested by several ornithologists. Again, in the grouping of those forms which possess little or no *epithema* sound characters are equally wanting for the divisions as yet set forth, and until further investigations have been made the limits of even the genera *Aceros* and *Toccus* cannot be laid down. Tickell in his manuscript *Birds of India* (in the library of the Zoological Society of London) divides the Hornbills of that country into two genera only, *Buceros* and *Aceros*, remarking that the birds of the former fly by alternately flapping their wings and sailing, while those of the latter fly by regular flapping only.[3] Several differences of structure are presented by the sternal apparatus of the various *Bucerotidæ*, and it is quite possible that these differences may be correlated with Tickell's observations so as to furnish, when more is known about these birds, a better mode of classing them, and the same may be said of those of the African group containing the genus *Toccus* and its allies.

Lastly, we have the genus *Bucorvus*, or *Bucorax* as some call it, confined to Africa, and containing at least two and perhaps more species, distinguishable by their longer legs and shorter toes, the Ground-Hornbills of English writers, in contrast to all the preceding, which are chiefly arboreal in their habits, and when not flying move by short leaps or hops, while the members of this group walk and run with facility. From the days of Bruce at least there are few African travellers who have not met with and in their narratives more or less fully described one or other of these birds, whose large size and fearless habits render them conspicuous objects.

As a whole the Hornbills, of which more than 50 species have been described, form a very natural and in some respects an isolated group, placed by Professor Huxley among his *Coccygomorphæ*. It has been suggested that they have some affinity with the Hoopoes (*Upupidæ*), but even if that view be good the affinity cannot be very near. Their supposed alliance to the Toucans (*Rhamphastidæ*) rests only on the apparent similarity presented by the enormous beak, and is contradicted by important structural characters. In many of their habits, so far as these are known, all Hornbills seem to be much alike, and though the modification in the form of the beak, and the presence or absence of the extraordinary excrescence,[4] whence their name is

[1] Such genera as *Euryceros*, *Scythrops*, and some others, together with the whole Family *Momotidæ*, which had been at various times and by various systematists placed among the *Bucerotidæ*, have evidently no real affinity to them.

[2] Apparently correlated with this structure is the curious thickening of the "prosencephalic median septum" of the cranium as also of that which divides the "prosencephalic" from the "mesencephalic chamber," noticed by Professor Owen (*Cat. Osteol. Ser. Mus. Roy. Coll. Surg. England*, i. p. 287); while the solid horny mass is further strengthened by a backing of bony props, directed forwards and meeting its base at right angles. This last singular arrangement, which is not perceptible in the skull of any other species examined by the present writer, does not seem to have been described.

[3] The noise made by the wings of some of the large species in their flight is compared by Mr Wallace, in an admirable article on the Family (*Intellectual Observer*, 1863, pp. 310 *et seqq.*), to the puffing of a locomotive steam-engine when starting with a train, and can be heard a mile off.

[4] Buffon, as was his manner, enlarges on the cruel injustice done to these birds by Nature in encumbering them with this deformity, which

derived, causes great diversity of aspect among them, the possession of prominent eyelashes (not a common feature in Birds) produces a uniformity of expression which makes it impossible to mistake any member of the family. Hornbills are social birds, keeping in companies, not to say flocks, and living chiefly on fruits and seeds; but the bigger species also capture and devour a large number of snakes, while the smaller are great destroyers of insects. The older writers say that they eat carrion, but further evidence to that effect is required before the statement can be believed. Almost every morsel of food that is picked up is tossed into the air, and then caught in the bill before it is swallowed. They breed in holes of trees, laying large white

Great Indian Hornbill (*B. bicornis*). After Tickell's drawing in the Zoological Society's library.

eggs, and when the hen begins to sit the cock plasters up the entrance with mud or clay, leaving only a small window through which she receives the food he brings her during her incarceration.

This remarkable habit, almost simultaneously noticed by Dr Mason in Burma, Tickell in India, and Livingstone in Africa, and since confirmed by other observers, especially Mr Wallace[1] in the Malay Archipelago, has been connected by Mr Bartlett (*Proc. Zool. Society*, 1869, p. 142) with a peculiarity as remarkable, which he was the first to notice. This is the fact that Hornbills at intervals of time, whether periodical or irregular is not yet known, cast the epithelial layer of their gizzard, that layer being formed by a secretion derived from the glands of the proventriculus or some other upper part of the alimentary canal. The epithelium is ejected in the form of a sack or bag, the mouth of which is closely folded, and is filled with the fruit that the bird has been eating. The announcement of a circumstance so extraordinary naturally caused some hesitation in its acceptance, but the essential truth of Mr Bartlett's observations has been abundantly confirmed by Professor Flower (*tom. cit.*, p. 150), and especially by Dr Murie (*op. cit.*, 1874, p. 420), and what seems now to be most wanted is to know whether these castings are really intended to form the hen bird's food during her confinement. (A. N.)

he declares must hinder them from getting their food with ease. The only corroboration his perverted view receives is afforded by the observed fact that Hornbills, in captivity at any rate, never have any fat about them. The part played by the wonderful *epithema* in the birds' economy is altogether unknown.

[1] In his interesting work (i. p. 213), this gentleman describes a nestling Hornbill (*B. bicornis*) which he obtained as "a most curious object, as large as a pigeon, but without a particle of plumage on any part of it. It was exceedingly plump and soft, and with a semi-transparent skin, so that it looked more like a bag of jelly, with head and feet stuck on, than like a real bird."

HORN-BOOK, a name sometimes given to an elementary treatise on any subject. It was originally applied to a sheet containing the letters of the alphabet, which formed a primer for the use of children. It was mounted on wood and protected with transparent horn. Sometimes the leaf was simply pasted against the slice of horn. The wooden frame had a handle, and it was usually hung at the child's girdle. The sheet, which in ancient times was of vellum and latterly of paper, contained first a large cross—the criss-crosse—from which the horn-book was called the Christ Cross Row, or criss-cross-row. The alphabet in large and small letters followed. The vowels then formed a line, and their combinations with the consonants were given in a tabular form. The usual exorcism—"in the name of the Father and of the Sonne and of the Holy Ghost, Amen"—followed, then the Lord's Prayer, the whole concluding with the Roman numerals. The horn-book is mentioned in Shakespeare's *Love's Labour's Lost*, v. 1, where the *ba*, the *a*, *e*, *i*, *o*, *u*, and the horn, are alluded to by Moth. It is also described by Ben Jonson—

> "The letters may be read, *through the horn*,
> That make the story perfect."

Horn-books are now of great rarity. A representation of a good specimen will be found prefixed to Halliwell's *Notices of Fugitive Tracts*, in the twenty-ninth volume of the works printed for the Percy Society.

HORNCASTLE, a market-town giving its name to a soke in Lincolnshire, England, is situated at the foot of a line of low hills called the Wolds, on an angle formed by the confluence of the Bain and Waring, and at the terminus of a branch line of the Great Northern Railway, 21 miles east of Lincoln. The principal buildings are the parish church of St Mary's (supposed to have been originally erected in the time of Henry VII., possessing a square embattled tower, many fine old monuments, and an old brass), Queen Elizabeth's grammar school founded in 1562, the dispensary opened in 1789, the corn exchange opened in 1856, with a room for public meetings, and accommodation for the mechanics' institute, a library, and a news-room. There are also national and Wesleyan schools, and an infant school for poor children. Among the charities is one for apprenticing orphan boys belonging to the parish. A few fragments still remain of the ancient fortification from which the town takes its name, and many Roman urns and coins have been discovered in the vicinity. Near the confluence of the rivers there at one time existed an ancient labyrinth called the Julian bower. To the south-east of the town there is a spot called Hangman's Corner, where criminals were formerly executed. The prosperity of the town is chiefly dependent on agriculture and its horse fairs,—that held in August being the largest of its class in England. Brewing, malting, and currying are carried on, and there is some trade in coal and iron. The population of the parish in 1871 was 4947, and of the soke 10,469.

Horncastle is believed to be the Roman *Banovallum*. The fort is said to have been originally constructed by the Romans, refortified and strengthened by Horsa, the brother of Hengest, but shortly afterwards demolished by Vortimer, king of the Britons. The manor at the time of the Norman survey belonged to the king, and after being for an unknown period in private hands, was sold in the reign of Henry III. to the bishop of Carlisle, who received from Henry a charter authorizing him to try felons and hold a court leet, and granting free warren and an annual fair.

HORNE, George (1730–1792), bishop of Norwich, was born on November 1, 1730, at Otham near Maidstone, where his father was a clergyman, and received his early education at the Maidstone school, whence he proceeded to University College, Oxford. In 1749 he became a fellow of Magdalen College, of which in 1768 he was appointed president. As a preacher he early attained great popularity; and his reputation was further helped by several clever if somewhat wrong headed publications, including a satirical pamphlet entitled *The Theology and Philosophy of Cicero's Somnium Scipionis* (1751), a defence of the Hutchinsonians in *A Fair, Candid, and Impartial State of the Case between Sir Isaac Newton and Mr Hutchinson* (1753), and critiques upon Dr Shuckford (1754) and Dr Kennicott (1760). In 1776 he published his well-known *Commentary on the Book of Psalms*, and in the same year he was chosen vice-chancellor of his university; in 1781 he was made dean of Canterbury, and in 1790 he was raised to the see of Norwich, which, however, he held for less than two years. He died at Bath January 17, 1792.

His collected *Works* were first published, with a Memoir by one of his chaplains (Jones), in 1795. There have been several subsequent editions, the latest being that of 1830. The most popular and also the best of his writings, the *Commentary on the Psalms*, has been still more frequently reprinted, occasionally along with an essay by James Montgomery, or with a much more remarkable discourse by Edward Irving.

HORNE, Thomas Hartwell (1780–1862), a well-known writer on Biblical introduction, was born in London on October 20, 1780, and from 1789–95 was educated at Christ's Hospital, where Coleridge was an elder contemporary. On leaving school, his circumstances not permitting him to proceed to the university, he became clerk to a barrister, but early manifested an unconquerable passion for literary pursuits. When barely twenty years of age he published (1800) *A Brief View of the Necessity and Truth of the Christian Revelation*, which reached a second edition in 1802. In the years immediately following he became the author of several minor works, and in 1814, having been appointed librarian of the Surrey Institution, he issued his *Introduction to the Study of Bibliography*. This was followed in 1818 by the work to which he had devoted the best part of many years, the *Introduction to the Critical Study of the Holy Scriptures*, which rapidly attained a rare popularity, and secured for its author a high and secure place among contemporary scholars. In 1819 he received ordination from the bishop of London, although unpossessed of the customary university degree, and some time afterwards he was appointed to the cure of the united parishes of St Edmund the King and St Nicolas Acons in London. On the breaking up of the Surrey Institution in 1823, he was appointed (1824) to superintend the classification and publication of the British Museum Catalogue. After the project of making a classed catalogue had been abandoned, he continued to take part in the preparation of the alphabetical catalogue, and his connexion with the museum continued to subsist until 1861, when his infirmities caused him to resign. He died in London on January 26, 1862.

Besides the works already mentioned Horne wrote numerous others of secondary importance, which, as catalogued in Allibone's *Dictionary* by himself, exceed forty in number. The *Introduction*, edited by Ayre and Tregelles, reached a 12th edition in 1869 (4 vols. 8vo); but, owing to the recent rapid advances of critical science, it is now somewhat out of date.

HORNELLSVILLE, a township and post village of Steuben county, New York, is situated on the Canisteo river and on the Erie Railway, 90 miles south-east of Buffalo. It is well supplied with schools and churches, and possesses planing-mills, tanneries, and factories for sashes and blinds, furniture, cars, mowing-machines, and boots and shoes. The population was 5639 in 1870, and 9852 in 1880.

HORNER, Francis (1778–1817), political economist, was born at Edinburgh, August 12th, 1778. After passing through the usual courses at the high school and university of his native city, he devoted five years, the first two in England, to comprehensive but desultory study, and in 1800 was called to the Scotch bar. Desirous, however, of a wider sphere, Horner removed to London in 1802, and occupied the interval that elapsed before his admission to the English bar in 1807 with researches in law, philosophy, and political economy, and latterly with parliamentary duties. In February 1806 he became one of the commissioners for adjusting the claims against the nawab of Arcot, and in November entered parliament as member for St Ives. Next year he sat for Wendover, and in 1812 for St Mawes, in the patronage of the marquis of Buckingham. In 1811, when Lord Grenville was organizing a prospective ministry, Horner had the offer, which he refused, of a treasury secretaryship. He had resolved not to accept office till he could afford to live out of office; and his professional income, on which he depended, was at no time proportionate to his abilities. His labours at last began to tell upon a constitution never robust, and in October 1816 his physicians ordered him to Italy, where, however, he sank under his malady. He died at Pisa, February 8, 1817. He was buried at Leghorn, and a marble statue by Chantrey was erected to his memory in Westminster Abbey.

Without the advantages of rank, or wealth, or even of genius, Francis Horner rose to a high position of public influence and private esteem. The speeches in the House of Commons on the occasion of moving for a new writ for St Mawes combine with the letters of private friends in testifying to the respect and honour commanded by his integrity and wide and cultured intellect, and to the affection won by his sweet and noble disposition, as well as to the general regret for the untimely death of one who gave promise of such abilities as a statesman. The early friend of Brougham and Jeffrey in Edinburgh, and welcomed in London by Romilly, Mackintosh, Abercromby, and Lord Holland, Horner was by sincere conviction a Whig. His special field was political economy. Master of that subject, and exercising a sort of moral as well as intellectual influence over the House of Commons, he, by his nervous and earnest rather than eloquent style of speaking, could fix its attention for hours on such dry topics as finance, and coinage, and currency. As chairman of the parliamentary committee for investigating the depreciation of bank notes, for which he moved in 1810, he extended and confirmed his fame as a political economist by his share in the famous *Bullion Report*. It was chiefly through his efforts that the paper-issue of the English banks was checked, and gold and silver reinstated in their true position as circulating media; and his views on free trade and commerce have been generally accepted at their really high value. Horner was one of the promoters of the *Edinburgh Review* in 1802. His articles in the early numbers of that publication, chiefly on political economy, form his only literary legacy.

Memoirs and Correspondence of Francis Horner, M.P., was published by his brother in 1843. See also the *Edinburgh* and *Quarterly Reviews* for the same year; and *Blackwood's Magazine*, vol. i.

HORNET. See Wasp.

HORNPIPE was originally the name of an instrument no longer in existence, and is now used for an English national dance. The sailor's hornpipe, although the most common, is by no means the only form of the dance, for there is a pretty tune known as the "College Hornpipe," and other specimens of a similar kind might be cited. The composition of hornpipes flourished chiefly in the last century, and even Handel did not disdain to use the characteristic rhythm. The hornpipe may be written in $\frac{3}{2}$ or in common time, and is always of a lively nature.

HORROCKS, JEREMIAH (1619–1641), an astronomer of extraordinary promise blighted by a premature death, was born in 1619 at Toxteth Park, near Liverpool. Of the circumstances of his family little is known, further than that they were poor; but the register of Emmanuel College, Cambridge, testifies to his entry as sizar, May 18, 1632. Isolated in his scientific tastes, and painfully straitened in means, he pursued amid innumerable difficulties his purpose of self-education. His university career lasted three years, and on his return to Lancashire he devoted to astronomical observations the brief intervals of leisure snatched from the harassing occupations of a laborious life. In 1636 he met with a congenial spirit in William Crabtree, a draper of Broughton, near Manchester; and encouraged by his advice he exchanged the guidance of Lansberg, a pretentious but inaccurate Belgian astronomer, for that of Kepler. He now set himself to the revision of the Rudolphine Tables (published by Kepler in 1627), and in the progress of his task became convinced that a transit of Venus overlooked by Kepler would nevertheless occur on the 24th of November (O.S.) 1639. He was at this time curate of Hoole, near Preston, having recently taken orders in the Church of England, although, according to the received accounts, he had not attained the canonical age. The 24th of November falling on a Sunday, his clerical duties threatened fatally to clash with his astronomical observations; he was, however, released just in time to witness the punctual verification of his forecast, and carefully noted the progress of the phenomenon during half an hour before sunset (3.15 to 3.45). This transit of Venus is remarkable as the first ever observed, that of 1631 predicted by Kepler having been invisible in Europe. Notwithstanding the rude character of the apparatus at his disposal, Horrocks was enabled by his observation of it to introduce some important corrections into the elements of the planet's orbit, and to reduce to its exact value the received estimate of its apparent diameter.

After a year spent at Hoole, he returned to Toxteth, and there, on the eve of a long-promised visit to his friend Crabtree, unexpectedly expired, January 3, 1641, in the twenty-second year of his age. It is difficult to overestimate the services which, had his life been prolonged, this singularly gifted youth might have rendered to astronomical science. To the inventive activity of the discoverer he already united the patient skill of the observer and the practical sagacity of the experimentalist. Before he was twenty he had afforded a specimen of his powers by an important contribution to the lunar theory. He first brought the revolutions of our satellite within the domain of Kepler's laws, pointing out that her apparent irregularities could be completely accounted for by supposing her to move in an ellipse with a variable eccentricity and directly rotatory major axis, of which the earth occupied one focus. These precise conditions were afterwards demonstrated by Newton to follow necessarily from the law of gravitation.

In his speculations as to the physical cause of the celestial motions, his mind, though not as yet wholly emancipated from the tyranny of gratuitous assumptions, was working steadily towards the light. He clearly perceived the significant analogy between terrestrial gravity and the force exerted in the solar system, and used an ingenious experiment to illustrate the composite character of the planetary movements. He also reduced the solar parallax to 14″ (less than a quarter of Kepler's estimate), corrected the sun's semi-diameter to 15′ 45″, recommended decimal notation, and was the first to make tidal observations.

Only a remnant of the papers left by Horrocks was preserved by the care of William Crabtree. After his death (which occurred soon after that of his friend), these were purchased by Dr Worthington, of Cambridge; and from his hands the treatise *Venus in sole visa* passed into those of Hevelius, and was published by him in 1662 with his own observations on a transit of Mercury. The remaining fragments were, under the directions of the Royal Society, reduced by Dr Wallis to a compact form, with the heading *Astronomia Kepleriana defensa et promota*, and published with numerous extracts from the letters of Horrocks to Crabtree, in a volume entitled *Jeremiæ Horroccii Opera Posthuma*, London, 1672. A memoir of his life by the Rev. Arundell Blount Whatton, prefixed to a translation of the *Venus in sole visa*, appeared at London in 1859.

HORSE

PART I.—ZOOLOGY AND ANATOMY.

Zoology.

THE horse and its near allies, the several species of asses and zebras, constitute the genus *Equus* of Linnæus, a small group of animals of the class *Mammalia*, so distinct in their organization from all other existing members of the class that in many of the older zoological systems they were placed in an order apart, under the name of *Solidungula* or *Monodactyla*.

Investigations in comparative anatomy have, however, demonstrated that their structure, at first sight so singular and exceptional, is really but a modification of the same general plan upon which the tapirs and rhinoceroses are formed, and the discovery and restoration of the characters of extinct species, inaugurated by Cuvier during his fruitful researches into the fauna of the Paris basin, continued in various European localities by Kaup, Rütimeyer, Gervais, Gaudry, Huxley, and others, and recently conducted on a more ample scale in the prolific fossiliferous strata of North America by Leidy, Marsh, and Cope, have revealed numerous intermediate stages through which the existing horses appear to have passed in their modification from a very different ancestral form.

We shall best understand what a horse really is if we first consider its origin and lineage; and this we are in a better position to do than with almost any other animal, as it is one of the few whose history (if the evidence afforded by palæontology can be relied upon) can be traced back through an almost unbroken chain of links as far as the earliest Tertiary age.

We have as yet no cognizance of the history of any mammals of the group to which the horse belongs before the dawn of the Eocene period. Of where they lived and what they were like, from what earlier forms and by what stages of modifications descended, our actual knowledge is an absolute blank. Conjecture helps us but little, and why none of their remains have not ere this been discovered is a palæontological mystery. We have, however, certain knowledge that when the land which formed the bottom of the great cretaceous ocean which flowed over a considerable part of the present continents of Europe and North America was lifted above the level of the water and became fitted for the habitation of terrestrial animals, it was very soon the abode of vast numbers of herbivorous mammals belonging to the group now called *Ungulata* or "hoofed animals." Wherever they came from, they had existed sufficiently long to have become already completely differentiated into two principal forms, separated from each other by many distinct points in their organization, among which one of the most externally conspicuous was the structure of their feet. From this character the one form has received the name of *Artiodactyla* or "even-toed," the other *Perissodactyla* or "odd-toed." It is only of the latter that we shall have to speak in this article.

Perhaps the best notion of a perissodactyle ungulate of the Eocene age can be derived from the tapir of the present day, an animal which has changed less from the primitive and generalized type of the group of that time than any other existing member of the order. These early forms had all the complete number of teeth found in so many of the mammals of that period of various orders, arranged according to the well-known formula—*incisors* $\frac{3}{3}$, *canines* $\frac{1}{1}$, *premolars* $\frac{4}{4}$, *molars* $\frac{3}{3} = \frac{11}{11}$ on each side, or 44 in all. The molar teeth had very short square crowns, with transverse or oblique ridges on the grinding surface. In the fore limbs the radius and ulna, and in the hind limbs the tibia and fibula, were distinct and well-developed bones. Whatever the number of toes on each foot, the one corresponding to the middle or third digit of the generalized pentadactyle limb was the longest; its ungual phalanx was symmetrical in itself, and it formed the centre of the foot, on each side of which the other toes were arranged in complete or partial symmetry according to the stage of development. In the hind foot in all known cases the symmetry was complete, only one toe on each side of the middle digit being present (fig. 3, *c*); but in the fore foot the primitive symmetry, formed by the presence of two toes on each side of the middle toe, had been lost in nearly all, by the disappearance of one of the outer toes (the first), the condition still retained by the tapirs (fig. 3, *a*); or it had been replaced by the second stage of symmetry, in which both outer toes are absent, and only three remain, as in the modern rhinoceros (fig. 3, *c*). By no animal of this period had the third, or most highly specialized stage of symmetry, that which, as we shall see, characterizes the modern horses (fig. 3, *e*), been attained.

By various and gradually progressing deviations from the common original type, these animals began at a very early period to break up into several groups, some of which (as *Macrauchenia*), after undergoing a considerable degree of specialization, have become extinct without leaving successors; but three of these modified types, already distinct at the close of the Eocene period, have continued up to the present day, gradually, as time advanced, becoming more and more divergent from each other. These are now represented by the three families of the rhinoceroses, the tapirs, and the horses. Great as may be the differences between these animals as we see them now, we can trace their history step by step, as revealed by the fragments preserved from former ages, further and further back in time, their differences continually becoming less marked, and ultimately blending together, if not into one common ancestor, at all events into forms so closely alike in all essentials that no reasonable doubt can be held as to their common origin.

Leaving out of further consideration the two collateral branches, it will be our purpose now to follow the history of the special subject of this article.

The remains of the earliest known animals to which it is possible to trace back the modern horse by a series of successive modifications are found in the lowest strata of the great lacustrine formations assigned to the Eocene period, spread over considerable portions of the present territories of New Mexico, Wyoming, and Utah in North America. That similar animals may have existed in other parts of the world is extremely probable. Negative evidence in such cases is of little value, as may be judged by the fact that it is only within a very few years that the existence of these deposits teeming with fossil remains of previously unsuspected forms has been brought to light, and their systematic exploration has scarcely yet commenced. A little animal, not larger than a fox, *Eohippus* of Marsh, presented the most generalized form of the perissodactyle type as yet discovered, as besides the four well-developed toes of the fore foot, found in so many others, it had at least a rudiment of a fifth. All analogy leads to the supposition that this must in its turn have been represented at a still earlier period by another form with all five toes complete, but direct evidence of this is at present wanting.

The transition from this horse-like animal of the early period to the horses of modern times has been accompanied by a gradual increase in size. The diminutive Eocene *Eohippus* and *Orohippus* were succeeded in the Miocene period by other forms to which the names of *Anchitherium* and *Miohippus* have been given, of the size of sheep; these again in Pliocene times by *Hipparion* and *Pliohippus*, as large as the modern donkeys; and it is only in the Pleistocene period that *Equidæ* appeared which approached in size the existing horse. Important structural modifications have also taken place, with corresponding changes in the mode of life of the animal. The neck has become elongated, the skull altered in form, the teeth greatly modified, and the limbs have undergone remarkable changes. The last two require to be described more in detail.

The teeth in the Eocene forms had, as mentioned above, the characteristic number of forty-four. This number has been retained throughout the series, at least theoretically; but one tooth on each side of each jaw, the anterior premolar, which in all the Eocene and Miocene species was a well-developed tooth, persisting through the life time of the animal, is in all modern horses rudimentary, functionless, and generally lost at an early period of life, evidently passing through a stage which must soon lead to its complete disappearance. The canines have also greatly diminished in size, and are rarely present in the female sex, so that practically a very large number of adult horses of the present day have eight teeth less than the number possessed by their predecessors. The diastema or interval between the incisor and premolar teeth, of essential importance in the domesticated horse to his master, as without it there could be no room for inserting the special instrument of subjugation to his commands, the bit, already existed in the earliest known forms, but has gradually increased in length. The incisors have undergone in comparatively recent times that curious change producing the structure which will be more fully described hereafter, and which distinguishes the horse's incisors from those of all other known animals. Lastly, the molars have undergone a remarkable series of modifications, much resembling in principle those that have taken place in several other groups of herbivorous animals. Distinctions in form which existed between the premolars, at least the anterior members of the series, and the true molars have gradually disappeared, the teeth becoming all very uniform in the shape and structure of their grinding surface. The crowns of all these teeth in the early forms were very short (see fig. 2, *a*); there was a distinct constriction, the neck, between the crown and roots; and when the tooth was developing, as soon as the neck once rose fairly above the alveolar margin, the tooth remained permanently in this position. The term "brachyodont" expresses this condition of teeth, the mode of growth of which may be illustrated by those of man. The free surface had two nearly transverse curved ridges, with valleys between (fig. 2, *a*); but the valleys were shallow and had no deposit of cementum filling them, the whole exposed surface of the unworn tooth being formed of enamel. When the ridges became worn down the dentine of the interior was exposed, forming islands surrounded by enamel. With the progress of time the crowns of the teeth gradually become longer, the valleys deeper, and the ridges not only more elevated but more curved and complex in arrangement. To give support to these high ridges and save them from breaking in use, the valleys or cavities between them became filled up to the top with cementum, and as the crown wore down an admirable grinding surface consisting of patches and islands of the two

FIG. 1.—*a*, Grinding surface of unworn molar tooth of *Anchitherium*; *b*, corresponding surface of unworn molar of young horse; *c*, the same tooth after it has been some time in use. The uncoloured portions are the dentine or ivory, the shaded parts the cementum filling the cavities and surrounding the exterior. The black line separating these two structures is the enamel or hardest constituent of the tooth

softer substances, dentine and cement, separated by variously reduplicated and contorted lines of intensely hard enamel, resulted (fig. 2, *c*). The crown continued lengthening until in the modern horses it has assumed the form called "hypsidont" (fig. 2, *b*). Instead of contracting into a neck, and forming roots, its sides continue parallel for a considerable depth in the socket, and as the surface wears away, the whole tooth slowly pushes up, and maintains the grinding edge constantly at the same level above the alveolus, much as in the perpetually growing rodent's teeth. But in existing horses there is still a limit to the growth of the molar. After a length is attained which in normal conditions supplies sufficient grinding surface for the lifetime of the animal, a neck and roots are formed, and the tooth is reduced to the condition of that of the brachyodont ancestor. It is perfectly clear that this lengthening of the crown adds greatly to the power of the teeth as organs of mastication, and enables the animals in which it has taken place to find their sustenance among the comparatively dry and harsh herbage of the open plains, instead of being limited to the more succulent vegetable productions of the marshes and forests in which their predecessors mainly dwelt.

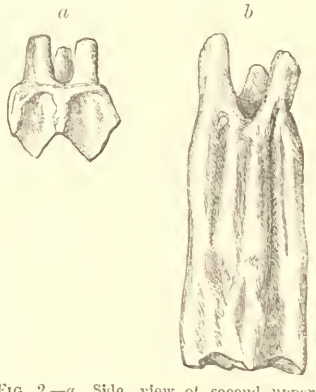

FIG. 2.—*a*, Side view of second upper molar tooth of *Anchitherium* (brachyodont form); *b*, corresponding tooth of horse (hypsidont form).

The modifications of the limbs which took place *pari passu* with those of the teeth must have been associated with increased speed, especially over firm and unyielding ground. Short, stout legs, and broad feet, with numerous toes, spreading apart from each other when the weight of the creature is borne on them, are sufficiently well adapted for plodding deliberately over marshy and yielding surfaces, and the tapirs and the rhinoceroses, which in the structure of the limbs have altered but little from the primitive Eocene forms, still haunt the borders of streams and lakes and the shady depths of the forests, as was probably the habit of their ancient representatives, while the horses are all inhabitants of the open plains, for life upon which their whole organization is in the most eminent degree adapted. The length and mobility of the neck, position of the eye and ear, and great development of the organ of smell, give them ample means of becoming aware of the approach of enemies, while the length of their limbs, the angles the different segments form with each other, and especially the combination of firmness, stability, and lightness in the reduction of all the toes to a single one, upon which the whole weight of the body and all the muscular power are concentrated, give them speed and endurance surpassing that of almost any other animal. When surprised, however, they are by no means helpless, both fore and hind feet becoming at need powerful weapons of defence.

If we were not so habituated to the sight of the horse as hardly ever to consider its structure, we should greatly marvel at being told of a mammal so strangely constructed that it had but a single toe on each extremity, on the end of the nail of which it walked or galloped. Such a formation is without a parallel in the vertebrate series, and is one of the most remarkable instances of specialization, or deviation from the usual type, in accordance with special conditions of life. It can be demonstrated, both by the structure of the foot itself, and also by an examination of the intermediate forms, that this toe corresponds to the middle or third of the complete typical or pentadactyle foot, the "ring finger" of man; and there is very strong evidence to show that by a gradual concentration of all the power of the limb upon this toe, and the concurrent dwindling away and final disappearance of all the others, the present condition of the horse's foot has been produced.

The small horse-like animals of the Eocene period with four, or rudiments at least of five, toes on the fore foot have been already mentioned. In the early Miocene period the animal most like an existing horse was the *Anchitherium*, the remains of which are found in a fossil state both in Europe and in America. In this genus there were three well-developed toes reaching the ground on each foot, and

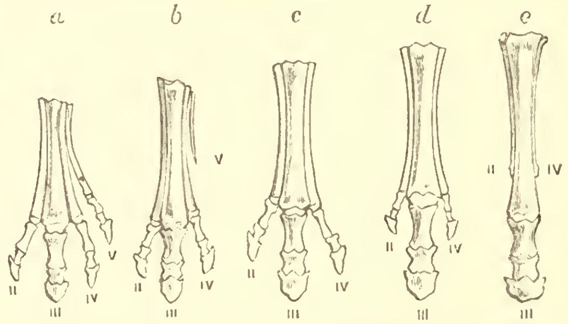

FIG. 3.—Successive stages of modification of the feet of extinct forms of horse-like animals (chiefly from Marsh), showing gradual reduction of the outer and enlargement of the middle toe (III). *a*, *Orohippus* (Eocene); *b*, *Mesohippus* (Early Miocene); *c*, *Miohippus* and *Anchitherium* (Late Miocene); *d* *Hipparion* and *Pliohippus* (Pliocene); *e*, *Equus* (Pleistocene).

the radius and ulna, and the tibia and fibula of the hind leg, were complete and distinct. This was succeeded on the European and Asiatic continent by *Hipparion* and in America by *Pliohippus*, perhaps more directly in the line of descent, as *Hipparion* has some special characters of its own in the teeth and skull, which make it probable that it is a collateral branch which became extinct without leaving descendants. In these and other forms which flourished at this period, the lateral toes, though containing the full number of bones, were much reduced in size, and did not reach the ground, but were suspended to the outside of and rather behind the large middle one, like the rudimentary outer toes of the deer, or the short first digit ("dew-claw") of the dog. Horses, or rather horse-like creatures, with this structure of feet were no longer met with in the Pleistocene period, but then for the first time appeared the true horse in its development exactly or very nearly as we know it now. The outer toes were reduced to rudiments of the metacarpals or metatarsals only, the so-called "splint bones" entirely concealed beneath the skin (fig. 3, *e*, II. and IV.), the middle toe (III.) greatly elongated, and with its ungual phalanx and hoof expanded, and the stability of the forearm and leg increased by the complete subordination of the ulna and fibula to the larger bones, the radius and tibia, which alone are concerned in the formation of the wrist and ankle joint.

Fossil remains of true horses, differing but very slightly from the smaller and inferior breeds of those now existing, are found abundantly in deposits of the most recent geological age, in almost every part of America, from Escholz Bay in the north to Patagonia in the south. In that continent, however, they became quite extinct, and no horses, either wild or domesticated, existed there at the time of the Spanish conquest, which is the more remarkable as, when introduced from Europe, the horses that ran wild proved by their rapid multiplication in the plains of South America and Texas that the climate, food, and other circumstances were highly favourable for their existence. The former great abundance of *Equidæ* in America, their complete extinction, and their perfect acclimatization when reintroduced by man, form curious but as yet unsolved problems in geographical distribution.

The existing species of the genus *Equus* are the following:—

(1.) The Horse, *Equus caballus*, Linn., is distinguished from the others by the long hairs of the tail being more abundant and growing quite from the base as well as the end and sides, and also by possessing a small bare callosity on the inner side of the hind leg, just below the "hock" or heel joint, in addition to the one on the inner side of the forearm above the carpus, common to all the genus. The mane is also longer and more flowing, and the ears shorter, the limbs longer, and the head smaller.

Though the existing horses are usually not marked in any definite manner, or only irregularly dappled, or spotted with light surrounded by a darker ring, many examples are met with showing a dark median dorsal streak like that found in all the other members of the genus, and even with dark stripes on the shoulders and legs indicating "the probability of the descent of all the existing races from a single dun-coloured, more or less striped, primitive stock, to which our horses still occasionally revert." [1]

In Europe wild horses were extremely abundant in the Neolithic or polished-stone period. Judging from the quantity of their remains found associated with those of the men of that time, the chase of these animals must have been among his chief occupations, and they must have furnished him with one of his most important food supplies. The characters of the bones preserved, and certain rude but graphic representations carved on bones or reindeers' antlers, enable us to know that they were rather small in size, and heavy in build, with large heads and rough shaggy manes and tails, much like, in fact, the present wild horses of the steppes of the south of Russia. These horses were domesticated by the inhabitants of Europe before the dawn of history, but it is doubtful whether the majority of the animals now existing on the Continent are derived directly from them, as it is more probable that they are descendants from horses imported though Greece and Italy from Asia, derived from a still earlier domestication, followed by gradual improvement through long-continued attention bestowed on their breeding and training. Horses are now diffused by the agency of man throughout almost the whole of the inhabited parts of the globe, and the great modifications they have undergone in consequence of domestication and selective breeding are well exemplified by comparing such extreme forms as the Shetland pony, dwarfed by uncongenial climate, the thoroughbred racer, and the London dray-horse. In Australia, as in America, horses imported by the European settlers have escaped into the unreclaimed lands, and multiplied to a prodigious extent, roaming in vast herds over the plains where no hoofed animal ever trod before.

(2.) *Equus asinus*, Linn.—The Domestic Ass is nearly as widely diffused and useful to man as the horse. It was known in Egypt long before the horse, and is probably of African origin, indeed its close resemblance to the existing wild ass of Abyssinia, *E. tæniopus*, Heuglin, leaves little doubt as to its identity with that species.

(3.) The Asiatic Wild Asses, which roam in small herds in the open plains of Syria, of many parts of Persia, of the north-west of India, and the highlands of Tartary and Tibet from the shores of the Caspian to the frontiers of China, differ from the last in being of a more rufous or isabelline colour, instead of pure grey, in wanting the dark streak across the shoulder, and having smaller ears. They have all a dark-coloured median dorsal stripe. Though it is considered probable by many zoologists that they form but a single species (*E. hemionus*, Pallas), they present such marked variations in size and form that they have commonly been divided into three—the Syrian Wild Ass (*E. hemippus*, Geoff.), the Onager (*E. onager*, Pall.) from Persia, the Punjab, Scinde and the desert of Cutch, and the Kiang or Dzeggetai (*E. hemionus*, Pallas) of the high table-lands of Tibet, where it is usually met with at an elevation of 15,000 feet and upwards above the sea-level. The last is considerably larger than either of the others, and differs from them in external appearance, having more the aspect of the horse. They are all remarkably swift, having been known to outstrip the fleetest horse in speed.

Lastly, there are three striped species, all inhabitants of South Africa. These constitute the genus *Hippotigris* of Hamilton Smith, but they are not separable except by their coloration from the true asses, and one of them (4), the Quagga (*E. quagga*, Gmel.), may be considered as intermediate. This animal has the dark stripes limited to the head, neck, and shoulders, upon a brown ground. In (5) the Dauw or Burchell's Zebra (*E. burchellii*, Gray), the ground colour is white, and the stripes cover the body and upper part of the limbs. This is the commonest species in the great plains of South Africa, where it roams in large herds, often in company with the quagga and numerous species of antelope. It ranges from the Orange River to the confines of Abyssinia. In (6) the Mountain Zebra (*E. zebra*, Linn.) the contrast between the clear white of the ground and the black of the stripes is most marked, and the latter extend quite down to the hoofs. This is, consequently, the most beautiful species of the group as regards colour, if the horse may bear the palm in elegance of form. It frequents mountainous districts rather than the open plains which are the dwelling-places of the other two species, and as it appears to be limited to the southern portion of the continent, within the confines of the Cape Colony, its numbers are rapidly diminishing under the encroachments of European civilization.

There are thus at least six modifications of the horse type at present existing, sufficiently distinct to be reckoned as species by all zoologists, and easily recognized by their external characters. They are, however, all so closely allied that each will, at least in a state of domestication or captivity, breed with perfect freedom with any of the others. Cases of fertile union are recorded between the horse and the quagga, the horse and the dauw or Burchell's zebra, the horse and the hemionus or Asiatic wild ass, the common ass and the zebra, the common ass and the dauw, the common ass and the hemionus, the hemionus and the zebra, and the hemionus and the dauw. The two species which are perhaps the farthest removed in general structure, the horse and the ass, produce, as is well known, hybrids or

[1] Darwin, *Variation of Animals and Plants under Domestication*, 1868, vol. i., chap. ii.

mules, which in some qualities useful to man excel both their progenitors, and in some countries and for certain kinds of work are in greater requisition than either. Although occasional instances have been recorded of female mules breeding with the males of one or other of the pure species, it is doubtful if any case has occurred of their breeding *inter se*, although the opportunities of doing so must have been great, as mules have been reared in immense numbers for at least several thousands of years. We may therefore consider it settled that the different species of the group are now in that degree of physiological differentiation which enables them to produce offspring with each other, but does not permit of the progeny continuing the race, at all events unless reinforced by the aid of one of the pure forms.

The several members of the group show mental differences quite as striking as those exhibited by their external form, and more than perhaps might be expected from the similarity of their cerebral organization. The patience of the ass, the high spirit of the horse, the obstinacy of the mule, have long been proverbial. It is very remarkable that, out of so many species, two only should have shown any aptitude for domestication, and that these two should have been from time immemorial the universal and most useful companions and servants of man, while all the others remain in their native freedom to this day. It is, however, still a question whether this really arises from a different mental constitution causing a natural capacity for entering into relations with man, or whether it may not be owing to their having been brought gradually into this condition by long continued and persevering efforts when the need of their services was keenly felt. It is quite possible that one reason why most of the attempts to add new species to the list of our domestic animals in modern times have ended in failure is that it does not answer to do so in cases in which existing species supply all the principal purposes to which the new ones might be put. It can hardly be expected that zebras and quaggas fresh from their native mountains and plains can be brought into competition as beasts of burden and draught with horses and asses, whose naturally useful qualities have been augmented by the training of thousands of generations of progenitors.

Not unfrequently instances occur of domestic horses being produced with a small additional toe with complete hoof, usually on the inside of the principal toe, and, though far more rarely, three or more toes may be present. These malformations are often cited as instances of reversion to the condition of some of the earlier forms of equine animals previously mentioned. Such explanations, however plausible they appear at first sight, are nevertheless very doubtful. All the feet of polydactyle horses which we have examined bear little resemblance to those of the extinct *Hipparion* or *Anchitherium*, but look rather as if due to that tendency to reduplication of parts which occurs so frequently as a teratological condition, especially among domestic animals, and which, whatever its origin, certainly cannot in many instances, as the cases of entire limbs superadded, or of six digits in man, be attributed to reversion.

ANATOMY.

The anatomical structure of the horse has been described in great detail in several works devoted to the subject, which will be mentioned in the bibliography, though these have generally been written from the point of view of the veterinarian rather than of the comparative anatomist. The limits of the present article will only admit of the most salient points being indicated, particularly those in which the horse differs from the other *Ungulata*. Unless otherwise specified, it must be understood that all that is stated here, although mostly derived from observation upon the horse, applies equally well to the other existing members of the group.

Skeleton.—The skull as a whole is greatly elongated, chiefly in consequence of the immense size of the face as compared with the hinder or true cranial portion. The basal line of the cranium from the lower border of the foramen magnum to the incisor border of the palate is very nearly straight. The orbit, of nearly circular form, though small in proportion to the size of the whole skull, is distinctly marked, being completely surrounded by a strong ring of bone with prominent edges. Behind it, and freely communicating with it beneath the osseous bridge (the post-orbital process of the frontal) forming the boundary between them, is the small temporal fossa occupying the whole of the side of the cranium proper, and in front is the great flattened expanse of the "cheek," formed chiefly by the superior maxilla, giving support to the long row of molar teeth, and having a prominent ridge running forward from below the orbit for the attachment of the masseter muscle. The lacrymal occupies a considerable space on the flat surface of the cheek in front of the orbit, and below it the malar does the same. The latter sends a horizontal or slightly ascending process backwards below the orbit to join the

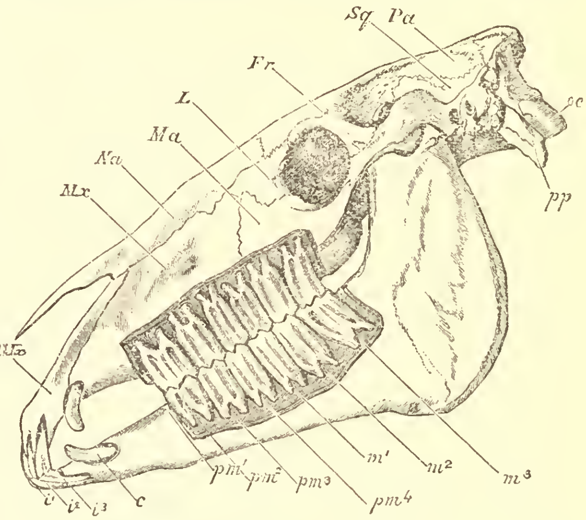

FIG. 4.—Side view of skull of horse, with the bone removed so as to expose the whole of the teeth. *PMx*, premaxilla; *Mx*, maxilla, *Na*, nasal bone; *Ma*, malar bone; *L*, lacrymal bone; *Fr*, frontal bone; *Sq*, squamosal bone; *Pa*, parietal bone; *oc*, occipital condyle; *pp*, paroccipital process; i^1, i^2, and i^3, the three incisor teeth; *c*, the canine tooth; pm^1, the situation of the rudimentary first premolar, which has been lost in the lower, but is present in the upper jaw; pm^2, pm^3, and pm^4, the three fully-developed premolar teeth; m^1, m^2, and m^3, the three true molar teeth.

under surface of the zygomatic process of the squamosal, which is remarkably large, and instead of ending as usual behind the orbit, runs forwards to join the greatly developed post-orbital process of the frontal, and even forms part of the posterior and inferior boundary of the orbit, an arrangement not met with in other mammals. The closure of the orbit behind distinguishes the skull of the horse from that of its allies the rhinoceros and tapir, and also from all of the perissodactyles of the Eocene period. In front of the cerebral cavity, the great tubular nasal cavities are provided with well-developed turbinal bones, and are roofed over by very large nasals, broad behind, and ending in front by a narrow decurved point. The opening of the anterior nares is prolonged backwards on each side of the face between the nasals and the elongated slender premaxillæ. The latter expand in front, and are curved downwards to form the semicircular alveolar border which supports the large incisor teeth. The palate is narrow in the interval between the incisor and molar teeth, in which are situated the large anterior palatine foramina. Between the molar teeth it is broader, and it ends posteriorly in a rounded excavated border opposite the hinder border of the penultimate molar tooth. It is mainly formed by the maxillæ, as the palatines are very narrow. The pterygoids are delicate slender slips of bone attached to the hinder border of the palatines, and supported externally by, and generally ankylosed to, the rough pterygoid plates of the alisphenoid, with no pterygoid fossa between. They slope very obliquely forwards, and end in curved, compressed, hamular processes. There is a distinct alisphenoid canal for the passage of the internal maxillary artery. The base of the cranium is long and narrow; the alisphenoid is very obliquely perforated by the foramen rotundum, but the foramen ovale is confluent with the large foramen lacerum medium behind. The glenoid surface for the articulation of the mandible is greatly extended transversely, concave from side to side, convex from before backwards in front, and hollow behind, and is bounded posteriorly at its inner part by a prominent post-glenoid process. The squamosal enters considerably into the formation of the temporal fossa, and, besides sending the zygomatic process forwards, it sends down behind the meatus auditorius a post-tympanic process which aids to hold in place the otherwise loose tympano-periotic bone. Behind this the exoccipital gives off a very long paroccipital process. The periotic and tympanic are ankylosed together, but not with the squamosal. The former has a wide but shallow floccular fossa on its inner side, and sends backwards a considerable "pars mastoidea," which appears on the outer surface of the skull between the post-tympanic process of the squamosal and the exoccipital. The tympanic forms a tubular meatus auditorius externus directed outwards and slightly backwards. It is not dilated into a distinct bulla, but ends in front in a pointed styliform process. It completely embraces the truncated cylindrical tympanohyal, which is of great size, corresponding with the large development of the whole anterior arch of the hyoid. This consists mainly of a long and compressed stylohyal, expanded at the upper end, where it sends off a triangular posterior process. The basi-hyal is remarkable for the long, median, pointed, compressed "glossohyal" process, which it sends forward from its anterior border into the base of the tongue. A similar but less developed process is found in the rhinoceros and tapir. The mandible is largely developed, especially the region of the angle, which is expanded and flattened, giving great surface for the attachment of the masseter muscle. The condyle is greatly elevated above the alveolar border; its articular surface is very wide transversely, and narrow and convex from before backwards. The coronoid process is slender, straight, and inclined backwards. The horizontal ramus, long, straight, and compressed, gradually narrows towards the symphysis, where it expands laterally to form with the ankylosed opposite ramus the wide, semicircular, shallow alveolar border for the incisor teeth.

The vertebral column consists of seven cervical, eighteen dorsal, six lumbar, five sacral, and fifteen to eighteen caudal vertebræ. There may be nineteen rib-bearing vertebræ, in which case five only will be reckoned as belonging to the lumbar series. The odontoid process of the atlas is wide, flat, and hollowed above, as in the ruminants. The bodies of the cervical vertebræ are elongated, strongly keeled, and markedly opisthocœlous, or concave behind and convex in front. The neural laminæ are very broad, the spines almost obsolete, except in the seventh, and the transverse processes not largely developed. In the trunk vertebræ the opisthocœlous character of the centrum gradually diminishes. The spinous processes of the anterior thoracic region are high and compressed. To these is attached the powerful elastic ligament, *ligamentum nuchæ*, or "paxwax," which passing forwards in the middle line of the neck above the neural arches of the cervical vertebræ, to which it is also connected, is attached to the occiput and supports the weight of the head. The transverse processes of the lumbar vertebræ are long, flattened, and project horizontally outwards or slightly forward from the arch. The metapophyses are moderately developed, and there are no anapophyses. The caudal vertebræ, except those quite at the base, are slender and cylindrical, without processes and without chevron bones beneath. The ribs are eighteen or nineteen in number on each side, flattened, and united to the sternum by short, stout, tolerably well ossified sternal ribs. The sternum consists of six pieces; the anterior or præsternum is extremely compressed, and projects forwards like the prow of a boat. The segments which follow gradually widen, and the hinder part of the sternum is broad and flat.

As in all other ungulates, there are no clavicles. The scapula is long and slender; the supra-scapular border is rounded, and slowly and imperfectly ossified. The spine is very slightly developed; rather above the middle its edge is thickened and somewhat turned backwards, but it gradually subsides at the lower extremity without forming any acromial process. The coracoid is a prominent rounded nodule. The humerus is stout and rather short. The ulna is quite rudimentary, being only represented by little more than the olecranon. The shaft gradually tapers below and is firmly ankylosed to the radius. The latter bone is of nearly equal width throughout. The three bones of the first row of the carpus (the scaphoid, lunar, and cuneiform) are subequal in size. The second row consists of a very broad and flat magnum, supporting the great third metacarpal, having to its radial side the trapezoid, and to its ulnar side the unciform, which are both small, and articulate distally with the rudimentary second and fourth metacarpals. The pisiform is large and prominent, flattened, and curved; it articulates partly with the cuneiform and partly with the lower end of the radius. The large metacarpal is called in veterinary anatomy "cannon bone"; the small lateral metacarpals, which gradually taper towards their lower extremities, and lie in close contact with the large one, are called "splint bones." The single digit consists of a moderate-sized proximal (*os suffraginis*, or large pastern), a very short middle (*os coronæ*, or small pastern), and a wide, semi-lunar, ungual phalanx (*os pedis*, or coffin bone). There is a pair of large nodular sesamoids behind the metacarpo-phalangeal articulation, and a single large transversely-extended sesamoid behind the joint between the second and third phalanx, called the "navicular bone."

The carpal joint, corresponding to the wrist of man, is commonly called the "knee" of the horse, the joint between the metacarpal and the first phalanx the "fetlock," that between the first and second phalanges the "pastern," and that between the second and third phalanges the "coffin joint."

In the hinder limb the femur is marked, as in all other known perissodactyles, by the presence of a "third trochanter," a flattened process, curving forwards, arising from the outer side of the bone, about one-third of the distance from the upper end. The fibula is reduced to a mere styliform rudiment of the upper end. The lower part is absent or completely fused with the tibia. The os calcis has a long and compressed calcaneal process. The astragalus has a large flat articular surface in front for the navicular, and a very small one for the cuboid. The navicular and the external cuneiform bones are very broad and flat. The cuboid is small, and the internal and middle cuneiform bones are small and united together. The metapodals and phalanges resemble very closely those of the fore limb, but the principal metatarsal is more laterally compressed at its upper end than is the corresponding metacarpal.

The joint between the femur and tibia, corresponding to the knee of man, is called the "stifle joint"; that between the tibia and tarsus, corresponding to the ankle of man, is called the "hock." The bones and joints of the foot have the same names as in the fore limb. The horse is eminently "digitigrade," standing on the extremity of the single digit of each foot, which is kept habitually in a position approaching to vertical.

The muscles of the limbs are modified from those of the ordinary mammalian type in accordance with the reduced condition of the bones and the simple requirements of flexion and extension of the joints, no such actions as pronation and supination, or opposition of digits, being possible or needed. The muscles therefore which perform these functions in other quadrupeds are absent or rudimentary.

Below the carpal and tarsal joints, the fore and hind limbs correspond almost exactly in structure as well as function. On the anterior or extensor surface of the limb a powerful tendon (7 in fig. 5), that of the anterior extensor

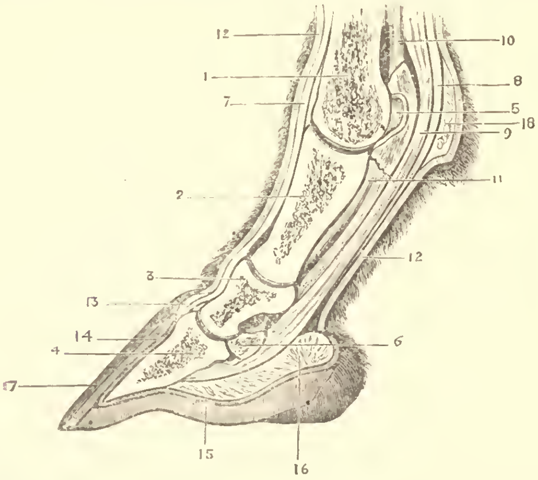

FIG. 5.—Section of foot of horse. 1, metacarpal bone; 2, first phalanx (*os suffraginis*); 3, second phalanx (*os coronæ*); 4, third or ungual phalanx (*os pedis*, or coffin bone); 5, one of the upper sesamoid bones; 6, lower sesamoid or navicular bone; 7, tendon of anterior extensor of the phalanges; 8, tendon of superficial flexor (*fl. perforatus*); 9, tendon of deep flexor (*fl. perforans*); 10, suspensory ligament of fetlock; 11, inferior or short sesamoid ligament; 12, derma or skin of the foot, covered with hair, and continued into 13, the coronary cushion, 14, the podophyllous or laminar membrane, and 15, the keratogenous membrane of the sole; 16, plantar cushion; 17, hoof; 18, fatty cushion of fetlock.

of the phalanges (corresponding to the *extensor communis digitorum* of the arm and *extensor longus digitorum* of the foot of man) passes down over the metacarpal bone and phalanges, to be inserted mainly into the upper edge of the anterior surface of the last phalanx or pedal bone. There is also a much smaller second extensor on the outer side of this in each limb, the lateral extensor of the phalanges. In the fore leg the tendon of this muscle (which corresponds with the *extensor minimi digiti* of man) receives a slip from that of the principal extensor, and is inserted into the first phalanx. In the hind leg (where it is the homologue apparently of the *peroneus brevis* of man) the tendon becomes blended with that of the large extensor.

A very strong ligamentous band behind the metapodium, arising from near the upper extremity of its posterior surface, divides into two at its lower end, and each division, being first connected with one of the paired upper sesamoid bones, passes by the side of the first phalanx to join the extensor tendon of the phalanges. This is called in veterinary anatomy the "suspensory ligament of the sesamoids," or of the "fetlock" (10 in fig. 5); but its attachments and relations, as well as the occasional presence of muscular fibres in its substance, show that it is the homologue of the interosseous muscles of other mammals, curiously modified both in structure and function, to suit the requirements of the horse's foot. Behind or superficial to this are placed the two strong tendons of the flexor muscles, the most superficial, or *flexor perforatus* (8), dividing to allow the other to pass through, and then inserted into the middle phalanx. The *flexor perforans* (9) is as usual inserted into the terminal phalanx. In the fore leg these muscles correspond with those similarly named in man. In the hind leg, the perforated tendon is a continuation of that of the plantaris, passing pulley-wise over the tuberosity of the os calcis. The perforating tendon is derived from the muscle corresponding with the long flexor of man, and the smaller tendon of the oblique flexor (*tibialis porticus* of man) is united with it.

The hoof of the horse corresponds to the nail or claw of other mammals, but is so constructed as to form a complete and very solid case to the expanded termination of the toe, giving a firm basis of support formed of a non-sensitive substance, which is continually renewed by the addition of material from within, as its surface wears away by friction against the ground. The terminal phalanx of the toe is greatly enlarged and modified in form to support this hoof, and the size of the internal framework of the foot is further increased by a pair of lateral fibro-cartilaginous masses attached on each side to the hinder edges of the bone, and by a fibro-cellular and adipose plantar cushion in the median part. These structures are all enclosed in the keratogenous membrane or "subcorneous integument," a continuation of the ordinary derma of the limb, but extremely vascular, and having its superficial extent greatly increased by being developed into papillæ or laminæ. From this the horny material which constitutes the hoof is exuded. A thickened ring encircling the upper part, called coronary cushion (13), and the sole (15), are covered with numerous thickly-set papillæ or villi, and take the greatest share in the formation of the hoof; the intermediate part constituting the front and side of the foot (14), corresponding with the wall of the hoof, is covered with parallel, fine longitudinal laminæ, which fit into corresponding depressions in the inner side of the horny hoof.

The horny hoof is divided into a wall or crust consisting of the front and sides, the flattened or concave sole, and the frog, a triangular median prominence, notched posteriorly, with the apex turned forwards, situated in the hinder part of the sole. It is formed of pavement epithelial cells, which are mainly grouped in a concentric manner around the vascular papillæ of the keratogenous membrane, so that a section near the base of the hoof, cut transversely to the long axis of these papillæ, shows a number of small circular or oval orifices, with cells arranged concentrically round them. The nearer the surface of the hoof, or further removed from the seat of growth, the more indistinct the structure becomes.

Small round or oval plates of horny epithelium called "chestnuts," growing like the hoof from enlarged papillæ of the skin, are found on the inner face of the fore arm, above the carpal joint in all species of *Equidæ*, and in the horse (*E. caballus*) similar formations occur near the upper extremity of the inner face of the metatarsus. Their use is unknown.

Dentition.—The dentition of the horse, when all the teeth are in place, is, as stated before, expressed by the formula $i.\ \frac{3}{3},\ c.\ \frac{1}{1},\ p.\ \frac{4}{4},\ m.\ \frac{3}{3} = 44$. The incisors of each jaw are placed in close contact, forming a semicircle. The crowns are broad, somewhat awl-shaped, and of nearly equal size. They have all the great peculiarity, not found in the teeth of any other mammal, and only in the *Equidæ* of comparatively recent geological periods, of an involution of the external surface of the tooth (see fig. 6), by which what should properly be the apex is carried deeply into the interior of the crown, forming a fossa or pit, the bottom of which becomes partially filled up with crusta petrosa or cementum. As the tooth wears, the surface, besides the external enamel layer as in an ordinary simple tooth, shows in addition a second inner ring of the same hard substance surrounding the pit, which of course adds greatly to the efficiency of the tooth as an organ for biting tough, fibrous substances. This pit, generally filled in the living animal with particles of food, is conspicuous from its dark colour, and constitutes the "mark" by which the age of the horse is judged, as in consequence of its only extending to a certain depth in the crown it becomes obliterated as the crown wears away, and then the tooth assumes the character of that of an ordinary incisor, consisting only of a core of dentine, surrounded by the external enamel layer. It is not quite so deep in the lower as in the upper teeth.

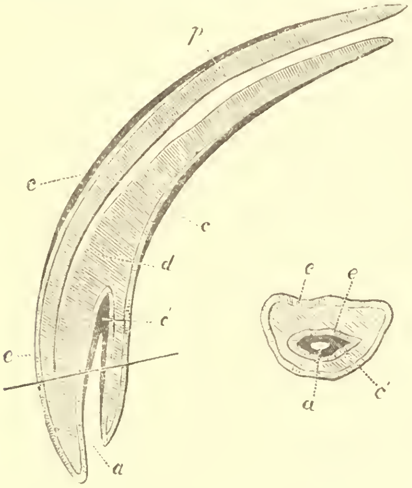

Fig. 6.—Longitudinal and transverse section of upper incisor of horse. *p*, pulp cavity; *d*, dentine or ivory; *e*, enamel; *c*, outer layer of cementum or crusta petrosa; *c′*, inner layer of cementum, lining *a*, the pit or cavity of the crown of the tooth.

The canines are either quite rudimentary or entirely absent in the female. In the male they are compressed, pointed, and smaller than the incisors, from which they are separated by a slight interval. The teeth of the molar series are all in contact with each other, but separated from the canines by a considerable toothless space. The anterior premolars are quite rudimentary, sometimes not developed at all, and generally fall by the time the animal attains maturity, so that there are but six functional grinding teeth,—three that have predecessors in the milk dentition, and hence are considered as premolars, and three true molars, but otherwise, except the first and last of the series, not distinguishable in form or structure. These teeth in both upper and lower jaws are extremely long-crowned or hypsidont, successive portions being pushed out as the surface wears away, a process which continues until the animal becomes advanced in age. The enamelled surface is infolded in a complex manner (a modification of that found in other perissodactyles), the folds extending quite to the base of the crown, and the interstices being filled and the surface covered with a considerable mass of cement, which binds together and strengthens the whole tooth. As the teeth wear, the folded enamel, being harder than the other constituents, the dentine and cement, forms projecting ridges on the surface arranged in a definite pattern, which give it great efficiency as a grinding instrument (see fig. 1, *b* and *c*). The free surfaces of the upper teeth are quadrate, except the first and last, which are nearly triangular. The lower teeth are much narrower than the upper.

The milk dentition consists of $i.\ \frac{3}{3}$, $c.\ \frac{0}{0}$, $m.\ \frac{3}{3} = 24$,—the canines and first or rudimentary premolars having apparently no predecessors. In form and structure they much resemble the permanent teeth, having the same characteristic enamel foldings. Their eruption commences a few days after birth, and is complete before the end of the first year, the upper teeth usually appearing somewhat earlier than those of the lower jaw. The first teeth which appear are the first and second milk molars (about five days), then the central incisor (from seven to ten days); this is followed by the second incisor (at one month), then the third molar, and finally the third incisor. Of the permanent teeth the first true molar appears a little after the end of the first year, followed by the second molar before the end of the second year. At about two and a half years the first premolar replaces its predecessor. Between two and a half and three years the first incisor appears. At three years the second and third premolars, and the third true molar have appeared, at from three and a half to four years the second incisor, at four to four and a half years the canine, and, finally, at five years, the third incisor, completing the permanent dentition. Up to this period the age of the horse is clearly shown by the condition of dentition, and for some time longer indications can be obtained from the wear of the incisor teeth, though this depends to a certain extent upon the hardness of the food or other accidental circumstances. As a general rule, the depression caused by the infolding of the surface of the incisor (the "mark") is obliterated in the first or central incisor at six years, in the second at seven years, and in the third at eight years. In the upper teeth, as the depressions are deeper, this obliteration does not take place until about two years later. After this period no certain indications can be obtained of the age of the horse from the teeth.

Digestive Organs.—The lips are flexible and prehensile. The membrane that lines them and the cheeks is quite smooth. The palate is long and narrow; its mucous surface has seventeen pairs of not very sharply defined oblique ridges, extending as far back as the last molar tooth, beyond which the velum palati extends for about 3 inches, having a soft corrugated surface, and ending posteriorly in an arched border without uvula. This embraces the base of the epiglottis, and, except while swallowing food, shuts off all communication between the cavity of the mouth and the pharynx, respiration being, under ordinary circumstances, exclusively through the nostrils. Between the mucous membrane and the bone of the hard palate is a dense vascular and nervous plexus. The membrane lining the fauces is soft and corrugated. An elongated raised glandular mass, 3 inches long and 1 inch from above downwards, extending backwards from the root of the tongue along the side of the fauces, with openings on the surface leading into crypts with glandular walls, represents the tonsil. The tongue, corresponding to the general form of the mouth, is long and narrow. It consists of a compressed intermolar portion with a flat upper surface, broad behind and becoming narrower in front, and of a depressed anterior part rather shorter than the former, and which is narrow behind and widens towards the evenly rounded apex. The dorsal surface generally is very soft and smooth. There are two large circumvallate papillæ near the base, rather irregular in form, about a quarter of an inch in diameter and half an inch apart. The conical papillæ are very small and close set, though longer and more filamentous on the intermolar portion. There are no fungiform papillæ on the dorsum, but a few not very conspicuous ones scattered along the sides of the organ.

Of the salivary glands the parotid is by far the largest, and elongated in the vertical direction, and narrower in the middle than at either upper or lower extremity. Its upper extremity embraces the lower surface of the cartilaginous ear-conch; its lower end reaches the level of the inferior margin of the mandible, along the posterior margin of which it is placed. Its duct leaves the inferior anterior angle, at first descends a little, and runs forward under cover of the rounded inferior border of the mandibular ramus, then curves up along the anterior margin of the masseter muscle, becoming superficial, pierces the buccinator, and enters the mouth by a simple aperture opposite the middle of the crown of the third premolar tooth. It is not quite so thick as a goosequill when distended, and nearly a foot in length.

The submaxillary gland is of very similar texture to the last, but much smaller; it is placed deeper, and lies with its main axis horizontal. It is elongated and slender, and flattened from within outwards. Its posterior end rests against the anterior surface of the transverse process of the atlas, from which it extends forwards and downwards, slightly curved, to beneath the ramus of the jaw. The duct which runs along its upper and internal border passes forwards in the usual course, lying in the inner side of the sublingual gland, to open on the outer surface of a distinct papillæ, situated on the floor of the mouth, half an inch from the middle line, and midway between the lower incisor teeth and the attachment of the frænum linguæ. The sublingual is represented by a mass of glands lying just beneath the mucous membrane of the floor of the mouth on the side of the tongue, causing a distinct ridge, extending from the frænum backwards, the numerous ducts opening separately along the summit of the ridge. The buccal glands are arranged in two rows parallel with the molar teeth. The upper ones are the largest, and are continuous anteriorly with the labial glands, the ducts of which open on the mucous membrane of the upper lip.

The stomach of the horse is simple in its external form, with a largely developed right *cul de sac*, and is a good deal curved on itself, so that the cardiac and pyloric orifices are brought near together. The antrum pyloricum is small and not very distinctly marked off. The interior is divided by the character of the lining membrane into two very distinct portions, right and left. Over the latter the dense white smooth epithelial lining of the œsophagus is continued, terminating abruptly by a raised crenellated border. Over the right part (rather the larger portion) the mucous membrane has a greyish-red colour and a velvety appearance, and contains very numerous peptic glands, which are wanting in the cardiac portion. The œsophageal orifice is very small, and is guarded by a strong crescentic or rather horseshoe-like band of muscular fibres, which is supposed to be the cause of the difficulty of vomiting in the horse. The small intestine is of great length (80 to 90 feet), its mucous membrane being covered with numerous fine villi. The cæcum is of conical form, about 2 feet long and nearly a foot in diameter; its walls are sacculated, especially near the base, having four longitudinal muscular bands; and its capacity is about twice that of the stomach. It lies with its base near the lower part of the abdomen, and its apex directed towards the thorax. The colon is about one-third the length of the small intestine, and very capacious in the greater part of its course. As usual it may be divided into an ascending, transverse, and descending portion; but the middle or transverse portion is folded into a great loop, which descends as low as the pubis; so that the colon forms altogether four folds, generally parallel to the long axis of the body. The descending colon is much narrower than the rest, and not sacculated, and, being considerably longer than the distance it has to traverse, is thrown into numerous folds.

The liver is tolerably symmetrical in its general arrangement, being divided nearly equally into segments by a well-marked umbilical fissure. Each segment is again divided by lateral fissures, which do not extend quite to the posterior border of the organ; of the central lobes thus cut off, the right is rather the larger, and has two fissures in its free border subdividing it into lobules. The extent of these varies, however, in different individuals. The two lateral lobes are subtriangular in form. The Spigelian lobe is represented by a flat surface between the postal fissure and the posterior border, not distinctly marked off from the left lateral by a fissure of the ductus venosus, as this vessel is buried deep in the hepatic substance, but the caudate lobe is distinct and tongue-shaped, its free apex reaching nearly to the border of the right lateral lobe. In most works on the anatomy of the horse this has been confounded with the Spigelian lobe of man. There is no gall-bladder, and the biliary duct enters the duodenum about 6 inches from the pylorus. The pancreas has two lobes or branches, a long one passing to the left and reaching the spleen, and a shorter right lobe. The principal duct enters the duodenum with the bile-duct, and there is often a second small duct which opens separately near to this.

Circulatory and Respiratory Organs.—The heart has the form of a rather elongated and pointed cone. There is one anterior vena cava, formed by the union of the two jugular and two axillary veins. The aorta gives off a large branch (the anterior aorta) very near its origin, from which arise—first, the left axillary, and afterwards the right axillary and the two carotid arteries.

Under ordinary circumstances the horse breathes entirely by the nasal passages, the communication between the larynx and the mouth being closed by the velum palati. The nostrils are placed laterally, near the termination of the muzzle, and are large and very dilatable, being bordered by cartilages upon which several muscles act. Immediately within the opening of the nostril, the respiratory canal sends off on its upper and outer side a diverticulum or blind pouch (called "false nostril") of a conical form, and curved, 2 to 3 inches in depth, lying in the notch formed between the nasal and premaxillary bones. It is lined by mucous membrane continuous with that of the nasal passage, and its use is not apparent. It is longer in the ass than in the horse. Here may be mentioned the guttural pouches, large air sacs, diverticula from the Eustachian tubes, and lying behind the upper part of the pharynx, the function of which is also not clearly understood. The larynx has the lateral sacculi well developed, though entirely concealed within the alæ of the thyroid cartilage. The trachea divides into two bronchi, one for each lung.

Nervous System.—The brain differs little, except in details of arrangement of convolutions, from that of other ungulates. The cerebral hemispheres are rather elongated and subcylindrical, the olfactory lobes are large and project freely in front of the hemispheres, and the greater part of the cerebellum is uncovered. The eye is provided with a nictitating membrane or third eyelid, at the base of which the ducts of the Harderian gland open.

Reproductive System.—The testes are situated in a distinct sessile or slightly pedunculated scrotum, into which they descend from the sixth to the tenth month after birth. The accessory generative glands are the two vesiculæ seminales, with the median third vesicle, or *uterus masculinus*, lying between them, the single bilobed prostate, and a pair of globular Cowper's glands. The penis is very large, cylindrical, with a truncated, expanded, flattened termination. When in a state of repose it is retracted, by a muscle arising from the sacrum, within the prepuce, a cutaneous fold attached below the symphysis pubis.

The uterus is bicornuate. The vagina is often partially divided by a membraneous septum or hymen. The mammæ are two, inguinally placed. The surface of the chorion is covered evenly with minute villi, constituting a diffuse non-deciduate placenta. The period of gestation is eleven months.

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PART II.—HISTORY, MANAGEMENT, AND BREEDING.

From the evidence of philology it is plain that the horse was already known to the Aryans before the period of their dispersion.[1]

The first mention of the British horse occurs in the well-known passages in Cæsar (*B. G.*, iv. 24, 33; v. 15, 16; *cf.* Pomp. Mela, iii. 6), in which he mentions the native "essedarii" and the skill with which they handled their war chariots. We are left quite in the dark as to the character of the animal thus employed; but there would appear to be much probability in the surmise of Youatt, who conjectures the horse to have been, "then as ever, the creature of the country in which he lived. With short fare, and exposed to the rigour of the seasons, he was probably the little hardy thing we yet see him; but in the marshes of the Nen and the Witham, and on the borders of the Tees and the Clyde, there would be as much proportionate development of frame and strength as we find at the present day." After the occupation of the country by the Romans, it appears that the horses of their cavalry were crossed with the native mares, and thus there was infused into the breed new blood, consisting probably of strains from every quarter from which Roman remounts were procured. As to the effect of this cross we are not, however, in a position to judge. We are also quite uncertain as to the extent to which the Jutes and Saxons may in their turn have again introduced a new breed of horses into England; and even to the close of the Anglo-Saxon period of English history allusions to the horse are still very unfrequent. The *horsthegn* we know, however, was from an early period a high court official; and from such a law as that of Athelstan prohibiting the exportation of horses except as presents, it may be inferred that the English breed was not only much valued at home but also in great request abroad.[2]

The period of the Norman Conquest marks an important stage in the history of the British horse. William the Conqueror's own horse was of the Spanish breed, and others of the same kind were introduced by the barons on their estates. But the Norman horses included many varieties, and there is no doubt that to the Conquest the inhabitants of Britain were indebted for a decided improvement in the native horse, as well as for the introduction of several varieties previously unknown. According to Giraldus Cambrensis, Roger de Bellesme, a follower of William I., afterwards created earl of Shrewsbury, imported some stallions from Spain into England; their produce was celebrated by Drayton the poet. It is curious to notice that agriculture seems to be the last use to which the horse has been put. The earliest suggestion that horses were used in agriculture is derived from a piece of the Bayeux tapestry, where a horse is represented as drawing a harrow. This, however, must have been an exceptional case, for we know that oxen were used until a comparatively late time, and that in Wales a law existed forbidding horses to be used for ploughing.

In 1121 two Eastern horses are said to have been imported,—one of them remaining in England, and the other being sent as a present by King Alexander I. to the church of St Andrews, in Scotland. It has been alleged that these horses were Barbs from Morocco, but a still more likely theory is that they existed only in name, and never reached either England or Scotland. The crusades were probably the means of introducing fresh strains of blood into England, and of giving opportunity for fresh crossings. The Spanish jennet was brought over about 1182. King John gave great encouragement to horse-breeding: one of his earliest efforts was to import a hundred Flemish stallions, and, having thus paved the way for improving the breed of agricultural horses, he set about acquiring a valuable stud for his own use.

Edward III. was likewise an admirer of the horse; he procured fifty Spanish horses, probably jennets. At this time there was evidently a tendency to breed a somewhat lighter and speedier horse; but, while the introduction of a more active animal would soon have led to the displacement of the ponderous but powerful cavalry horse then in use, the substituted variety would have been unable to carry the weight of armour with which horse and rider were alike protected; and so in the end the old breed was kept up for a time. With the object of preserving to England whatever advantages might accrue from her care and skill in breeding an improved stamp of horses, Edward III. forbade their exportation; they consequently improved so rapidly in value that Richard II. compelled dealers to limit their prices to a fixed maximum. In the ninth year of his reign, Edward received from the king of Navarre a present of two running horses, supposed to have been valuable. The wars of 1346 checked the improvement of horses, and undid much of what had been previously accomplished, for we read that the cavalry taken into France by Edward III. were but

[1] Compare Sanscr., *açva*; Zendish and Old Persian, *açpa*; Lithuanian, *aszra* (mare); Prussian, *asvinan* (mare's milk); Old High German, *ehu*; Anglo-Saxon, *eoh*; Icel., *iör*; Gothic, *aihos*, *aihous* (?); Old Irish, *ech*; Old Cambrian and Gaelic, *ep* (as in *Epona*, the horse goddess); Lat., *equus*; Gr., ἵππος or ἴκκος. The word seems, however, to have disappeared from the Slavonic languages. The root is probably *ak*, with the idea of sharpness or swiftness (ἄκρος, ὠκύς, *acus*, *ocior*). See Pott, *Etym. Forsch.*, ii. 256, and Hehn, *Kulturpflanzen u. Hausthiere in ihrem Uebergang aus Asien nach Griechenland u. Italien sowie in das übrige Europa* (3d ed., 1877), p. 38. The last-named author, who points out the absence of the horse from the Egyptian monuments prior to the beginning of the 18th century B.C., and the fact that the earliest references to this animal in Hebrew literature (Judg. v. 22, 28; *cf.* Josh. xi. 4) do not carry us any further back, is of opinion that the Semitic peoples as a whole were indebted for the horse to the lands of Iran. He also shows that literature affords no trace of the horse as indigenous to Arabia prior to about the beginning of the 5th century A.D., although references abound in the pre-Islamitic poetry. Horses were not numerous even in Mahomet's time (Sprenger, *Leb. Moh.*, iii. 139, 140). Compare Ignazio Guidi's paper "Della sede primitiva dei popoli Semitici" in the *Transactions* of the Accademia dei Lincei (1878–79).

[2] Some fragments of legislation relating to the horse about this period may be gleaned from *Ancient Laws and Institutes of England* (fol., London, 1840), and *Ancient Laws and Institutes of Wales* (fol., London, 1841).

indifferently mounted, and that in consequence he had to purchase large numbers of foreign horses from Hainault and elsewhere for remounts. The reign of Richard III. does not seem to have been remarkable for the furtherance of horse-breeding; but it was then that post-horses and stages were introduced.

Our information on the whole subject is but scanty down to the reign of Henry VII., who continued the enactment against the exportation of stallions, but relaxed it in the case of mares above two years old. His object was to retain the best horses in the country, and to keep the price of them down by limiting the demand and encouraging the supply. In his reign gelding is believed to have had its origin, on account of numerous herds of horses belonging to different proprietors grazing together, especially in time of harvest. Henry VIII. was particularly careful that horse-breeding should be conducted on right principles, and his enactments, if somewhat arbitrary, were singularly to the point. In the thirty-second year of this reign, the "bill for the breed of horses" was passed, the preamble of which runs thus:—"Forasmuch as the generation and breed of good and strong horses within this realm extendeth not only to a great help and defence of the same, but also is a great commodity and profit to the inhabitants thereof, which is now much decayed and diminished, by reason that, in forests, chases, moors, and waste grounds within this realm, little stoned horses, and nags of small stature and of little value, be not only suffered to pasture thereupon, but also to cover mares feeding there, whereof cometh in manner no profit or commodity." Section 2 of the Act provides that no entire horse being above the age of two years, and not being of the height of 15 "handfulls," shall be put to graze on any common or waste land in certain counties; any one was to be at liberty to seize a horse of unlawful height, and those whose duty it was to measure horses, but who refused to do so, were to be fined 40s. By section 6 all forests, chases, commons, &c., were to be "driven" within fifteen days of Michaelmas day, and all horses, mares, and colts not giving promise of growing into serviceable animals, or of producing them, were to be killed. The aim of the Act was to prevent breeding from animals not calculated to produce the class of horse suited to the needs of the country. By another Act (27 Henry VIII. chapter 6), after stating that the "breed of good strong horses" was likely to diminish, it was ordered that the owners of all parks and enclosed grounds of the extent of one mile should keep two mares 13 hands high for breeding purposes, or, if the extent of the ground was four miles, four mares. The statute was not to extend to the counties of Westmoreland, Cumberland, Northumberland, or the bishopric of Durham. Henry took great pains to improve the royal stud: according to Sir Thomas Chaloner—a writer in the reign of Elizabeth—he imported horses from Turkey, Naples, and Spain.

Queen Elizabeth is reputed to have been an accomplished horsewoman, and to have indulged in riding late in life. In the first year of her reign she revived an Act passed by Henry VIII. making it felony "to sell, exchange, or deliver within Scotland, or to the use of any Scottishman, any horse;" this, however, was very naturally repealed by James I. Carriages were soon after introduced, and the use of them speedily became so fashionable that a bill was brought in "to restrain the excessive and superfluous use of coaches." Prior to the introduction of carriages, horseback was the means of locomotion, and Queen Elizabeth rode in state to St Paul's on a pillion; but even after carriages were used, horseback was held to be more dignified, for James I. and his judges rode on horseback to Westminster Hall. One advantage of the introduction of carriages was that it created a demand for a lighter and quicker sort of horse, instead of the ponderous animal which, despite all attempts to banish him, was still the horse of England—the age of chivalry having been the first epoch of the British horse.

Gunpowder, too, was invented; and now that the weight of the cavalry soldier was diminished by the substitution of lighter armour, a quicker and better bred horse was thought desirable for military service. The introduction of carriages and the invention of gunpowder thus opened out a new industry in breeding; and a decided change was gradually creeping on by the time that James I. came to the throne (1603), which commences the second epoch. James was a thorough sportsman, and his taste for racing, in which he freely indulged, caused him to think but little of the speed of even the best English horses. With the laudable motive therefore of effecting improvement in horses, he gave the then large sum of 500 guineas for an Arab stallion which had been procured from Constantinople by a Mr Markham, since known as the "Markham Arabian." This is the first authentic account we have of the importation of Arab blood, and the *Stud-Book* says he was the first of that breed ever seen in England. The people having to do with horses at that time were as conservative in their notions as most of the grooms are now, and the "Markham Arabian" was not at all approved of. The duke of Newcastle, in his treatise on horsemanship, said that he had seen the above Arabian, and described him as a small bay horse and not of very excellent shape. In this instance, however, prejudice (and it is difficult to believe that it was anything else) was right, for King James's first venture does not appear to have been a success either as a race-horse or as a sire, and thus Arabian blood was brought into disrepute. The king, however, resolved to give Eastern blood another trial, and bought a horse known as Place's White Turk from a Mr Place, who subsequently held some office in connexion with the stable under Cromwell. Charles I. followed in the footsteps of James, and lent such patronage to the breeding of a better kind of horse that a memorial was presented to him, asking that some measures might be taken to prevent the old stamp of horse "fit for the defence of the country" from dying out.

We now come to a very important period in the history of the British horse, for Charles II. warmly espoused the introduction of Eastern blood into England. He sent his master of the horse abroad to purchase a number of foreign horses and mares for breeding, and the mares brought over by him (as also many of their produce) were called "royal mares"; they form a conspicuous feature in the annals of breeding. The *Stud-Book* shows of what breed the royal mares really were: one of them, the dam of Dodsworth (who, though foaled in England, was a natural Barb), was a Barb mare; she was sold by the stud-master, after Charles II.'s death, for forty guineas, at twenty years old, when in foal by the Helmsley Turk.

James II. was a good horseman, and had circumstances been more propitious he might have left his mark in the sporting annals of the country. In his reign, according to the *Stud-Book*, the Stradling or Lister Turk was brought into England by the duke of Berwick from the siege of Buda.

The reign of William III. is noteworthy as the era in which, among other importations, there appeared the first of three Eastern horses to which the modern thoroughbred race-horse traces back as the founders of his lineage. This was the Byerly Turk, of whom nothing more is known than that—to use the words of the first volume of the *Stud-Book*—he was Captain Byerly's charger in Ireland in King William's wars. The second of the three horses above alluded to was the Darley Arabian, who was a genuine Arab, and was imported from Aleppo by a brother of Mr Darley of Aldby Park, Yorkshire, about the end of the reign of William III. or the beginning of that of Anne. The third horse of the famous trio, the Godolphin Arabian or Barb, brought to England about five and twenty years after the Darley Arabian, will be more particularly referred to further on. All the horses now on the turf or at the stud trace their ancestry in the direct male line to one or other of these three,—the Byerly Turk, the Darley Arabian, and the Godolphin Arabian or Barb. In the female line their pedigrees can be traced to other sources, but for all practical purposes it suffices to regard one or other of these three animals as the *ultima Thule* of racing pedigree. Of course there is a large interfusion of the blood of each of the trio through the dams of horses of the present day; indeed, it is impossible to find an English race-horse which does not combine the blood of all three.

Thorace-horse. *The Thoroughbred.*—The third and last epoch of the British horse, viz., that of the thoroughbred racer, may be taken to date from the beginning of the 18th century. By thoroughbred is meant a horse or mare whose pedigree is registered in the *Stud-Book* kept by Messrs Weatherby, the official agents of the Jockey Club—originally termed the keepers of the match-book—as well as publishers of the *Racing Calendar*. The first attempt to evolve order out of the chaos which had long reigned supreme was made in 1791, for we find in the preface of the first volume of the *Stud-Book*, published in 1808, that "with a view to correct the then increasing evil of false and inaccurate pedigrees, the author was in the year 1791 prevailed upon to publish an *Introduction to a General Stud-Book*, consisting of a small collection of pedigrees which he had extracted from racing calendars and sale papers and arranged on a new plan." It will be seen that the compiler of the volume on which so much depends had to go back fully a century, with little else to guide him but odds and ends in the way of publications and tradition. Mistakes under such circumstances are pardonable. The *Stud-Book* then (vol. i.), which is the oldest authority we have, contains the names and in most cases the pedigrees, obscure though they may be, of a very large number of horses and mares of note from the earliest accounts, but with two exceptions no dates prior to the 18th century are specified in it. These exceptions are the Byerly Turk, who was "Captain Byerly's charger in Ireland in King William's Wars (1689, &c.)," and a horse called Counsellor, bred by Mr Egerton in 1694, by Lord D'Arcy's Counsellor by Lord Lonsdale's Counsellor by the Shaftesbury Turk out of sister to Spanker—all the dams in Counsellor's pedigree tracing back to Eastern mares. There is not the least doubt that many of the animals named in the *Stud-Book* were foaled much earlier than the above dates, but we have no particulars as to time; and after all it is not of much consequence.

The *Stud-Book* goes on to say of the Byerly Turk that he did not cover many bred mares, but was the sire of the Duke of Devonshire's Basto, Halloway's Jigg, and others. Jigg, or Jig, is a very important factor, as will be seen hereafter. The *Stud-Book*, although silent as to the date of his birth, says he was a common country stallion in Lincolnshire until Partner was six years old—and we know from the same authority that Partner was foaled in 1718; we may therefore conclude that Jigg was a later foal than Basto, who, according to Whyte's *History of the Turf*, was a brown horse foaled in 1703.

The reign of Queen Anne, however (1702 to 1714), is that which will ever be inseparably connected with the thoroughbred race-horse on account of the fame during that period of the Darley Arabian, a bay stallion, from whom our very best horses are descended. According to the *Stud-Book*, "Darley's Arabian was brought over by a brother of Mr Darley of Yorkshire, who, being an agent in merchandise abroad, became member of a hunting club, by which means he acquired interest to procure this horse." The *Stud-Book* is silent, and other authorities differ, as to the date of the importation of this celebrated Arab, some saying he came over in the year 1700, others that he arrived somewhat later; but we know from the *Stud-Book* that Manica (foaled in 1707), Aleppo (1711), Almanzor (1713), and Flying Childers (1715) were got by him, as also was Bartlett's Childers, a younger brother of Flying Childers. It is generally believed that he was imported in Anne's reign, but the exact date is immaterial, for, assuming that he was brought over as early as 1700 from Aleppo, he could scarcely have had a foal living before 1701, the first year of the 18th century. The Darley Arabian did much to remove the prejudice against Eastern blood which had been instilled into the public mind by the duke of Newcastle's denunciation of the Markham Arabian. Prince George of Denmark, consort of Queen Anne, was himself a large horse-owner; and it was in a great measure owing to his intervention that so many valuable stallions were imported during her reign.

At this period we find, among a mass of horses and mares in the *Stud-Book* without any dates against their names, many animals of note with the earliest chronology extant, from Grey Ramsden (1704) and Bay Bolton (1705) down to a mare who exercised a most important influence on the English blood-horse. This was Roxana (1718) by the Bald Galloway, her dam sister to Chanter by the Akaster Turk, from a daughter of Leedes's Arabian and a mare by Spanker. Roxana threw in 1732 the bay colt Lath by the Godolphin Arabian, the sorrel colt Roundhead by Childers in 1733, and the bay colt Cade by the Godolphin Arabian in 1734, in which year she died within a fortnight after foaling, the produce—Cade—being reared on cow's milk. The Godolphin Barb or Arabian, as he was commonly called, was a brown bay about 15 hands in stature, with an unnaturally high crest, and with some white on his off hind heel. He is said to have been imported into England from France by Mr Coke, where, as the editor of the *Stud-Book* was informed by a French gentleman, he was so little thought of that he had actually drawn a cart in the streets of Paris. Mr Coke gave him to a Mr Williams, who in his turn presented him to the earl of Godolphin. Although called an Arabian, there is little doubt he was a Barb pure and simple. In 1731, being then the property of Mr Coke, he was teazer to Hobgoblin, and on the latter refusing his services to Roxana, the mare was put to the Godolphin, and the produce was Lath (1732), the first of his get, and the most celebrated race-horse of his day after Flying Childers. He was also the sire of Cade, own brother to Lath, and of Regulus the maternal grandsire of Eclipse. He died at Gogmagog in Cambridgeshire, in the possession of Lord Godolphin, in 1753, being then, as is supposed, in his twenty-ninth year. He is believed to have been foaled in Barbary about 1724, and to have been imported during the reign of George II.

In regard to the mares generally, we have a record of the royal mares already alluded to, and likewise of three Turk mares brought over from the siege of Vienna in 1684, as well as of other importations; but it is unquestionable that there was a very large number of native mares in England, improved probably from time to time by racing, however much they may have been crossed at various periods with foreign horses, and that from this original stock were to some extent derived the size and stride which characterized the English race-horse, while his powers of endurance and elegant shape were no doubt inherited from the Eastern horses, most of which were of a low stature, 14 hands or thereabouts. It is only necessary to trace carefully back the pedigree of most of the famous horses of early times to discover faults on the side of the dam—that is to say, the expression "dam's pedigree unknown," which evidently means of original or native blood. Whatever therefore may be owing to Eastern blood, of which from the middle of the 17th to the beginning of the 18th century a complete wave swept over the British Isles, some credit is unquestionably due to the native mares (which Blaine says were mostly Cleveland bays) upon which the Arabian, Barb, or Turk blood was grafted, and which laid the foundation of the modern thoroughbred. Other nations may have furnished the blood, but England has made the race-horse.

Without prosecuting this subject further, it may be enough here to follow out the lines of the Darley Arabian, the Byerly Turk, and the Godolphin Arabian or Barb, the main ancestors of the British thoroughbred of the 18th and 19th centuries, through several famous race-horses, each and all brilliant winners,—Flying Childers, Eclipse, Herod, and Matchem,—to whom it is considered sufficient to look as the great progenitors of the race-horse of to-day.

1. The Darley Arabian's line is represented in a twofold degree—first, through his son Flying Childers, his grandsons Blaze and Snip, and his great-grandson Snap, and, secondly, through his other son Bartlett's Childers and his great-great-grandson Eclipse. Flying or Devonshire Childers, so called to distinguish him from other horses of the same name, was a bay horse of entirely Eastern blood, with a blaze in his face and four white feet, foaled in 1715. He was bred by Mr Leonard Childers of Carr House near Doncaster, and was purchased when young by the duke of Devonshire. He was got by the Darley Arabian from Betty Leedes, by Careless from sister to Leedes, by Leedes's Arabian from a mare by Spanker out of a Barb mare, who was Spanker's own mother. Spanker himself was by D'Arcy's Yellow Turk from a daughter of the Morocco Barb and Old Bald Peg, by an Arab horse from a Barb mare. Careless was by Spanker from a Barb mare, so that Childers's dam was closely in-bred to Spanker. Flying Childers—the wonder of his time—was never beaten, and died in the duke of Devonshire's stud in 1741, aged twenty-six years. He was the sire of, among other horses, Blaze (1733) and Snip (1736). Snip too had a celebrated son called Snap (1750), and it is chiefly in the female line through the mares by these horses, of which there are fully thirty in the *Stud-Book*, that the blood of Flying Childers is handed down to us.

The other representative line of the Darley Arabian is through Bartlett's Childers, also bred by Mr Leonard Childers, and sold to Mr Bartlett of Masham, in Yorkshire. He was for several years called Young Childers,—it being generally supposed that he was a younger brother of his Flying namesake, but his date of birth is not on record,—and subsequently Bartlett's Childers. This horse, who was never trained, was the sire of Squirt (1732), whose son Marske (1750) begat Eclipse and Young Marske (1762), sire of Shuttle (1793). This at least is the generally accepted theory, although Eclipse's dam is said to have been covered by Shakespeare as well as by Marske. Shakespeare was the son of Hobgoblin by Aleppo, and consequently the male line of the Darley Arabian would come through these horses instead of through Bartlett's Childers, Squirt, and Marske; the *Stud-Book*, however, says that Marske was the sire of Eclipse. This last-named celebrated horse—perhaps the most celebrated in the annals of the turf—was foaled on the 1st of April 1764, the day on which a remarkable eclipse of the sun occurred, and he was named after it. He was bred by the duke of Cumberland, after whose decease he was purchased by a Mr Wildman, and subsequently sold to Mr D. O'Kelly, with whom he will ever be identified. His dam Spiletta was by Regulus, son of the Godolphin Barb, from Mother Western, by a son of Snake from a mare by Old Montague out of a mare by Hautboy, from a daughter of Brimmer and a mare whose pedigree was unknown. In Eclipse's pedigree there are upwards of a dozen mares whose pedigrees are not known, but who are supposed to be of native blood. Eclipse was a chestnut horse with a white blaze down his face; his off hind leg was white from the hock downwards, and he had black spots upon his rump—this peculiarity coming down to the present day in direct male descent. His racing career commenced at five years of age, viz., on the 3d May 1769, at Epsom, and terminated on the 4th October 1770, at Newmarket. He ran or walked over for eighteen races, and was never beaten. It was in his first race that Mr O'Kelly took the odds to a large amount before the start for the second heat, that he would place the horses. When called upon to declare, he uttered the exclamation, which the event justified, "Eclipse first, and the rest nowhere."

Eclipse commenced his stud career in 1771, and had an enormous number of foals, of which four only in the direct male line have come down to us, viz., Potoooooooo, or, as he is commonly called, Pot-8-os (1773), his most celebrated son, King Fergus (1775), Joe Andrews (1778), and Mercury (1778), though several others are represented in the female line. Pot-8-os was the sire of Waxy, (1790) out of Maria (1777) by Herod out of Lisette (1772) by Snap. Waxy, who has been not inaptly termed the ace of trumps in the *Stud-Book*, begat Whalebone (1807), Web (1808), Woful (1809), Wire (1811), Whisker (1812), and Waxy Pope (1806), all but the last being out of Penelope (1798) by Trumpator (1782) from Prunella (1788) by Highflyer out of Promise by Snap, while Waxy Pope was out of Prunella, dam of Parasol (1800) by Pot-8-os. Trumpator was a son of Conductor, who was by Matchem out of a mare by Snap.

Whalebone's best sons were Camel (1822) and Sir Hercules (1826). Camel was the sire of Defence (1824) and Touchstone (1831), while Sir Hercules was the sire of Birdcatcher (1833) and Faugh-a-Ballagh (1841), own brothers, and of Gemma di Vergy (1854). Touchstone was the sire of Newminster (1848), who begat Lord Clifden, Adventurer, and the Hermit, as well as of Orlando (1841) sire of Teddington (1848). Whalebone's blood also descends through Waverley (1817) and his son the Saddler (1828), while Whisker is represented by the Colonel (1825) and by Economist (1825) and his son Harkaway (1834), sire of King Tom (1851). Birdcatcher begat, besides Saunterer (1854), the Baron (1842), sire of Stockwell (1849) and of Rataplan (1850). Stockwell, who was a chestnut with black spots, was the sire of Blair Athol (1861), a chestnut, and also of Doncaster (1870), another chestnut, but with the characteristic black spots of his grandsire; and Doncaster was the sire of the chestnut Bend Or (1877).

To turn to Eclipse's other sons. King Fergus (1775) was the sire of Beningbrough (1791), whose son was Orville (1799), whence comes some of the stoutest blood on the turf, including Emilius (1820) and his son Priam (1827), Plenipotentiary (1831), Muley (1810), Chesterfield (1834), and the Hero (1843). Joe Andrews (1778) was the sire of Dick Andrews (1797), and from him descend Tramp (1810), Lottery (1820), Liverpool (1828), Sheet Anchor (1832), Lanercost (1835), Weatherbit (1842), Beadsman (1855), and Blue Gown (1865). Mercury was sire of Gohanna (1790), who was foaled in the same year as Waxy, and the two, who were both grandsons of Eclipse and both out of Herod mares, had several contests, Waxy generally getting the better of his cousin. Gohanna's descendants come down through Golumpus (1802), Catton (1809), Mulatto (1823), Royal Oak (1823), and Slane (1833).

2. The Byerly Turk's line is represented by Herod, the Turk being the sire of Jigg, who was the sire of Partner (1718), whose son Tartar (1743) begat King Herod, or Herod as he was commonly called, foaled in 1758. Herod's dam was Cypron (1750) by Blaze (1733), son of Flying Childers. Cypron's dam was Selima by Bethel's Arabian from a mare by Graham's Champion from a daughter of the Darley Arabian and a mare who claims Merlin for her sire, but whose mother's pedigree is unknown. In Herod's pedigree there are fully a dozen dams whose pedigree is unknown. Herod was a bay horse about 15 hands 3 inches high, possessed both of substance and length,—those grand requisites in a race-horse,—combined with uncommon power and stamina or lasting qualities. He was bred by William, duke of Cumberland, uncle of King George III. He commenced his racing career in October 1763, when he was five years old, and ended it on the 16th of May 1767. He ran ten times, winning six and losing four races. He died in 1780, and among other progeny left two famous sons, Woodpecker (1773), whose dam was Miss Ramsden (1760) by Cade, son of the Godolphin Barb, but descended also on the dam's side from the Darley Arabian and the Byerly Turk, and Highflyer (1774), whose dam was Rachel (1763) by Blank, son of the Godolphin Barb from a daughter of Regulus, also son of the Godolphin. These two horses have transmitted Herod's qualities down to the present day in the direct male line, although in the female line he is represented through some of his other sons and his daughters as well. Woodpecker was the sire of Buzzard (1787), who in his turn became the father of three celebrated sons, Castrel (1801), Selim (1802), and Rubens (1803), all three chestnuts, and all out of an Alexander mare (1790), who thereby became famous. This mare was by Eclipse's son Alexander (1782) out of a mare by Highflyer (son of Herod) out of a daughter of Alfred, by Matchem out of a daughter of Snap. Bustard (1813), whose dam was a daughter of Shuttle, and his son Heron (1833), Sultan (1816) and his sons Glencoe (1831) and Bay Middleton (1833) and Middleton's sons Cowl (1842) and the Flying Dutchman (1846), Pantaloon (1824) and his son Windhound (1847), Langar (1817) and his son Epirus (1834) and grandson Pyrrhus the First (1843), are representatives of Castrel and Selim.

Highflyer is represented through his greatly esteemed son Sir Peter Teazle, commonly called Sir Peter (1784), whose dam was Papillon by Snap. Sir Peter had five sons at the stud, Walton (1790), Stamford (1794), and Sir Paul (1802) being the chief.

Paulowitz (1813), Cain (1822), Ion (1835), Wild Dayrell (1852), and his son Buccaneer (1857) bring down Sir Paul's blood; whilst Walton is represented through Phantom (1806), Partisan (1811) and his sons Glaucus (1829) and Venison (1833) and Gladiator (1833), Venison's sons Alarm (1842) and Kingston (1849), Gladiator's son Sweetmeat (1842), Sweetmeat's sons Macaroni (1860) and Parmesan (1857), and Parmesan's sons Favonius (1868) and Cremorne (1869). It may be added that in the first volume of the *Stud-Book* there are nearly a hundred Herod and Highflyer mares registered.

3. The Godolphin Barb is represented by Matchem, as the former was the sire of Cade (1734), and Cade begat Matchem, who was foaled in 1748. He was thus ten years the senior of Herod, representing the Byerly Turk, and sixteen years before Eclipse, though long subsequent to Flying Childers, who represent the Darley Arabian. Matchem was a brown bay horse with some white on his off hind heel, about 15 hands high, bred by Sir John Holme of Carlisle, and sold to Mr W. Fenwick of Bywell, Northumberland. His dam was sister to Miss Partner (1735) by Partner out of Brown Farewell by Makeless (son of the Oglethorpe Arabian) from a daughter of Brimmer out of Trumpet's dam, by Place's White Turk from a daughter of the Barb Dodsworth and a Layton Barb mare; while Brimmer was by D'Arcy's Yellow Turk from a royal mare. Matchem commenced his racing career on the 2d of August 1753, and terminated it on 1st September 1758. Out of thirteen engagements he won eleven and lost two. He died in 1781, aged thirty-three years. His best son was Conductor (1767) out of a mare by Snap; Conductor was the sire of Trumpator (1782), whose two sons, Sorcerer (1790) and Paynator (1791), transmit the blood of the Godolphin down to modern times. Sorcerer was the sire of Soothsayer (1808), Comus (1809), and Smolensko (1810). Comus was the sire of Humphrey Clinker (1822), whose son was Melbourne (1834), sire of West Australian (1850) and of many valuable mares, including Canezou (1845) and Blink Bonny (1854), dam of Blair Athol. Paynator was the sire of Dr Syntax (1811), who had a celebrated daughter called Beeswing (1833), dam of Newminster by Touchstone.

The gems of the three lines may be briefly enumerated thus:—(1) of the Darley Arab's line—Snap, Shuttle, Waxy, and Orville—the stoutest blood on the turf; (2) of the Byerly Turk's line—Buzzard and Sir Peter—speedy blood, the latter the stouter of the two; (3) of the Godolphin Barb's line—Sorcerer—often producing large-sized animals, but showing a tendency to die out, and becoming rare.

On the principle that as a rule like begets like, it has been the practice to select as sires the best public performers on the turf, and of two horses of like blood it is sound sense to choose the better as against the inferior public performer. But there can be little doubt that the mating of mares with horses has been often pursued on a haphazard plan, or on no system at all; to this the *Stud-Book* testifies too plainly. Recently more attention seems to be paid to the successful blending of certain strains of blood, though it cannot be said that more than two or three really first class horses are produced each year. The following is a list of the principal sires whose progeny find a place among the winners of the three great races, the Derby (D), Oaks (O), and St Leger (L):—

Eclipse: Young Eclipse (D), Saltram (D), Sergeant (D), Annette (O).
Herod: Bridget (O), Faith (O), Maid of the Oaks (O), Phenomenon (L).
Matchem: Teetotum (O), Hollandaise (L).
Florizel (son of Herod): Diomed (D), Eager (D), Tartar (L), Ninety-three (L).
Highflyer: Noble (D), Sir Peter Teazle (D), Skyscraper (D), Violante (O), Omphale (L), Cowslip (L), Spadille (L), Young Flora (L).
Pot-8-os: Waxy (D), Champion (D, L), Tyrant (D), Nightshade (O).
Sir Peter (D): Sir Harry (D), Archduke (D), Ditto (D), Paris (D), Hermione (O), Parasite (O), Ambrosio (L), Fyldener (L), Paulina (L), Petronius (L).
Waxy (D): Pope (D), Whalebone (D), Blucher (D), Whisker (D), Music (O), Minuet (O), Corinne (O).
Whalebone (D): Moses (D), Lapdog (D), Spaniel (D), Caroline (O).
Woful: Augusta (O), Zinc (O), Theodore (L).
Whisker (D): Memnon (L), The Colonel (L).
Phantom: Cedric (D), Middleton (D), Cobweb (O).
Orville (L): Octavius (D), Emilius (D), Ebor (L).
Tramp: St Giles (D), Dangerous (D), Barefoot (L).
Emilius (D): Priam (D), Plenipotentiary (D), Oxygen (O), Mango (L).
Priam (D): Miss Seltz (O), Industry (O), Crucifix (O).
Sir Hercules: Coronation (D), Faugh-a-Ballagh (L), Birdcatcher (L).
Touchstone (L): Cotherstone (D), Orlando (D), Surplice (D, L), Mendicant (O), Blue Bonnet (L), Newminster (L).
Birdcatcher (L): Daniel O'Rourke (D), Songstress (O), Knight of St George (L), Warlock (L), The Baron (L).
The Baron (L): Stockwell (L).
Melbourne: West Australian (D, L), Blink Bonny (D, O), Sir Tatton Sykes (L).
Newminster (L): Musjid (D), Hermit (D), Lord Clifden (L).
Sweetmeat: Macaroni (D), Mincemeat (O), Mincepie (O).
Stockwell (L): Blair Athol (D, L), Lord Lyon (D, L), Doncaster (D), Regalia (O), St Albans (L), Caller Ou (L), The Marquis (L), Achievement (L).
King Tom: Kingcraft (D), Tormentor (O), Hippia (O), Hannah (O, L).
Rataplan (son of the Baron): Kettledrum (D).
Monarque: Gladiateur (D, L).
Parmesan (son of Sweetmeat): Favonius (D), Cremorne (D).
Buccaneer: Kisber (D), Formosa (O, L), Brigantine (O).
Lord Clifden (L): Jannette (O, L), Hawthornden (L), Wenlock (L), Petrarch (L).
Adventurer: Pretender (D), Apology (O, L), Wheel of Fortune (O).
Blair Athol (D, L): Silvio (D, L), Craig Millar (L).

The successes of the St Leger winners, the Baron and his son Stockwell and his grandson Blair Athol, as well as of Touchstone and his son Newminster and his grandsons Lord Clifden and Adventurer, as stud horses, are more marked than perhaps those of any others in the annals of the turf, except Waxy and his descendants, of whom Whalebone is perhaps the best. Indeed the most successful cross of modern times is the double cross of Whalebone, the "ready money" cross as it is called, which is arrived at by intermixing the descendants of Whalebone through Sir Hercules, Birdcatcher, the Baron, Stockwell, Rataplan, Camel, Touchstone, Newminster, and Adventurer. Isonomy, by Sterling, son of Oxford by Birdcatcher, is a case in point; he is one of the best and best bred horses of the century. He has no less than five strains of Whalebone and seven of Waxy in his pedigree, as well as one of Shuttle, the scarcest blood of all.

In regard to mares it has very frequently turned out that animals which were brilliant public performers have been far less successful as dams than others which were comparatively valueless as runners. Beeswing, a brilliant public performer, gave birth to a good horse in Newminster; the same may be said of Alice Hawthorn, dam of Thormanby, of Canezou, dam of Fazzoletto, of Crucifix, dam of Surplice, and of Blink Bonny, dam of Blair Athol; but many of the greatest winners have dropped nothing worth training. On the other hand, there are mares of little or no value as racers who have become the mothers of some of the most celebrated horses on the turf; among them we may cite Queen Mary, Pocahontas, and Paradigm. Queen Mary, who was by Gladiator out of a daughter of Plenipotentiary and Myrrha by Whalebone, when mated with Melbourne produced Blink Bonny (winner of the Derby and Oaks); when mated with Mango and Lanercost she produced Haricot, dam of Caller Ou (winner of the St Leger). Pocahontas, perhaps the most remarkable mare in the *Stud-Book*, never won a race on the turf, but threw Stockwell and Rataplan to the Baron, son of Birdcatcher, King Tom to Harkaway, Knight of St Patrick to Knight of St George, and Knight of Kars to Nutwith—all these horses being 16 hands high and upwards, while Pocahontas was a long, low mare of about 15 hands or a trifle more. She also gave birth to Ayacanora by Birdcatcher, and to Araucaria by Ambrose, both very valuable brood mares, Araucaria being the dam of Chamant by Mortemer, and of Rayon d'Or by Flageolet, son of Plutus by Touchstone. Paradigm again produced, among several winners of more or less celebrity, Lord Lyon (winner of the Two Thousand Guineas, Derby, and St Leger) and Achievement (winner of the St Leger), both being by Stockwell. Another mare that has become famous was Manganese (1853) by Birdcatcher from Moonbeam by Tomboy from Lunatic by the Prime Minister from Maniac by Shuttle. Manganese when mated with Rataplan threw Mandragora, dam of Apology, winner of the Oaks and St Leger, whose sire was Adventurer, son of Newminster. She also threw Mineral, who, when mated with Lord Clifden, produced Wenlock, winner of the St Leger, and after being sold to go to Hungary, was there mated with Buccaneer, the produce being Kisber, winner of the Derby. It is usual to select sound, roomy mares, giving preference to those that are comparatively speaking low and long, and whose temper and disposition are good, of course paying strict attention to their blood, more especially if breeding from such large horses as the sons of Pocahontas.

We append the pedigree of Blair Athol, winner of the Derby and St Leger in 1864, who, when subsequently sold by auction, fetched the unprecedented sum of 12,000 guineas, as it contains, not only Stockwell (the emperor of stallions, as he has been termed), but Blink Bonny and Eleanor—in which latter animal are combined the blood of Eclipse, Herod, Matchem, and Snap,—the only two mares that have ever won the Derby, in 1801 and 1857 respectively, as well as those queens of the stud, Eleanor's great-granddaughter Pocahontas and Blink Bonny's dam Queen Mary. Both Eleanor and Blink Bonny won the Oaks as well as the Derby, and it may be observed that they are the only winners of the former race that appear in the pedigree.

Blair Athol*‡ (1861	Stockwell‡ (1849)	The Baron‡ (1842)	Birdcatcher‡ (1833)	Sir Hercules (1826)	Whalebone* (1807)	Waxy* (1790)
						Penelope (1798)
					Peri (1822)	Wanderer (1790)
						Thalestris (1809)
				Guiccioli (1823)	Bob Booty (1804)	Chanticleer (1787)
						Ierne (1790)
					Flight (1809)	Escape (1802)
						Young Heroine
			Echidna (1838)	Economist (1825)	Whisker* (1812)	Waxy* (1790)
						Penelope (1798)
					Floranthe (1818)	Octavian (1807)
						Caprice (1797)
				Miss Pratt (1825)	Blacklock (1814)	Whitelock (1803)
						Coriander mare (1799
					Gadabout (1812)	Orville‡ (1799)
						Minstrel (1803)
		Pocahontas (1837)	Glencoe (1831)	Sultan (1816)	Selim (1802)	Buzzard (1787)
						Alexander mare (1790)
					Bacchante (1809)	Williamson's Ditto (1800
						Sister to Calomel (1791)
				Trampoline (1825)	Tramp (1810)	Dick Andrews (1797)
						Gohanna mare
					Web (1808)	Waxy* (1790)
						Penelope (1798)
			Marpessa (1830)	Muley (1810)	Orville‡ (1799)	Beningbrough (1791)
						Evelina (1791)
					Eleanor*† (1798)	Whiskey (1789)
						Young Giantess (1790)
				Clare (1824)	Marmion (1806)	Whiskey (1789)
						Young Noisette (1789)
					Harpalice (1811)	Gohanna (1790)
						Amazon (1799)
	Blink Bonny*† (1854)	Melbourne (1834)	Humphrey Clinker (1822)	Comus (1809)	Sorcerer (1796)	Trumpator (1782)
						Young Giantess (1790
					Houghton Lass (1801)	Sir Peter* (1784)
						Alexina (1788)
				Clinkerina (1812)	Clinker (1805)	Sir Peter* (1784)
						Hyale (1797)
					Pewet (1786)	Tandem (1773)
						Termagant
			Daughter of (1825)	Cervantes (1806)	Don Quixote (1784)	Eclipse (1764)
						Grecian Princess (1770)
					Evelina (1791)	Highflyer (1774)
						Termagant
				Daughter of (1818)	Golumpus (1802)	Gohanna (1790)
						Catherine (1795)
					Daughter of (1816)	Paynator (1791)
						Sister to Zodiac
		Queen Mary (1843)	Gladiator (1833)	Partisan (1811)	Walton (1799)	Sir Peter* (1784)
						Arethusa (1792)
					Parasol (1800)	Pot-8-os (1773)
						Prunella (1788)
				Pauline (1826)	Moses* (1819)	Whalebone* by Waxy* (1807)
						Gohanna mare
					Quadrille (1815)	Selim (1802)
						Canary Bird (1806)
			Daughter of (1840)	Plenipotentiary* (1831)	Emilius* (1820)	Orville‡ (1799)
						Emily (1810)
					Harriett (1819)	Pericles (1809)
						Selim mare (1812)
				Myrrha (1830)	Whalebone* (1807)	Waxy* (1790)
						Penelope (1798)
					Gift (1818)	Young Gohanna (1810)
						Sister to Grazier by Sir Peter* (1803)

* Winner of the Derby. † Winner of the Oaks. ‡ Winner of the St Leger.

oints of e race- rse.

The shape of a race horse is of considerable importance, although it is said with some degree of truth that they win in all shapes. There are the neat and elegant animals, like the descendants of Saunterer and Sweetmeat; the large-framed, plain-looking, and heavy-headed Melbournes, often with lop ears; the descendants of Birdcatcher, full of quality, and of more than average stature, though sometimes disfigured with curby hocks; and the medium-sized but withal speedy descendants of Touchstone, though in some cases characterized by somewhat loaded shoulders. In height it will be found that the most successful racers average from 15 to 16½ hands, the former being considered somewhat small, while the latter is unquestionably very large; the mean may be taken as between 15½ and 16 hands (the hand = 4 inches). The head should be light and lean, and well set on; the ears small and pricked, but not too short; the eyes full; the forehead broad and flat; the nostrils large and dilating; the muzzle fine; the neck moderate in length, wide, muscular, and yet light; the throat clean; the windpipe spacious and loosely attached to the neck; the crest thin, not coarse and arched. The withers may be moderately high and thin; the chest well developed, but not too wide or deep; the shoulder should lie well on the chest, and be oblique and well covered with muscle, so as to reduce concussion in galloping; the upper and lower arms should be long and muscular; the knees broad and strong; legs short, flat, and broad; fetlock joints large; pasterns strong and of moderate length; the feet should be moderately large, with the heels open and frogs sound

—with no signs of contraction. The body or barrel should be moderately deep, long, and straight, the length being really in the shoulders and in the quarters; the back should be strong and muscular, with the shoulders and loins running well in at each end; the loins themselves should have great breadth and substance, this being a vital necessity for weight-carrying and propelling power uphill. The hips should be long and wide, with the stifle and thigh strong, long, and proportionately developed, and the hind quarters well let down. The hock should have plenty of bone, and be strongly affixed to the leg, and show no signs of curb; the bones below the hock should be flat, and free from adhesions; the ligaments and tendons well developed, and standing out from the bone; the joints well formed and wide, yet without undue enlargement; the pasterns and feet similar to those of the forehand. The tail should be high set on, the croup being continued in a straight line to the tail, and not falling away and drooping to a low set tail. Fine action is the best criterion of everything fitting properly, and all a horse's points ought to harmonize or be in proportion to one another, no one point being more prominent than another, such as good shoulders, fine loins, or excellent quarters. If the observer is struck with the remarkable prominence of any one feature, it is probable that the remaining parts are deficient. A well-made horse wants dissecting in detail, and then if a good judge can discover no fault with any part, but finds each of good proportions, and the whole to harmonize without defect, deformity, or deficiency, he has before him a well-shaped horse; and of two equally well-made and equitably proportioned horses the best bred one will be the best. As regards hue, the favourite colour of the ancients, according to Xenophon, was bay, and for a long time it was the fashionable colour in England; but for some time chestnut thoroughbreds have been the most conspicuous figure on English race-courses, so far as the more important events are concerned. Eclipse was a chestnut; Castrel, Selim, and Rubens were chestnuts; so also were Glencoe and Pantaloon, of whom the latter had black spots on his hind quarters like Eclipse, and more recently Stockwell and Doncaster. Birdcatcher was a chestnut, so also were Stockwell and his brother Rataplan, Manganese, Mandragora, Thormanby, Kettledrum, St Albans, Blair Athol, Regalia, Formosa, Hermit, Marie Stuart, Doncaster, George Frederick, Apology, Craig Millar, Prince Charlie, Rayon d'Or, and Bend Or. The dark browns or black browns, such as the Sweetmeat tribe, are not so common as the bays, and black or grey horses are almost as unusual as roans. The skin and hair of the thoroughbred are finer, and the veins which underlie the skin are larger and more prominent than in other horses. The mane and tail should be silky and devoid of curl, which is a sign of impurity.

Whether the race-horse of to-day is as good as the stock to which he traces back has often been disputed, chiefly no doubt because he is brought to more early maturity, commencing to win races at two years instead of at five years of age, as in the days of Childers and Eclipse; but the highest authorities, and none more emphatically than the late Admiral Rous, aver that he can not only stay quite as long as his ancestors, but also go a good deal faster. In size and shape the modern race-horse is unquestionably superior, being on an average fully a hand higher than the Eastern horses from which he is descended; and in elegance of shape and beauty of outline he has certainly never been surpassed. That experiments, founded on the study of his nature and properties, which have from time to time been made to improve the breed, and bring the different varieties to the perfection in which we now find them, have succeeded, is best confirmed by the high estimation in which the horses of Great Britain are held in all parts of the civilized world; and it is not too much to assert that, although the cold, humid, and variable nature of their climate is by no means favourable to the production of these animals in their very best form, Englishmen have by great care, and by sedulous attention to breeding, high feeding, and good grooming, with consequent development of muscle, brought them to the highest state of perfection of which their nature is capable. See the section on Horse-Racing, p. 199.

The hunter.

The Hunter.—A good specimen of an English hunter may be described as a horse for universal use. He may be a coach-horse, for in many of the animals running in the coaches called into existence during the summer months by the coaching revival may be recognized a hunter of known character; he may be a good roadster, for, so far as conformation is concerned, there is nothing in a hunter to unfit him from being a first-class hack; nor is hunting incompatible with military duties, for, by the regulations of the service, officers are permitted to hunt their second chargers. For harness work he is perfectly adapted, provided only the vehicle to be drawn is in proportion to his size; while most people will recall instances of hunters having for some reason or other to be so far humbled as to have to take a turn at the plough or harrow, or, in their older days, even in a chaff-cutter.

Thorough-bred hunters.

A hunter may be either thoroughbred or halfbred. In the grass countries, such as Leicestershire or Northamptonshire, riders to hounds endeavour to get their hunters as nearly clean bred as possible; but, in spite of this ambition, it may be doubted whether one in twenty, even in the most fashionable countries, is thoroughbred, thereby proving that a thoroughbred hunter, although undoubtedly a luxury, is not a virtual necessity. When it can be acquired, a thoroughbred hunter that knows his business is a most desirable possession, save perhaps in a rough country, where his fine skin shrinks from contact with the objects therein encountered. The comparative scarceness of these animals is, however, easily accounted for. From 12 to 14 stone is by no means an uncommon weight for a man to ride hunting, saddle included, but few thoroughbreds are up to it; one that is commands a large price, from £250 upwards, according to "manners." It is often said that thoroughbreds do not make pleasant hunters, but the complaint, if there is any ground for it at all, is really against the result of the treatment to which nineteen out of twenty thoroughbreds have to submit, and not against pure blood itself. A large proportion of thoroughbred stock come to the starting-post at two years old; and this means that they have been in the trainer's hands since they were yearlings at least. Now a training stable is just the place for colts to pick up sundry undesirable tricks, which may at some future time cause the unprofessional rider a little trouble; they get to lean on the hand, often turn out fidgety and fractious, and are not unfrequently inveterate pullers. When fit to go, the young one will have been tried, and if he fails to gallop half a mile at best pace he is probably turned out of training, although perhaps it was not till the last dozen yards were reached that there was any sign of failing power. Now, although the colt may be unable to stand the test applied to him by the trainer, there is no reason at all why he should not be able to go all day at hunting pace, because the powers of speed are not taxed to the same degree. The young thoroughbred is then perhaps educated for hunting; and hence it is that nearly all hunters—thoroughbred ones, that is to say—begin life in a training stable. Instances are comparatively rare of persons breeding thoroughbred stock and then keeping them for hunting purposes. The ranks of hurdle-racers and steeple-chasers too are filled by thoroughbred horses, which but for these interventions come under the care of the hunting groom.

alf- ed nters. The halfbred hunter, as he is technically called, may be, and is, a very good substitute for the thoroughbred; he may have nineteen-twentieths of pure blood in his veins, and still be only "halfbred." Perhaps seven-eighths of pure blood is about the average for high-class horses; but, taking English hunters all round, the majority are halfbred in a more literal sense, being for the most part by a horse nearly, if not quite, thoroughbred, out of a common mare. It is much to be regretted that the breeding of halfbred hunters is too often neglected altogether, or at least conducted on haphazard principles. Many men take it into their heads to breed a colt simply because they have a mare which, owing to age or accident, is no longer fitted for active work; and then, be the mare good, bad, or indifferent, there is little or no judgment exercised in the choice of a sire. Nearly all country places are periodically visited by travelling stallions, many of which are utterly worthless, but nevertheless the services of one of them are probably secured by the intending breeder simply because of the saving of trouble. He forgets that there is but little difference between the charge for a good and that for a bad horse, and finds, when the offspring is ready for sale, that the result of his happy-go-lucky system remains on his hands for lack of a buyer, and costs as much to keep as a valuable animal. Very often, too, a man who has expected to breed a hunter will find himself the owner of a fairly promising colt for a brougham, but having hoped for a hunter he is unwilling to believe it anything else.

eed- g. Compare this method of setting to work with that adopted by breeders of thoroughbred stock, and indeed by all judicious breeders. To begin with, the choice of a dam is a matter of moment; and it is difficult to see why anything should be thought good enough for a hunter, even by the inexperienced. The first requisite for a brood-mare is that she should be free from all constitutional infirmities, such as roaring, bad sight, &c.; and the breeder should be on his guard when breeding from mares whose legs have given way. True, it may be the result of an accident, but care should be taken to ascertain that it arose from that cause, and that a predisposition to inflammation had nothing to do with it. For the same reason persons should be chary of breeding from mares that have splints, spavins, &c., and should certainly reject one whose dam or sire had them as well. Mares that have done much hard work are not the best dams that can be selected, as they are apt to slip their foals, or to throw undersized ones. The selection of a stallion is the more important the more defects there are in the mare. Should she be the least delicate, the stallion should be remarkable for a hardy constitution, for considering that a hunter has to be out of his stable for as much as twelve hours sometimes, and rarely less than seven or eight, and has to carry a heavy weight and gallop and jump, it is plain that a horse with no stamina would be nearly worthless as a hunter, no matter what other good qualities he might possess. So, too, as to shape: should the mare be too long on the leg or in the back, or too low in front, the stallion should be singularly free from the defect in question.

While the mare is in foal she should be kept on the best food, for the nourishment given to her is given indirectly to the foal. The keep of the foal in its early days is not less important than the choice of dam and sire. Thoroughbred colts eat corn from the time they are a month or five weeks old; and the same generous diet should be allowed to halfbred horses, as it is only by this, accompanied of course by proper exercise, that the frames of young horses expand to their full extent, or that a foundation is laid for a good constitution. This system is, of course, more expensive than keeping a colt on hay and grass during the first three years of his life, but it will repay itself in the long run, for very often under its influence a colt will develop into a weight-carrying hunter or valuable carriage horse, where, under more parsimonious treatment, he would never have grown into anything strong enough to carry over 11 or 12 stone.

The breaking and training of hunters is all-important, because, in spite of the care that may have been expended upon the choice of sire and dam and the keep of the colt, many young ones are ruined beyond all hope of recovery during this process. The colt should be handled from the day of its birth, so that it may grow thoroughly accustomed to man, without ever having experienced the feeling of fear. The person selected to attend on mares and foals, as well as he that undertakes the training part, should be naturally fond of animals; he should be cool, and of an almost imperturbable temper, or he will be unfitted to deal with the waywardness of some of his pupils, which during their early career may at times expose him to personal danger, especially if they be well bred; he should therefore be well endowed with courage and firmness, for an irresolute man is sure to spoil every horse he has to do with. Breaking and training.

When about six months old the colt should receive his first lesson in jumping. Where practicable, there is no better plan than to feed him in one spot, the approach to which is guarded by a stout rail, which should in the first instance lie on the ground, and over which he must step in order to reach his corn. In the course of about a month the rail may be raised 6 inches, and so on from time to time, but the process should be gradual in the extreme; 2 or 3 inches a month is sufficient until it is a couple of feet high, where it should remain for a time, but at three years the colt should jump it at 3 feet. Before he reaches this age the saddle should have been put on and left there for half an hour at a time, the groom letting the girths and stirrups flap about. At three years the pupil should be backed by a light weight; if the rider be the usual attendant, so much the better, for then it is improbable that much resistance will be shown. The riding exercise should be varied by the young horse being led by a rather long rein over roughish ground, such as a common or a ploughed field, when it is not too hard, and over little ditches and very low fences, but they must be small, as it is very undesirable to have a horse refuse at first, or to have him fall down in attempting a jump. He should be subsequently ridden over small places, but should always have a lead given to him by an old horse; and the two should stand in adjoining boxes, so that the colt may be accustomed to his pilot. At four years old he may be ridden to the meet, and suffered to see a fox found, but should on no account be ridden up to the hounds, nor should he be used as a regular hunter till he is six,—if not till seven it will be all the better for him.

In the hunting field there are three kinds of jumps at which many refusals and falls take place. The first is timber, the second water or wide open ditches, and the third a hedge with a ditch on the taking off side. As to timber jumping, the course we have just recommended is the best possible preparation; in jumping the rail, the colt begins early to exercise, and therefore to strengthen, the very muscles he will want by and by in jumping a gate,—if his owner ever rides him at one. A further course of instruction in this most useful art may be given in a "circus," that is, a double row of posts and rails in a circle about the size of a circus ring. Between the two sets a couple of strong timber jumps should be put up, one of about 3 feet and the other of about 3 feet 6 inches in height; the horse is then put into the space between the two rails, one person standing in the centre holding a lunge rein, while an assistant is present with a whip, which should, however, be used but sparingly. Really good water jumpers are so scarce that it would well repay the owner of a promising young one to teach him, or have him taught, this most important part of a hunter's business. If a small water-course can be found handy, it will do for a commencement; the colt should, in his early days, be led over this; and, if possible, the place should be widened gradually, and the water dammed up, the colt being always lunged over it before being ridden, and when ridden led over by an old horse. The same course should be pursued in the case of dry ditches, and hedges with a ditch on the taking off side, both of which must be jumped boldly, if the rider wish to keep his place with hounds. This gradual teaching, and the trouble it undoubtedly entails, may sound too theoretical to some who are desirous of turning out a finished hunter in the space of six weeks; but it is to this hurrying, and the substitution of coercive measures for time and gentleness, that we are to attribute the number of indifferent hunters we find. Every hunting man knows the enormous prices realized by really clever hunters; and these animals are simply ordinary horses on whose education much trouble has been expended.

Qualifications for a hunter.

Qualifications for a Hunter.—Of horses equally good jumpers, and equally fast, that will be most valuable which can gallop and jump with the greatest weight on his back. Very good horses for 10 or 11 stone can be obtained at any time, and at a moderate price, but a horse up to weight will always fetch a large sum. Whatever weight has to be carried, mere size must not be confounded with power; a horse 16½ hands high is not necessarily a weight carrier. A compact well-knit frame is of primary importance; and although it is a task of great difficulty to explain the points of a horse on paper, the intending buyer may with advantage have his attention drawn to some of the more important requisites. To cross a country well, the hunter must have long and oblique shoulders; and, in the case of a weight carrier, they should be rather thick. Should the reader have any difficulty in deciding what oblique shoulders are, he may get some assistance from putting a saddle on a horse, setting it of course in the right place, and then looking at the horse from a side view. Should the horse have good shoulders, the stirrup leather will hang down at some distance behind the forelegs; but if, on the other hand, the shoulders be upright, the stirrups will be comparatively close to the forelegs, and, on mounting, the rider will find himself sitting over the legs instead of behind them. Care should be taken, however, that the shoulder is well clothed with muscle. The chest should be broad; narrow horses are supposed to be faster, but under weight they knock their legs about. The arm must be long, and of course muscular, the knee wide, the "cannon bone" (*i.e.*, the bone between the knee and the fetlock) short, and the legs flat, with strong back sinews. The foot should be moderately wide, and have good strong heels, or they will not stand the battering about that falls to the lot of even the most carefully ridden hunter.

The chest must be deep (otherwise the horse will in all likelihood be a short-winded one), and as a consequence the girth will be great; a weight carrier should measure 6 feet 3 inches in condition round the barrel, just where the girth comes. A horse with a well-developed frame, and of large girth, is generally a short-legged horse, as it is called, not that the legs are really shorter—very short legs are a deformity—but the body is not too small in proportion to the height of the leg.

It is commonly said that the back of a weight carrier must be short; but this does not mean that the horse should be short from the chest to the tail, for he should have much of his length in his shoulders and quarters. For very heavy men, the back proper should not be long; but, as a matter of fact, few horses are found the length of whose back would be adjudged perfection. A moderate length of back is essential to pace, and on this question the late Major Whyte Melville writes as follows:—"It may not be out of place here to observe, as an illustration of the well-known maxim 'Horses can go in all shapes,' that of the three heaviest men I can call to mind who rode perfectly straight to hounds, the best hunter owned by each was too long in the back." The loins should be strong, and the hips wide; if ragged they will be none the worse.

The hind legs are most important, not only because the seat of the propelling power is there, but also because they affect the carriage of the animal, and the way in which he yields to his rider's hand. The thigh should be long and muscular, the hock well bent, and not bending inwards, when the horse is called "cow-hocked," nor outwards, like a bandy-legged man. The shank bone should be well guarded by strong sinews, and the pasterns moderately long, and by no means straight. Horses with straight, short pasterns are rough to ride, and ill adapted to stand hard work.

So far, then, as the body is concerned, strong legs, wide hips, depth of girth, and a short back, or, more properly, a back not too long, are all important; but it must be remembered that, beyond a certain point, the development of any extraordinary strength is accompanied by a loss of speed, therefore very heavy men must be content to be carried by an animal not unlike an active cart-horse, for a well-bred horse capable of galloping and jumping under 18 stone is rarely seen, and the few that do exist cannot be acquired except at an enormous outlay.

When a man gets on a horse to try him, the formation and the carriage of the head and neck have a great deal to do with the subsequent purchase or rejection of him. If appearance be a *sine qua non*, the head should be small, but, except for the look of the thing, the size is immaterial, provided it be well set on to a properly shaped neck, the characteristics of which will be presently explained. The jaws should be wide, as also should the head between the ears. The nostrils, through which alone a horse breathes, should be moderately large, otherwise free respiration will be interfered with. The eye should be bright and full, but not unduly prominent; small pig-like eyes are nearly certain indications of bad temper. The neck should rise out of the shoulders in an easy curve, and be neither very long nor very short; muscular it must be, and the principal muscle is the one running along the top of the neck; a muscular development here is usually accompanied by muscular proportions generally. The strength of the neck is important, because upon this the position of the head depends, and if the head be wrongly placed, the horse will never go pleasantly to the hand; indeed, of such moment is the position of the head that a horse is often unmanageable when his head is in an improper position, although he is easy of control when it is in the right place. A short-necked horse is sure to make the rider carry its head, because, from the lower part being thick, as it must be where it springs from the shoulder, the head cannot be set on at a proper angle. It has been said that a long neck is productive of the same inconvenience, but the better opinions are hostile to this theory, and experience does not tend to convince one that a long-necked horse is necessarily heavy in the hand.

A hunter should have a good mouth, and should not pull,—both which matters depend a good deal upon the rider,—and should not be given to shying. He should, however, be naturally bold, or he may refuse any fence of an uninviting appearance. Good temper is an absolute necessity. A strong and resolute rider may put up with a puller, in consideration of many good points, but a bad-tempered horse is of no use in the field, as he is sure to lose his rider his place in a run; moreover, a horse that will be wanted all day cannot afford to lose his temper and take what is equal to half an hour's work out of himself at every turn or check, or at every gate-post that may be encountered during the day.

Whatever number of good points a hunter may possess, they will all be utterly valueless unless he be sound into the bargain. There are two kinds of soundness, practical and legal. A horse is not legally sound, that is to say, he is legally unsound, if there is any structural alteration, however slight, in any part of his body, though it may not unfit him in any degree for the immediate performance of his duties. To be legally sound, a horse must be in the same perfect state as when foaled; and each reader must determine for himself how often this can be found in a field of say one hundred horses. To be practically sound, a horse must have nothing the matter with him that is likely to interfere with his duties as a hunter, and he can be in this condition without being legally sound. For instance, suppose a man, after buying a horse warranted sound, take off the shoes and find the smallest possible corn, which would never be felt, nor diminish the value by one penny, that horse is not legally sound, because the corn, small as it is, is held to be a structural alteration; so, too, a pimple on the body where the saddle would cover it is an unsoundness in a hunter while it lasts, if it prevents the saddle from being put on. A temporary cough is also an unsoundness; so is lameness caused by being pricked during shoeing; yet for some of these no man in the world would reject a good hunter. It need hardly be added that any enlarged joints, or other tokens of work, prevent a horse from being legally sound. On the other hand a horse, if not actually lame, is legally sound although its legs are so badly formed that the merest tyro could predict lameness as the inevitable result of half an hour's journey.

As to the wind and eyes, however, a hunter should be legally and absolutely sound. The usual method of testing the wind by punching the horse or pinching the windpipe is not quite satisfactory; the horse should be galloped. The amateur will do well to get the best veterinary surgeon within reach to examine the eyes of any horse he contemplates buying. Cataract, in its incipient stage, is so difficult to discover that it escapes the notice of any but the most practised person. With regard to the feet and legs, the buyer will have to rest satisfied with an assurance that his horse is practically sound; for of really sound horses there are not two in a hundred.

The Purchase of a Hunter.—The nature of the country in which the horse is to be used should be the intending purchaser's first consideration, because upon it will depend the stamp of animal required, and it is advisable, if possible, to get a horse that has been used to the prevalent style of fences. Where the fields are large and strongly enclosed with what are called flying fences, nothing is better than a horse which is nearly or quite thoroughbred; but if the enclosures are small, and separated from each other by banks, with or without hedges on the top, and with a ditch on one or both sides, a rather more compact horse will not only be more suitable, but cheaper into the bargain. A horse intended for Leicestershire, or any other grass country, *must* be nearly thoroughbred, and not under 15 3, or he would be blown before he had crossed half a dozen of the big fields there; while a little horse would take too much out of himself at each fence. But for Devonshire, Surrey, Essex, or Sussex, where the fields are small and the fencing for the most part what is called cramped, a horse with less blood and of smaller stature will answer every purpose, and, what is a great consideration, can be bought for about one-third of the price of a Leicestershire horse. So too a horse unaccustomed to water would be useless in Lord Fitzhardinge's country, nor would a bad timber jumper show to advantage with the Blackmoor Vale hounds. Whatever stamp of horse is used, however, the points we have insisted on must exist: good shoulders, back, loins, legs, hocks, and feet are needed in every hunting country in the United Kingdom.

The horse may be purchased either at auction, from a private person, or from a dealer. The first method is not to be recommended unless the buyer or his agent be a good judge of a horse, or unless one or the other happen to know something of the antecedents of any lot intended to be purchased. Few real bargains are picked up at the hammer. Horses of known character, especially if comprised in a stud, always fetch their full value; and to buy a horse of which nothing is known is simply to take part in a lottery. Buying from a private person is not always a satisfactory proceeding, even when the performances of the horse are known. People entertain different ideas as to what constitutes unsoundness: and in many cases the groom is the only person who knows that there is a screw loose somewhere, and what that screw is. Purchasing from a dealer requires some little knowledge. Some men trade only in the highest class of horses, and must perforce ask long prices to afford a fair margin of profit to cover the original outlay, coupled with the expense of schooling and keep. Others again make a specialty of "useful" animals at a moderate price. The buyer's success in either case will, to a great extent, depend upon how he goes to work. The best course is to select a dealer who has a name to lose, and to tell him at once the kind of horse that is wanted, and about the price the purchaser is willing to pay. The dealer will then offer whatever horses he can sell at the price, and the buyer can take or reject them as he pleases.

Formerly a warranty of soundness by the seller was a necessary factor in every horse sale; but now warranties are going out of fashion, many of the leading dealers refusing altogether to give one. Nor is this surprising when the effect of a warranty is looked at; no lapse of time puts an end to a warranty. The seller of a yearling may have an action brought against him in four years' time, and, if the jury can be got to believe that the unsoundness complained of existed at the time of sale, the buyer will win. In giving a warranty, the seller of a horse insures, as it were, the care and skill of the buyer, and may have to suffer for selling a sound horse which ignorance and carelessness reduced to the level of a screw in six months.

There is also a limited warranty; that is, the dealer may be willing to warrant the horse for one month, or fourteen days, or for any other fixed period. In this case, the dealer only warrants against such defects as may be discovered within the stipulated time. This kind of warranty should be looked at with some amount of suspicion. It is very often given with a horse that might not pass the veterinary surgeon, and that has some defect of which the dealer knows, which renders it problematical whether he will keep sound for any lengthened period. With a limited warranty the horse often escapes the veterinary surgeon's inspection; he lasts sound for a short time, and then goes lame, the time of the limited warranty having meanwhile expired.

The most satisfactory and at present perhaps the most usual course of business is for a horse to be sold subject to a veterinary examination and a trial. A skilful man should discover all symptoms of what may be called external unsoundness, while as to disease of the liver, or any internal complaint, if the veterinary surgeon cannot discover it there is no reason why the dealer should have been able to find it out. The trial the buyer will probably make himself, and, if with hounds, it will be well to ascertain what condition the horse is in. An animal just out of a dealer's show stable would have neither his muscles nor his wind in a state that would enable him to live with hounds ten minutes, even at a moderate pace. Early symptoms of distress therefore, under such circumstances, should not of themselves prompt the rejection of a horse, if he is satisfactory at starting, and if his physical structure is that of a hunter. The age of the horse is determined by the appearance of the teeth till he is seven years old, but the legs are as good a test as anything. Many a horse at five years old is often worth less as a hunter than one of ten or twelve years old, owing either to a natural want of stamina or to premature overwork. If the legs show much signs of work, and if the joints are round and big, the money paid should as a rule differ materially from a "sound price." Not that perfectly fresh legs can be expected in aged horses, particularly if good performers; but there is a point below which "honourable scars" should be looked upon as an objection, unless the buyer intend to have a "screw."

The Hack.—Under the term "hack" may be ranked cover hack, park hack, cob, pony, and, in short, saddle horses of all kinds save hunters and racers. The hack.

The park hack, as its name implies, is for use in fashion-frequented places, and must therefore be worth looking at. Fashion has prescribed that the genuine thing shall be about 14 3, with a small and well set-on head, good sloping shoulders, and well formed hind legs; he must also be very well bred. So much for his points. A wonderfully good temper is absolutely essential. Street vehicles give but little place to the equestrian, and a series of hurried retreats out of harm's way might ruffle a horse of uncertain temper and not hard worked into the bargain. Tricks of all sorts must be unknown; a whole week's idleness should not produce any uncalled-for gambols. The park hack's breeding and shape will probably have endowed him with a fair turn of speed; this is not a necessity, providing his walk and trot be perfection. He should be able to walk 5 miles in an hour, or he will be perpetually breaking into an uncomfortable jog when required to keep pace with a quick walking companion. In trotting he should have good but not extravagant action, and, if he is equally easy whether going $5\frac{1}{2}$ or 9 miles per hour, he is one of twenty. He should be bitted to a nicety, and should have been thoroughly well trained. Especial care should be exercised in the selection of the lady's horse; and the perfection which is so often theoretical in the case of a gentleman's hack should approach a reality when a horse is intended to carry a lady. With regard to the size, it had better not be under 15 1 at the least, and should have very good shoulders and by no means a short neck, or else the rider will experience that uncomfortable sensation of having nothing in front of the saddle. Park hack.

The cob is a nondescript animal, but withal a very valuable one when good. An underbred thickset animal, termed a "stocky" horse in some parts of England, is not the fashionable cob, which should have a good deal of breeding and the strength of a dray horse. Although a cob should not exceed 14·1, he should be master of 15 stone, being generally ridden by elderly heavy persons. To be worth a large sum he must unite to a symmetrical shape an even temper, perfect manners, and easiness in his paces. "If any one," says a writer in the *Field*, "possesses a cob up to 16 stone, who can walk 4 miles an hour and trot 12, with a good mouth and amiable disposition, who fears nothing, and never stumbles, let him, if a rich man, keep him, he will not get another such in a hurry; if a poor one, let him, in offering him for sale, fear not to 'open his mouth' boldly, and demand for him a price which shall make a difference in his (the owner's) year's income; for people must, and usually are ready to, pay for their fancies, and a good cob, as already remarked, is, of all the equine race, essentially a fancy article, and one too for which the demand is always brisk." Cob.

A Galloway, although strictly speaking a distinct breed, is commonly understood to be a horse not over 14 hands. Prior to the introduction of railways, or even before the fast coaches were put upon the road, Galloways were a Galloway.

favourite means of locomotion by persons of moderate weight and stature.

ny. A pony must be less than 52 inches (13 hands) from the ground to the top of the withers; else he is a Galloway. Ponies, as a rule, will do far more work than a full-sized horse; they improve wonderfully in a well organized stable; they are, it is said, never lame in the feet, and seldom become roarers; but, as a set off against these good points, they are often very tricky, and sometimes troublesome in the stable. In proof of the powers of endurance possessed by ponies, it is related that a well known one, 12 hands high, called Sir Teddy, raced the mail from London to Exeter, beating it by 59 minutes, and doing the 172 miles in 23 hours and 28 minutes. The extraordinary little animal was led between two other horses all the way, and carried no weight.

ver cks. The chief use of the cover hack is to take the rider to the meet, usually at the unnecessarily hasty pace of 10 to 12 miles an hour, at which rate the hack should be able to go with tolerable ease to himself and great ease to his rider. He should be from 14 to 15 hands in size, and should, in fact, be a somewhat undersized light-weight hunter. Although the cover hack will generally be asked to canter or gallop, he may be required to trot, and this must be done at 9 or 10 miles per hour. To accomplish this he must have good hind action, but in front he should waste no time by picking up his feet after the showy manner of his park brother; in fact, appearance is not of much importance so long as the necessary working qualifications exist. A good temper is desirable, and, although the cover hack need not have such a perfect mouth as the London horse, he should be by no means a puller.

eed- g of cks. The breeding of hacks, like breeding for any particular stamp of horse, is all chance work, especially in the case of halfbreds. A rather small thoroughbred horse and a hackney mare may produce a thing like a pony, or a bigger animal that is quite useless for saddle work. Even in breeding for hunters, two or perhaps three out of five colts will grow up more fitted for the shafts than for a bridle. Perhaps the generality of hacks are either thoroughbreds which have been turned out of training, or horses that have grown up too small for hunting purposes.

arger l op- rse. *The Charger and Troop-Horse.*—These are bracketed together because their training and duty are nearly identical (the charger of a field officer of an infantry regiment need only be a decent saddle horse that will stand fire), the chief difference between the two being that the latter being paid for by the country is ordinarily a cheaper article than the former, which the officer buys for himself.

A charger, fit for the mounted arm of the service, is a difficult article to meet with, at least a perfect one is, because so many good qualities must be found combined. A hunter is capital raw material out of which to make a charger; but appearance, which is not a *sine qua non* in a hunter, is indispensable in a charger, which must also have high action, though the paces must be easy in consequence of much riding having to be done without stirrups. The best size for a charger or a trooper is about 15·2 or 15·3; moderate-sized horses can be made more handy than larger ones, and experience seems to show that they are more hardy and better doers than horses of greater stature. When a horse has been found that for shape and size will do for a charger, he must be of the right colour for the regiment, if it be *de rigueur* to have any particular colour, and he must be passed as sound by the regimental veterinary surgeon.

The troop-horse must be as much like the charger as possible, but, as the trooper's price is limited to about £40, a difference, and that a very striking one, must always exist. The bulk of the troop-horses are bought when rising four years, having of course been passed by the veterinary surgeon; and, being nourished on the best food, these often develop into well-grown animals by the time they take their place in the ranks. Before that time comes, however, there is a good deal to be done in the way of training, for no matter how quiet the four year old may be to ride, or how well he may have been broken from a civilian's point of view, he is no more fitted for cavalry purposes, until he has passed through the rough rider's hands, than if he had never been handled at all.

The young horse's presence at barracks shows that both the colonel and the regimental veterinary surgeon are satisfied with him. Lunging constitutes the first part of his education, after which he is ridden. Now comes the formation of the paces, instruction in passaging, *i.e.*, walking sideways on a pressure by the rider's leg on the side opposite to that towards which the horse is required to move, and in reining back. All these things are done with the snaffle only; and, when something like familiarity with these exercises has been acquired, the bit is used. The troop-horse goes more on his haunches than a civilian's horse, and, while he is taught to walk at a fairly quick pace, the canter is practised as slowly as possible. Then comes jumping practice over the bar; and finally sword, carbine, or lance exercise is performed by his rider, and he is ridden first at drill practice, then at ordinary drills, and last of all on a field day.

As the cavalry soldier has to use his weapons with one hand, he has only one for the reins; and this renders it important first that the horse should be so broken that the rider can effect with his leg or heel what civilians do with the second hand, and next that the horse should be well under the control of a single hand. As before remarked, the position of the head makes a great difference in the ease with which the horse can be governed, and as troopers have all to do the same things in the saddle, it follows that they should as far as possible all ride the same sort of horses; accordingly all troop-horses are trained to carry their heads as nearly as possible in one position, that being chosen in which the angle formed by the head and neck gives most power to the rider.

Harness Horses.—Just as a hunter is metamorphosed Harness into a hack by using a sharper bit and riding him on the horses. road, so the mere fact of driving a horse in harness makes him a harness horse, whether he really be hack, hunter, or charger. Carriages are now made of endless patterns and of all sizes, so that there is not a saddle horse to be found that could not be accommodated with something adapted to his appearance and powers. Perhaps the only class of harness horses except cart horses that are not fitted for saddle work are the regular heavy carriage horses—great upstanding animals 16½ or 17 hands high. These are generally bay, and are bred in Yorkshire or abroad. They are purchased at three years old by the few dealers who trade in them, and are brought to town, where they are carefully driven about by an experienced breaksman until they are well used to the sights and sounds of London, and have action and strength enough to go to regular work. One well-known firm of dealers never sells these horses, but jobs them, the charge for a year varying from £80 to £120 for a pair, according to the value, the hirer of course keeping them, but having the right to call upon the dealers to send a fresh horse to replace one that may fall sick or become lame or fail to give satisfaction to the hirer. During the London season many of these pairs may be seen in the carriages of the titled and the wealthy. They are imposing-looking animals owing to their great size and to the massiveness of the harness, but when closely examined they exhibit many faults. Their heads are often large, shoulders straight, and hind legs defective in power. They are not a very profitable stamp of horse to have much to do with; they must have a certain amount of action, and this on the London stones soon knocks to pieces legs that are not particularly calculated to withstand wear and tear in the first instance; and it very often happens that during breaking a horse's legs show signs of failing, and he has to be thrown up for a while. Carriage horses are of course not always bay; but greys, chestnuts, and browns are not of any distinct breed.

A really well-matched pair, with good action, are worth a long price; and it is most unreasonable for persons, after selecting their horses no less with an eye to their natural good appearance than for other qualities, to persist in making them carry themselves in a highly unnatural position, by the grossly unnatural use of the bearing rein, which is buckled up cruelly short. If a carriage horse carried his head naturally in the position into which it is forced by the abuse of this contrivance, he would be rejected at once; tight reining up is the cause of many horses becoming roarers.

With regard to harness horses of a smaller size, their ranks may be recruited from the class that supplies hunters and hacks; but straight and loaded shoulders and straight hind legs, unpardonable defects in a saddle horse, are not quite so objectionable behind the collar. Phaeton horses should have moderately high action, and be compactly built, and should not exceed 15·1, unless the vehicle be very high on the wheel. Stage coaching, as a trade, no longer exists in England, but, during the summer months, many well-appointed coaches are put on different roads to places within a day's journey, not only from London, but elsewhere. For this work the leaders are generally about 15·2, and the wheelers an inch higher; they should all have good sound legs and feet, and free but not high action; the wheelers should have plenty of strength for the exertion required of them in going down hill.

art-orse. *The Cart-Horse.*—At the present time it is difficult to classify cart-horses, and to point to any distinct breeds. The true Cleveland horse is practically extinct, and the animal now called a Cleveland bay bears but a slight resemblance to his ancestors. The old Cleveland horses were noted for their strength; they are said to have *carried* a weight of 760 lb, or more than 54 stone, a distance of 60 miles in 24 hours. The old Suffolk Punch, originally descended from Norman stallions and Suffolk cart mares, is also extinct, the modern representative of that breed being the result of different crossings; he is found of two different kinds, light and heavy. The Clydesdale horse is well adapted for use in a hilly country. It derives its name from a district on the Clyde in Scotland, whither it was introduced by one of the dukes of Hamilton, who crossed the Lanark mares with imported Flemish stallions.

The native English cart-horse is a huge animal, usually of a black colour, and stands about 17 hands high and more. These horses are bred chiefly but not solely in Lincolnshire. At two years old they are generally sold by the breeder, who thus is enabled to secure a fair profit at an early period. They are at once put to gentle work by the first purchaser, and so earn something towards their keep. During this period they are well fed, and when they have attained their fourth year they are made up for the market, by being fed with oilcake, grains, and other fattening food, besides oats. When their preparation is finished, they find purchasers at a sum sometimes exceeding £100.

The use of these very heavy horses is now chiefly confined to brewers' drays, to contractors' trollies for conveying blocks of stone, and for drawing carts containing building materials, and heavy iron work, such as boilers, parts of bridges, &c. From their great size they require a large amount of food; and, although occasionally useful for drawing heavy weights, they are being gradually displaced by a lighter and more active horse.

Stable Management.

In treating of this part of the subject, it is assumed that the stable is in a healthy situation, for in an unhealthy one trouble or expense will be simply thrown away. Horses dislike bad smells; the drainage of the stable should therefore be well looked to, and the traps should be as far from the stable as circumstances will permit. The pit for the reception of the manure and foul litter, which should be constantly removed, should also be some distance from the stable.

Stalls. Stalls should not be less than 6 feet wide; if 3 inches more can be had so much the better. The partitions should be long enough to prevent horses kicking each other, and high enough, towards the head, to prevent them biting one another. Some authorities recommend that the partitions be so arranged that horses cannot see each other; it makes them restless they say. The soundness of this advice is open to question: it may perhaps hold good with regard to race-horses; but the horse is fond of company, and certainly horses that are driven together, or ridden in company, seem to like the society of their fellows in the stable, while, as already stated, a stable companion is useful to lead young horses over fences in their early attempts at leaping.

In dealers' stables the floor of the stalls often slopes considerably from front to back. This makes a horse look bigger than he really is, but it throws all the strain of supporting the body on to the back tendons, and should not be permitted in private stables. A fall of $2\frac{1}{2}$ inches is more than enough for the purposes of draining.

Lighting. As regards the internal arrangements, especial care should be paid to light, ventilation, and temperature. A sufficient amount of light is indispensable for the health of the horse. Horses, like men, are greatly influenced by surroundings, and, considering the number of hours in the week spent indoors, a horse can no more thrive in a dark stable than a man in a dark room. Moreover, a horse brought out of a dark stable is much more likely to shy than one whose eyes had not been dazzled by the sudden change from dark to light. Dark stables were once thought to be conducive to good feeding, and to making a horse lie down, but the idea is now exploded. The horse owner may here be warned against seeking to make up for a deficiency of natural light by having the whole of the interior of the stable whitewashed. To the height of 7 feet from the ground the walls should be coloured with some neutral tint, that the horse's eyes may not be injured by the glare inseparable from whited walls. Dark stables encourage carelessness in the groom, the result being an accumulation of dirt; and, even if the stableman be an honest worker, he cannot see to clean the floors and corners properly unless light be freely admitted to the building.

Ventilation. In the ventilation of stables many theories have been propounded, and many appliances suggested, but most of the latter have failed from letting in cold currents to a greater extent than they let out the foul air. In nineteen cases out of twenty, the ventilation of private stables consists of holes in the brickwork. In using these it will be found advisable to have thin pieces of zinc, with felt edging to prevent noise, and with easy working hinges, nailed outside the wall, to act as valves; then should the wind set from the quarter in which the ventilators are situated, the zinc coverings will be blown against the apertures, and the entrance of cold currents to any great extent thereby hindered. When the stable is empty, doors and windows should be thrown open if the weather allow it to be done without reducing the temperature too much. These remarks on ventilation apply chiefly to smaller stables built in the vicinity of a dwelling house; in the case of stables built in open spaces, for the reception of a large stud, recourse will generally be had to the advice of a civil engineer on the question of ventilation, but even then experience has shown that the difficulty will not be wholly overcome. The apertures in the walls for the escape of foul air, which, being lighter than fresh, ascends, should in no case be less than 7 feet from the ground. If the ventilators are lower than this there will be a current of cold air blowing on the horse's body, which would be injurious at all times, but especially when the horse comes in warm from work.

emper-ure. Temperature is of course an important matter, but chiefly so during the colder portions of the year. In summer it is all but impossible to keep stables cool when the thermometer is standing at 80° Fahr. in the shade; still if the situation is favourable to coolness, and the temperature can be kept below 70°, so much the better. During the hunting season, stables may be too warm by accident or from design: they may be overheated owing to insufficient ventilation, or because the groom connects a glossy coat with a stable bordering on tropical heat. About 55° Fahr. is a good mean temperature, but this cannot of course be maintained when the outside air is some 10 or 15 degrees higher; the most that can be done is to keep the temperature up to that point in cold weather A moderate temperature and moderate clothing are better than too low a temperature with excessive covering, or too high a temperature with but little clothing.

oth-g. Having mentioned clothing incidentally, it may here be said that the best shape is the ordinary sheet, cut out at the neck, and buckled across the chest; the sheet should be long enough to reach the root of the tail, and should be large enough to buckle easily round the chest; if it be tight the hair will be rubbed. Some people prefer a straight rug that does not buckle, the front being formed of a separate breast cloth. Hoods are only needed when at exercise in bad weather, or when the horse is travelling by railway. Particular care should be taken that the roller does not touch the back bone; the pads should be so placed that there is a clear space of 4 inches between them, so as to leave a clear channel over the back bone. The neglect of this precaution will inevitably produce a sore back, and, while first of all making the horse shy of being touched, may subsequently make him vicious in the stable.

neral nage-nt. Regularity is absolutely indispensable to successful stable management; without it, the horse may be subjected to a dozen different kinds of treatment in as many days, a course obviously detrimental to his health.

The engagement of a good groom is the first step. Where there is a stud of ten or more horses, a stud groom will probably be kept, and, as he will not do much work himself, —indeed it is better that he should not,—he should know how things ought to be done, and see that they are done. In small establishments, however, there will be but one or two men; but the head one should be a thorough stableman. The more ignorant he is of the veterinary art the better; indeed, every horse owner should, in the strictest terms, forbid his servants to administer any drug or medicine whatever without permission; and the owner himself may be advised never to sanction the giving of any physic, but always to seek good professional advice if any signs of sickness are visible.

Stable work should commence early, as soon after 6 A.M. as possible. The first duty is to examine each animal carefully, to discover whether any injury has been received during the night from kicking, getting cast, or any other cause. Horses are then fed and watered, the litter is turned up, that which has been in use during the night not being allowed to remain in the stable during the day, and the stable is put in order; exercise succeeds, after which the animals are thoroughly dressed, but the dressing should never be performed out of doors. Feeding takes place again at 12 noon, 4 P.M., and 8 P.M., when the horses are done up for the night.

Of the feeding of race-horses nothing need be said here, as their care is a business of itself, with which the private person has nothing to do. Feeding

Oats and hay form the diet upon which horses are kept, to which beans are added for hunters and horses in hard work; while bran, linseed, and carrots are used for special purposes, in addition to, or sometimes in substitution for, the regular food. Hacks and horses in light work will do well on a daily allowance of 8 to 10 ℔ of oats and 10 or 12 ℔ of hay. Beans, which contain about 30 per cent. of nutriment, are heating, and should be given only now and then in small quantities. The oats are best divided into four feeds, and beans when used should be given at the midday and last feeds A handful or two of chaff is useful with each feed, as it compels a horse to masticate, but in many stables there is a prejudice against it, and the hay is put into the rack four times a day, not more than 3 ℔ being given at one time. Oats should be bruised; but, as they soon turn sour, it will be best to bruise every morning only as much as will suffice for the day's consumption.

Bran is indigestible, but it is a laxative, and, so far as hunters are concerned, it is only given in the form of a mash after a day's hunting, and on Saturday nights. To make a bran mash, put half a pint of linseed in a pan, pour a quart of boiling water upon it, and let it soak for four hours, then take about 2½℔ of bran and mix with it enough hot water to saturate it; stir the linseed composition into this, and it is fit for use. Should the mash be put in the manger, the latter should be scoured out with hot water afterwards, or the sourness of the remains of the mash will make many horses refuse their corn.

A few carrots, which must be carefully washed and scraped, given every now and then, are useful as tending to keep the blood in good order, and checking any symptoms of fever induced by the dry food upon which horses live.

Maize or Indian corn contains so small a proportion of nutritious matter that it is not fit for hunters or for horses from which fast work is required. The London General Omnibus Company feed their large stud almost entirely on this diet, and it is found to answer (see Mr Church's evidence before Lord Rosebery's Horse Committee, 1873). It is given in the same quantity as oats.

Of late years corn merchants have introduced the system of foraging gentlemen's horses at the fixed price of one shilling per hand per week. Thus a horse of 15·2 would be foraged for 16s., and one between 14 and 15 hands for 15s.

A correct system of watering horses is no less important than proper feeding with dry food. Many grooms, in their horror at giving too much, fall into the opposite extreme, and stint the horses under their care to an extent that is positively cruel. The result of such a system is fever in various shapes, and a general loss of condition. There has of late years been a growing tendency to favour the plan of letting horses have access to water at all hours of the day and night, and experience has shown that the effect is beneficial. A separate tank in the stall or loose box is fed by a tap, and a constant supply should be kept up. If a horse watered on this plan be watched, it will be seen that Watering.

he never takes more than a very few small mouthfuls at a time, nothing like the quantity allowed by the most stingy groom; and, if the amount consumed be measured, it will be found that, after the first day or two, the horse actually drinks less than when watered at stated intervals. Where the *ad libitum* plan is not adopted, horses should be watered four times a day. Nothing can be more unwise than the undue stinting hunters of their water on hunting days; no one could expect a satisfactory day's work from an animal suffering from excessive thirst. Where horses can have water when they like, it will scarcely be necessary to do more than to put the cover on the water tank at about 9·30 on hunting mornings, assuming the meet to be at 11. It need hardly be said that the quality of water supplied to stables should be carefully attended to. Horses are easily made sick by impurities, and are very dainty in their choice of water. When on a journey, horses should never be allowed to drink at public troughs, as disease is very likely to be contracted by such a proceeding.

Exercise. Exercise is a great preservative of health, but, like food and medicine, it should be given at proper times and in proper quantities. Exercise must not be confounded with work; the severe work horses are sometimes called upon to perform takes much out of them, and exercise is one of the means adopted to counteract any ill effects of hard work. In order that the muscles of a horse may not become prematurely tired, it is not sufficient that they should be violently taxed some three days a fortnight as with hunters; they must be used every day, and the exercise by which this is effected causes all the tissues of the body to receive their support by reason of the tone given to the circulation of the blood. Hacks, harness horses, and particularly ladies' horses, should be sufficiently well exercised to guard against an excessive exuberance of spirits; for nothing is more annoying than to have an animal, quiet enough in an ordinary way, perpetually jumping about at the approach of vehicles or other horses, merely because he is too fresh. Hunters should have two hours walking exercise daily; sometimes a slow trot of 3 or 4 miles may be indulged in, but, when the hunting season fairly sets in, and horses are hunted regularly, cantering should be forbidden at exercise unless either master or man happens to be a very good judge of what kind of exercise a horse requires.

Treatment of hunters. Hacks and harness horses are but rarely called upon to perform duties so exhausting as those of the hunter. In the case of the former animals, a suitable stable, good food and water, ventilation, and exercise, coupled of course with careful supervision, should, save under exceptional circumstances, suffice to keep them in good health. All the previous remarks apply in the case of hunters, but with them something more is needed. First there is the getting the animal into condition, and then comes the proper mode of treatment after work, when the system is exhausted, and the horse suffering perhaps from the effects of a blow or a fall. The art of getting hunters into condition has made great strides during the last fifty years. Nowadays one seldom hears of horses dying in the field through sheer exhaustion; and it cannot be said that their work is lighter now than it was then.

To begin at the beginning, a hunter should be fit for use by the end of October, and the question then arises, How long before this time should he have been in what may be called training?—using the word, of course, in a different sense from what is understood by training in a racing stable. The answer to this question depends very much upon how, at the termination of the last hunting season, the owner solved the difficulty of "what to do with the horses." Assuming horses are to be kept through the summer, it will probably be nearly a month after the last hunting day before the summering treatment is adopted. A dose of physic will have been administered, and, if wise, the owner will have called in a veterinary surgeon to see what damages have been sustained; but he should be one used to hunters and their peculiar infirmities.

Many persons with the best intentions, and following very ancient traditions, turn their horses out to grass, saying that a "summer's run" will put new life into them, but not explaining why a horse that up to Monday night is kept clothed in a warm stable and fed on hard food, should be greatly benefited by being turned into a field on Tuesday without his clothing, and left to subsist entirely on grass. This sudden change of living, which used to be so universal in the case of horses, is condemned in the human subject; and that is not the least powerful argument that can be urged against it. Moreover, most veterinary surgeons agree that more hunters have been made roarers or contracted disease of some kind from being turned out to grass than from almost any other cause. In the days when summering in the fields was the usual method pursued, a hunter was never really fit until the season was far advanced, and the turning out to grass in May was simply undoing all that had been done since the previous August. Although here and there a few individuals adopted a more common sense way of summering their hunters, the full evils of the grazing system were not impressed upon the public until "Nimrod," in letters to the *Old Sporting Magazine*, advocated the adoption of a more enlightened system, and showed the weak points in the old one. The advantages claimed for the plan of turning out to grass were that the horse's system and his feet benefited, and that it was cheaper. But violent changes in the manner of living cannot be beneficial, and, as regards the feet, Mr Goodwin, veterinary surgeon to George IV., said: "I have invariably observed, where horses are turned out to grass during the dry and hot summer months, that, on bringing them up to be put into stable condition, their feet are in a much worse state than when they went out, dried up, and so hard and brittle that, on the application of a tool to bring them into a form to receive a shoe, the horn breaks like a piece of glass, and all the naturally tough and elastic property is lost, so that it requires some months to remove its bad effects. . . . . . . Horses at grass are much inclined to thrush." As to the expense, the objection is too trifling to be taken as a set off against any real advantages the system advocated by "Nimrod," and now generally adopted, may be found to possess.

But in whatever way a horse is summered, it is clear that there must be a great change from a state of hard work to one of absolute rest and quiet, and this change should not be the work of a moment. Unless an owner be particularly lucky, some one or more of his hunters will generally show signs of wear and tear before the end of the season has arrived, and these should be the first thrown up. They should be exercised daily, but their corn should be diminished, and their dressing in the stable need not be of the same thorough kind as when they were in full work. After about a fortnight of this treatment summering may begin in its full sense. The state of the horse's legs, and the judgment of the owner, will determine whether the horse shall be exercised during the summer, or left to exercise himself. In the former case he must remain shod, and have his feet stopped two nights a week with damp tow, or, if there be much tendency to fever, with tow dipped in the best Stockholm tar. Exercise should take place in the cool of the day, in the morning for choice, on soft ground, for about an hour and a half. Where the horse is left to exercise himself, he should be housed in a good-sized shed or box opening into a straw-yard or small paddock, which should be shaded by trees or buildings, so that the maximum of air can be breathed with the minimum of exposure to the sun. A horse thus kept should have his shoes removed, and, as his feet cannot then be stopped, he should stand once or twice a week, for an hour at a time, on wet clay.

The constitution of each particular horse should be taken into account in deciding how he shall be fed during the summer months. The aim to be kept in view is to maintain the strength, but not to engender fever,—to let the system down as it were, but not to undo all that has been done during the hunting season to a greater extent than may be found necessary. As a general rule, three feeds of oats a day (the feeds being rather smaller than those given during work) will be sufficient; beans should be eschewed, but 8 or 9 lb of hay may be given. Green food should be given with caution, say twice or thrice a week, to assist in maintaining a healthy action of the bowels.

The getting the horse into condition again for the ensuing season should be accomplished gradually, and all violent exertion should be avoided. About the beginning of August the shoes should be put on the unshod horse, and he should have an hour's walking exercise daily for about a week, when the time may be extended by degrees. The horse that has been exercised all the summer will need no special attention until the beginning of September, about which time all the horses should have slow trotting exercise twice a week on soft, but not deep, ground. During October cantering may be indulged in twice a week, but plenty of walking exercise should form part of every day's work. The quantity of oats given should of course be increased as the work gets stronger, until, before the commencement of the hunting season, the full quantity is reverted to.

It is of course the groom's duty to get a hunter into condition, and to apply the proper treatment on his return to the stable, when tired by the day's work; but during the day the horse will be under the care of the rider, and carelessness or want of judgment on his part may occasion injuries not to be overcome by any known system of stable management. As soon as the hounds leave off, the rider, if more than a mile or two from home, or if the day has been at all severe, should get his horse some gruel at the nearest inn or cottage, or, failing gruel, a little tepid water, with or without a handful or two of flour stirred into it. A horse's stomach is small in proportion to the size of his body; he should not therefore be kept without sustenance of some sort longer than is necessary. Should the animal show signs of great distress, he should be got into the first stable that is reached, or if there is not one handy into a shed, and the more airy it is the better. The head and legs should be well rubbed; clothing should be put on the body, and a cordial of some sort administered as quickly as possible,—sherry, spirits, or beer will do; and a veterinary surgeon should be sent for at once.

When the hunter returns to his own stable, he should first have his pail of warm gruel and linseed made according to the receipt given above; and after he is dressed, it will only be necessary to see whether he feeds as usual. If he does not, water with the chill off may be given to him. Should he be merely fatigued, a night's rest in an airy box will soon restore him; and here it may be observed that all stables should include at least one loose box for the reception of a horse returning from hunting; rest cannot be so satisfactorily taken in a stall.

reat- ent of rses' gs. The treatment of horses' legs is a most important part of stable management, and one which is but too often imperfectly understood by men who, though nothing but strappers, call themselves grooms. In many stables it is the custom to wash the feet and legs of horses returning from work, but the practice is calculated to produce cracked heels, a state of things which often results also from a too frequent use of wet linen bandages. The better plan is to forbid the use of water above the hoof; and, as soon as the hunter comes in, some rough serge bandages (kept for the purpose) should be put loosely on his legs. These may be removed after the rest of his body has been dressed, when the legs will be found quite dry, and the mud will crumble off like sand, while half the labour that would have been needed to dry the washed legs will suffice to brush every particle of grit from the hair and skin. The legs should then be well hand-rubbed, and the ordinary bandages may be put on for about four hours; on their removal more hand-rubbing should take place. A constant use of bandages is to be deprecated, unless it is ordered for some particular purpose by the veterinary surgeon.

nor sual- s. The reader has been already warned against being his own veterinary surgeon; but there are certain minor casualties to which every horse is liable, and which an average groom should know how to treat. A very common cause of a hunter being laid up is a blow on the leg, which may be either on the skin or on the sinew. If on the skin, the leg should be bathed with hot vinegar and water, in equal proportions, three or four times a day. A blow on the bone often causes a bony enlargement, but beyond constituting a blemish is of no importance. A blow on the sinew is generally the cause of a long period of lameness, and firing may be needed. If the blow be only a slight one, bathing in cold water is the best thing that can be done.

Cutting. Cutting is sometimes the result of malformation of the legs, and sometimes the result of fatigue, for some horses will now and then brush themselves after a long and tiring day, who never do so in going to cover. A boot and change of shoeing must be resorted to.

Corns. Corns are to be laid at the door of the shoeing smith. They arise from the shoe being too tight, or from its being nailed too near the heel. A careful groom should superintend the shoeing, and should instruct the smith to pare the sole at the seat of the corn, and to take care that the new shoes do not press upon the sole. The sole must be kept well pared and dressed with tar. Should the corns be so bad as to suppurate, hot linseed meal poultices should be applied, and work dispensed with.

Thrush. Thrush is a diseased state of the frog, caused, in most instances, by the feet being neglected in the stable. The diseased parts should be cut away, and the openings in the hoof stopped with tow dipped in tar.

Cracked heels. Cracked heels generally owe their existence to the legs having been left wet after washing. In the early stages cut the hair from the sore part, wash with warm water, dry, and apply glycerin lotion. If riding or driving a horse with cracked heels, never allow the sores to be rubbed with grease before starting, as the dust or dirt will cling to this, and by getting into the sore make it worse than ever.

Over-reach. An over-reach is a not uncommon occurrence in the hunting field. An old piece of linen, folded three or four times, should be soaked in water and fastened on the place, and a piece of oiled silk should be kept on over the linen to prevent evaporation.

Sore back. Sore backs are very troublesome to get rid of, and would not happen so often as they do were more attention paid to the fitting of the saddle and the way it is stuffed. Most saddlers put too little stuffing in a saddle, and so after it is used a few times the inside becomes hard. When the skin is found to be rubbed, use the wet linen and oiled silk as for an over-reach, and afterwards chloride of zinc lotion.

Fever in feet. Fever in the feet is generally the result of too much knocking about on hard roads. Directly lameness appears, take off the shoe and place the foot in cold water, putting on a poultice at night.

PART III.—HORSEMANSHIP.

Horses being ridden for several distinct purposes, viz., in the cavalry service, for hunting, racing, steeple-chasing, on the road, and in the school, there are separate styles of horsemanship adapted to each purpose, and a rider excelling in one is not of necessity a proficient in the others; in fact few persons, if any, are equally good, for instance, at military or *manége* riding and at steeple-chasing.

ount- . The first step in horsemanship is to mount a horse; but for the performance of this apparently simple feat no fixed rule can be laid down for the guidance of the civilian. Having taken up the reins, the rider should stand at his horse's near shoulder facing towards the tail, and in that position hold the stirrup with his right hand for the reception of his left foot. By standing at the shoulder the rider is out of harm's way in the event of the horse kicking while he mounts. It is perfectly easy to carry out these directions when the man and horse are both of middle height; but it is simply impossible for a short man to mount a horse of 16 hands high in such a manner, he must risk the kick and stand where he can reach the stirrup—behind it. Having gained the saddle, the necessity arises for seat and hands. The fact that the seat of a civilian rider must vary to some extent according to the size and shape of the animal upon which he finds himself, does not preclude certain principles from applying in the formation of it, and it is towards the proper understanding of these principles, and the adoption of the right position of the legs and body, that good instruction is desirable at the outset.

The great desideratum in a seat on horseback is that it should be firm, and this for two reasons. In the first place, a rider with an insecure seat is apt to be thrown by any unexpected movement the horse may make, such as a slight stumble, or shying; and secondly, without a firm seat, the acquirement of good hands is well nigh hopeless, because, when the balance is once disturbed, the rider will have to depend on something else for the maintenance of his seat, and this other means of support will generally take the shape of "riding the bridle," a practice as much opposed to good horsemanship as it is injurious to the horse's mouth.

Having gained the saddle, the rider should seat himself in the middle of it, and should never allow any part of his person to overlap the cantle, as is but too often seen. Many rules are given for adjusting the stirrups to the proper length before mounting, but in practice they are not to be depended upon,—first, because all men are not made in quite the same proportions; secondly, where two men are of equal height, the man with the thicker and rounder legs will require a shorter stirrup than the one with lean and flat legs; and thirdly, men of any build will need a shorter stirrup on a wide horse than on a narrow one, besides which, if a horse pulls at all, another hole or two will give the rider additional power over his animal. The proper length of stirrup, then, cannot be satisfactorily ascertained till the rider is mounted. Sitting well in the middle of the saddle, the thighs being turned in, and the heels drawn somewhat back, the stirrup leathers may be let out or taken up until the tread of the stirrup is on a level with the inner ankle bone, and at this length, when the rider stands up, his fork will clear the pommel of the saddle by about 3 inches. For maintaining his seat the horseman should depend upon his thighs and knees, and not upon the knee and calf only; at times, of course, when on a restive horse, every available muscle may have to be brought into play, but the proper rule is as stated. Some people say they ride by balance only, and others that they ride by grip; a proper seat should be an admixture of the two: a man riding by balance only is sure to be kicked off, while to grip with all one's might during an hour's ride is to undertake as much exertion as should last for a whole day. The position of the foot exercises some influence on the security of the seat; at one time it was thought proper to turn the toes in and depress the heel, a posture that tended to diminish the grip of the thighs, but now the toe should be turned a little outward, and but very little upward. A good seat on a horse should not be strong merely; it should be as graceful as the make and shape of horse and rider allow; but it should not be a stiff, stuck-up seat, which is never graceful, because it is not natural. Above the loins the body should be loose, so as readily to adapt itself to every motion of the horse; but it should be upright, for if the rider lean forward in his saddle, a false step on the part of the horse is very apt to send him flying over its head. The position of the hands has a great deal to do with the seat, but the hands and the reins will be treated of presently.

Beginners are often advised to learn to ride without stirrups; if they do, they should have no saddle either, for riding in a saddle without stirrups is likely to produce rupture. The soundness of this advice, however, may be questioned, because, although riding without stirrups will undoubtedly tend to a firm seat, it will not be one of the same sort as when stirrups are used; there must therefore be a process of learning and unlearning. The better plan is to practice both ways concurrently. Thus let the pupil be properly placed in a saddle with stirrups, and when he has ridden half an hour let a cloth be substituted for the saddle for about ten minutes, care being taken to observe the rules already laid down for the position of the legs; in this way the proper seat will be strengthened, instead of a new one being formed.

The hands and the reins.

The proper adjustment of the reins is the next thing to be attended to, and as the management of these depends so much upon the seat being firm and independent of the bridle, the acquisition of a firm seat is certainly half way towards the acquirement of good hands. Assuming a single rein snaffle to be the bridle used, the second, third, and fourth fingers of the left hand should be inserted between the reins, which should be drawn up gently with the right hand until the rider feels that he has got an equal hold of his horse's mouth on both sides, and with just so much pressure that the slightest movement of the left or right rein would cause him to turn to the left or right respectively; the fore and middle fingers of the right hand should then take hold of the right rein, which may be drawn out from the left hand so as to enable the hands to be held about 4 or 5 inches apart. The arms from the shoulder to the elbow should hang naturally close to the sides, and the arms from elbow to wrist should be about parallel to the ground, the wrist being kept loose, so as to yield gently with every motion of the horse. The rider sitting in the position described, square to the front, with his shoulders well back, will be riding with fairly long reins, one of the secrets of good hands; if he stoop forward and carry his bridle hand at some distance in front of his body, so as to take a short hold of his horse's head, seat and hands will both be bad.

When a double reined bridle is used, the third finger of the left hand should be first inserted between the snaffle reins, and then the little, third, and second fingers should be between the curb reins, the two outside reins will then be the curb, and the two inside ones the snaffle. In this manner of holding the reins the snaffle is not so likely to slip, while the curb can be easily slackened or drawn tighter. As military riders invariably use the curb only, the position of snaffle and curb as just explained is reversed in the cavalry service.

When the horse is in motion, the hands should not be kept in one spot, so as to act like the peg on the pad of a harness horse to which the bearing rein is fastened, as the mouth would thereby become dead, and the horse would lean unpleasantly on the bit; but the rider should give and take, so that while the pressure is not stronger at one moment than at another (unless there be a reason for it), yet, on the other hand, the hold should never be entirely relaxed.

Walking.

In order to encourage the horse to walk, the head must not be confined, but the light feeling on the horse's mouth must be kept up. Should the horse break into that uncomfortable pace, a jog trot, which, by the way, a well-broken hack should not do, never snatch at his mouth, but restrain him gently. To trot press the legs to the saddle, raise the bridle hand a little, and urge him if necessary with the voice. The rising to the trot should be performed easily; the legs must not swing backwards and forwards, nor should the hands be jerked up and down, while the action of the rider should be in perfect time with the motion of the horse, or a passer by may remark that the horseman is riding faster than his horse. To start in the canter take up the curb rein a little and turn the horse's head slightly to the right, at the same time pressing the left leg behind the saddle, the horse will then lead with the off fore leg, which is generally preferred under ordinary circumstances; but a well-broken hack should be taught to lead with either, and if he be cantered in a circle to the left he must lead with the near leg, as otherwise an ugly fall is likely to result from the leg being crossed. Galloping is a pace not generally indulged in by hack riders; when it is, the hands should be kept low, the body thrown back, and an extra grip taken, as nearly all horses pull more or less when extended.

Hitherto, only road or park riding has been considered, and, with wise people, hacking (except hacking to cover, or in the performance of a journey against time) means progressing at a strictly moderate pace—for the sake of their horse, if for no other reason.

Beginners of all ages are strongly advised to undergo proper instruction when commencing to learn to ride. The few directions already given may serve to remind a person what to avoid, but an hour's teaching is worth volumes of theory. The instructor should, however, be a practical and well-taught horseman himself; to be this it matters not whether he be a professional riding-master or not. When once the proper place for the legs and hands is pointed out, and the proper way of handling a horse and sitting in the walk, trot, and canter,—when, in short, a person has been put in the way of becoming a fair road rider, he has made some progress towards being a hunting man. But if, on the other hand, first principles are disregarded, and a rider believes in the system of "it doesn't matter how you ride so long as you only stick on," it will be a long while before he reaches his own standard, except with the comparatively few men who seem to have been intended by nature for horsemen. Few self-taught riders attain to anything like excellence; they may ride quiet horses with fair success, and even in hunting, if possessed of plenty of courage, and mounted on a bold and not too tender-mouthed horse, they may keep a good place, but horsemen in the proper sense of the word they never will be.

Now, assuming the beginner to have acquired some proficiency in riding, and to have had a little practice over the leaping bar, he may be desirous of making his first appearance with hounds, and the question then arises how is the hacking-seat to be exchanged for the hunting one, of which he will probably have heard a great deal, and have seen some very extraordinary specimens.

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For practical purposes the chief difference between a park seat and a hunting one consists in the substitution of boots and breeches for trousers, and the shortening of the stirrups some two or three holes. Next to that of a jockey, the seat of the hunting man is the most important of any connected with amusement; he must sit firm, so as not to be thrown off when his horse leaps, or makes a slight mistake, technically called "pecking," on landing after jumping a fence, and so as to be able to handle his horse delicately under all circumstances, and to make as much of him as possible. As with road riding, so with hunting, the actual length of the stirrups will depend a good deal upon the form and action of the horse, but the nature of the animal and the peculiarities of the country ridden over will also have something to do with their adjustment. A puller will compel the rider to pull up his leathers one or perhaps two extra holes—a course that may also be rendered necessary in a hilly country, for, in going down hill, the stirrups, if kept at the ordinary length, will generally feel a great deal too long. The rider's body must be kept close to the saddle in leaping, for if he were jerked up, the weight of say only a 10-stone man coming down on the horse a couple of seconds after he has negotiated a large fence is sufficient to throw him down. Nothing but actual practice with hounds can teach a man the kind of horsemanship required for hunting where land of all kinds has to be ridden over, and obstacles of various sorts, natural and artificial, have to be encountered.

Considerable progress may, as already stated, be made in seat and hands within the four walls of a good riding school, but as the art of warfare must be learned on active service, and not on the parade ground, so nothing but actual practice in the hunting field will teach a man that kind of horsemanship adapted to the ever-varying conditions and different situations to be met with in a single day's hunting. For example, the ground gone over is not always the level springy turf of the race-course; it is up hill and down dale, across ridge and furrow, over ground studded with ant-hills (which, unlike mole-hills, are often very hard), over ploughed lands, and in boggy countries. Now each of these varieties requires a different method of riding over, and nearly every horse will require different handling under similar circumstances; some can go well through the dirt, while others can only go on the top of the ground; some will require rousing at their fences, while others will want quieting.

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It will therefore be seen that much depends on the rider having good hands. This qualification, though generally understood, is very difficult to define. A rider with good hands never depends upon his reins for retaining his seat; nor does he pull at the horse's mouth so as to make him afraid to go up to his bit; nor again does he ever use any more force than is necessary for the accomplishment of what he desires to perform. But besides all this, there is an unaccountable something about the man with good hands that cannot be described. Pullers appear to renounce pulling, refusers take to jumping, and clumsy horses appear nearly as handy as a trick horse in a circus. Though "hands" can to a great extent be acquired by care and practice, yet in the highest form it is a gift like the "hand for crust" which is denied to many cooks and cannot be learned.

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There are different kinds of "fences," as all obstacles are generically called. First, there is timber, such as gates, stiles, and rails; the first two are, nine times out of ten, awkward jumps, as the take off is either poached by cattle, or else is on the ascent or descent. Hedges vary according to the custom of the country in which they are found: they either grow in the soil of the field, and are protected by a ditch on one side, or are planted on a bank with a ditch on one side or sometimes on both. The rider may here be reminded that if a bank is high and the ditch before it but small, there is pretty certain to be another ditch on the far side, for the bank is made by throwing up the earth taken from the ditches. Then again there are the large banks found in Wales, Devon, and Cornwall. Lastly come water jumps, which are met with in two forms: the water is either within an inch or two of the top of the bank, so as to be about on a level with the field through which it flows, or there may be a space of some 6 or 7 feet from the bank to the water. For the successful negotiation of brooks a bold horse is required, ridden by a bold man. No fence that is ever encountered stops such a large proportion of the field as water; even a clear 6 feet of it will prove a hindrance to some, while anything over 10 or 12 feet will in general be crossed only by a very few. Some horses, good performers over any other description of fence, will not jump water under any circumstances; while the chance of a ducking deters many from riding at it; and, however bold the horse may be, he will soon refuse water if his rider be perpetually in two minds when approaching a brook.

The pace at which a hunter should be ridden at his fences depends upon the nature of the fence itself, and the peculiarities of each individual horse. With some very good jumpers—they can hardly be called good hunters—to steady them is to bid for a fall, while with some very clever hunters to hurry them is to bring them to grief. With ordinary horses, however, it is a good general rule to ride at fences of all descriptions as slowly as the nature of the obstacle admits. In grass countries, where "flying fences" are found, the rate of speed must of necessity be quicker than when about to take a Devonshire bank of some 7 feet high, but even at a flying fence the rider should steady his horse so as to contract the length of his stride, in order that he may measure the distance for taking off with greater accuracy. Flying fences consist of a hedge with or without a post and rail, and with or without a ditch on one or both sides; consequently a horse has to jump both high and wide to clear them. But in jumping a gate, or a flight of rails, as ordinarily situated, there is no width to be covered, and to make a horse go through the exertion of jumping both high and wide when he need only do one is to waste his power, added to which to ride fast at timber, unless very low with a ditch on the landing side, is highly dangerous.

All hedges on banks, banks, and doubles must be ridden at slowly; they are usually of such a size as to make flying them impossible, or at least undesirable. Horses jump them on and off, and in taking them at a moderate pace there is a chance of stopping on the top and choosing a better place to jump from, or, if needs be, of returning and taking the fence at another place. Cramped places will have to be jumped from a walk or even at a stand; for instance, a tree may be in a line with and close to the only practicable place in a fence; it then becomes necessary to go round the tree before a run at the place can be managed. So, too, with places that have to be crawled over between trees, or with dykes to be crawled down.

In jumping an ordinary hedge or ditch at moderate speed, there is of course a moment of time during which the horse is on his hind legs, and in theory the rider should then lean forward, but, in practice, this position is so momentary, and the lash out of the hind legs in the spring is so powerful, that it is best not to lean forward at all, because of the difficulty, if not impossibility, of getting back in time for the reverse movement, when the rider should be preparing to render the horse some assistance with the bridle as his feet touch the ground.

Water, as was said before, stops a field more than any other kind of fence, because, so far as the rider is concerned, a strain to the horse's back or a bad over-reach is likely to result, and the contemplation of a ducking is not pleasant on a cold day. Then as to the horse, if he ever got into a brook when young, and found any difficulty in getting out again, it is ten to one against his ever taking kindly to water afterwards. When a line of willows indicates the whereabouts of a brook, the horse should be well collected, a clear place selected, so far as circumstances allow, and the pace increased, though in short strides, up to the very brink. If the hounds jump at the brook, even though they fail to clear it, the rider may take it for granted that at that place the leap is within the capacity of any ordinary hunter in his stride; hence if, when going at three parts speed, a horse's feet come just right to take off, the mere momentum of his body would take him over a place 15 feet wide.

Riding to hounds. Now jumping a fence is one thing, and riding to hounds is another; a man may be a very good horseman, and yet be a very bad man to hounds. The leading hounds should be watched, and when they turn right or left the rider should turn too. Then the choice of ground is important; ridge and furrow should be taken diagonally, or, if the field be entered towards either end, time will ultimately be saved in going round by the firmer ground at the sides. Ploughed land requires the rider's special attention; an injudicious hurry over a couple of deep fields has settled many a good hunter for the remainder of the run. In jumping into a ploughed field the fence should be taken slowly, and the rider should lean well back in the saddle, because, lacking the elasticity of turf, a ploughed field, especially after rain or a frost, will let a horse's legs sink in deep on landing, and if he has been ridden at the fence quickly, the sudden resistance offered by the soft ground will inevitably cause a fall. When the ground is deep, therefore, the rider's judgment will be shown in avoiding, where possible, large flying fences into a ploughed field, and in choosing places that can be jumped quietly.

Pace. Pace is a relative term; when the thoroughbred is but cantering, the underbred will be doing his utmost; the horseman must therefore always have an eye to his horse, and must be careful not to press him beyond a certain pace, unless of course he means to be satisfied with a short life and a merry one.

Gate opening. The experience of a single day's hunting will teach the novice that gates are far oftener opened than jumped; it is therefore necessary that a hunter should be handy at opening them. Many accidents have arisen from horses rushing through a gateway directly the latch is released, or from their jumping a gate at which they have been pulled up to enable the rider to open it. The horse should be taught to obey the leg as well as the hand, and, by a slight pressure of the leg, should throw his haunches round to the left or right as occasion may require.

Falls. Most writers on hunting aver that there is an art in falling, and the young sportsman is duly told to get clear of his horse as soon as possible. It is not to be denied that the number of accidents in the hunting field are but few considering the number of falls that take place during the hunting season, but the rarity of accidents can hardly be ascribed in all seriousness to a proficiency in the art of falling. In the first place, ditches cause many falls, by the horse dropping his hind legs into them; that is to say, his progress is arrested while the rider continues in the course his horse would have taken had the ditch not been there. When the hind legs are dropped the rider clutches instinctively with his hands and legs, and the violence of his fall is thereby broken, while in ninety-nine cases out of every hundred the ditch prevents the horse from rolling over the recumbent sportsman. Then again as to falls at flying fences taken at a somewhat quick rate, it is lucky for hunting men that under such circumstances the rider is in the majority of instances thrown clear of his horse independently of any skill or effort of his own. It is only in what may be termed "slow falls" that the rider can save himself by presence of mind and activity. When a horse slips into a ditch, or drops quietly on to his knees preparatory to rolling on his side, a practised rider has time to get clear; but in falls over timber, or over fences ridden at quickly, the freedom from accident must in sober truth be ascribed to luck rather than to good judgment.

Saddles and bridles. Saddles and bridles form no unimportant feature in the equestrian art, as well as in the establishment of a sportsman. A well-made saddle and bridle make a horse look worth an extra £20, while nothing contributes more to the safety and comfort of a rider than a well-made roomy saddle. The hunting man will be well advised if he patronizes only such establishments as make hunting saddles their peculiar study. Each horse should have its own saddle, and the closer it fits, provided it does not press upon the withers or touch the spine, the better; but, as even the best saddlers are addicted to putting too little stuffing into them, the purchaser should, when ordering, stipulate for a liberal quantity. The stirrup irons should be moderately heavy, and, if they are for full grown men, of the largest size made, for the foot will be all the less likely to be caught in the event of a fall.

The selection of a bridle will depend upon the horse's mouth and upon the rider's hands. For hacking purposes a double bridle is almost invariably used, the curb enabling the rider to make the horse appear to the best advantage; and, as a general rule, a double bridle with an easy curb bit (the curb chain being protected by a leather strap) is best for hunting purposes, as with it the horse can be collected at his fences, and held together in deep ground better than with the snaffle only. Some persons use nothing but snaffles on principle, and will submit to a vast amount of discomfort rather than call in the aid of a curb; but there are not five perfect snaffle-bridle hunters out of a hundred, and riding a horse in a snaffle is quite another thing from riding a snaffle-bridle horse. The curb, however, should be of no greater severity than is absolutely necessary; pulling is far more often caused by the pain of a sharp bit than by anything else. Whatever bit be used, it is useless to keep up one continued drag at the horse's mouth, as it thereby becomes callous and ceases to be sensitive to any gentle indications. With a puller the bit should be kept moving in the mouth, and a change of bits is often beneficial, each pattern acting in a different way, and taking a horse, so to speak, by surprise.

The less whips and spurs are used the better; unfinished riders will do well to leave the latter at home, for although they are very useful on the heels of a skilful person, an unintentional application of them is often attended with disastrous consequences.

Training of jockeys. The qualities possessed by a good jockey, either on the flat or over a country, fully bear out what has been said before concerning the value of early instruction in riding, and the impossibility of the existence of any regular system of civilian horsemanship. After having been some time in a training stable, a lad is put on a quiet horse at exercise; his stirrups are adjusted, and the reins knotted for him at a proper length. He subsequently rides other horses, each with some peculiarity perhaps, and, to keep his place in the string, a slug must be kept going, and an impetuous one restrained; they cannot both be ridden alike, but they must both be ridden as a jockey should ride them. In this way the lad learns the principle of holding a puller, getting pace out of a lazy one, and leaving well alone with a nice free but temperate mover; he learns to do everything in a horsemanlike manner, and when he has raised himself to the pitch of a "fashionable" jockey, he will frequently be called upon to ride three or four horses a day at race meetings. A jockey must therefore, more than any other civilian rider, have a hand for all sorts of horses, and in the case of two and three year olds a very good hand it must be. The same ability to adapt himself to circumstances must be possessed by the steeple-chase jockey, who should possess fine hands to enable him to handle his horse while going at his fences at three-quarter speed. In most details the nearer a hunting man approaches to a steeple-chase jockey the better; but in the matter of the seat it must be remembered that a jockey's exertions last but a few minutes, while none can tell when the hunting man may finish his day's work; the jockey can therefore ride with more absolute grip during his race than the rider to hounds.

PART IV.—HORSE-RACING.

Probably the earliest instance of horse-racing recorded in literature occurs in *Il.* xxiii. 212–650, where the various incidents of the chariot race at the funeral games held in honour of Patroclus are detailed with much vividness. How far such competitions, which bear in Homer a semi-religious character, may have arisen out of the not unnatural practice an instance of which occurs earlier in the same connexion (*Il.* xxiii. 13, 14) can only be conjectured; it is certain, however, that they very soon came to be of national importance. According to the ancient authorities the four-horse chariot race was introduced into the Olympic games as early as the 23d Olympiad; to this the race with mounted horses was added in the 33d; while other variations (such as two-horse chariot races, mule races, loose-horse races, special races for under-aged horses) were admitted at a still later period. Of the training and management of the Olympic race-horse we are left in ignorance; but it is known that the equestrian candidates were required to enter their names and send their horses to Elis at least thirty days before the celebration of the games commenced, and that the charioteers and riders, whether owners or proxies, went through a prescribed course of exercise during the intervening month. At all the other national games of Greece (Pythian, Isthmian, Nemean), as well as at many of the local festivals (the Athenian Olympia and Panathenæa), similar contests had a prominent place. Some indication of the extent to which the passion for horse-racing was indulged in at Athens, for example, about the time of Aristophanes may be obtained from the scene with which *The Clouds* opens; while it is a significant fact that the Bœotians termed one of the months of their year, corresponding to the Athenian Hecatombæon, Hippodromius ("Horse-race month"; see Plutarch, *Cam.* 15). Details as to the chariot-races and horse-races of the Greeks, and also of their imitators the Romans, will be found under the headings CIRCUS and GAMES.

There is no direct historical evidence to show that the ancient Britons addicted themselves to any form of this amusement; but there are indications that among some at least of the Germanic tribes, from a very early period, horse-racing was an accompaniment of their religious cultus. There can be no doubt that the Romans encouraged the pursuit in Britain, if they did not introduce it; traces of race-courses belonging to the period of their occupation have been frequently discovered. The influence of the Christian Church was everywhere at first strongly against the practice. The opinion of Augustine and other fathers of the church with regard to attendance at the spectacles, whether of theatre or of circus, is well known; those who performed in them were rigidly excluded from church fellowship, and sometimes even those who merely frequented them. Thus the first council of Arles, in its fourth canon, declared that those members of the church who drove chariots at the public games should, so long as they continued in that employment, be denied communion. (Compare the rule in the *Ap. Const.*, viii. 32; *ap.* Bingham, *Ant. Chr. Church*, xvi. 4, 10.) In many cases, however, the weight of ecclesiastical authority proved insufficient to cope with the force of old custom, or with the fascination of a sport the unchristian character of which was not very easily demonstrable; and ultimately in Germany and elsewhere the old local races appear to have been admitted to a recognized place among the ceremonies peculiar to certain Christian festivals.

The first distinct indication which contemporary history affords of horse-racing as a sport occurs in the "Description of the City of London" of William Fitzstephen (*c.* 1174). He says that in a certain "plane field without one of the gates (quidam planus campus re et nomine—*Smithfield*, quasi Smoothfield) every Friday, unless it be one of the more solemn festivals, is a noted show of well-bred (*nobilium*) horses exposed for sale. The earls, barons, and knights who are resident in the city, as well as a multitude of citizens, flock thither either to look on or buy." After describing the different varieties of horses brought into the market, especially the more valuable chargers (*dextrarios preciosos*), he says: "When a race is to be run by such horses as these, and perhaps by others which, in like manner, according to their breed are strong for carriage and vigorous for the course, the people raise a shout and order the common horses to be withdrawn to another part of the field. The jockeys, who are boys expert in the management of horses, which they regulate by means of curb bridles, sometimes by threes and sometimes by twos, as the match is made, prepare themselves for the contest. Their chief aim is to prevent a competitor from getting before them. The horses too, after their manner, are eager for the race; their limbs tremble, and impatient of delay they cannot stand still; upon the signal being given they stretch out their limbs, hurry on the course, and are borne along with unremitting speed. The riders, inspired with the love of praise and the hope of victory, clap spurs to their flying horses, lashing them with whips, and inciting them by their shouts" (see Stow's Translation).

In the reign of Richard I. knights rode at Whitsuntide on steeds and palfreys over a three-mile course for "forty pounds of ready gold," according to the old romance of Sir Bevys of Hampton. The feats of the tilt-yard, however, seem to have surpassed horse-racing in popular estimation at the period of the crusades. That the sport was to some extent indulged in by King John is quite possible, as running horses are frequently mentioned in the register of royal expenditure; and we know that Edward III. had a number of running horses, but it is probable they were chiefly used for field sports.

An evidence of the growing favour in which horse-racing was held as a popular amusement is furnished by the fact that public races were established at Chester in 1512. Randle Holme of that city tells us that towards the latter part of Henry VIII's reign, on Shrove Tuesday, the company of saddlers of Chester presented to "the drapers a wooden ball embellished with flowers, and placed upon the point of a lance. This ceremony was performed in the presence of the mayor at the cross of the Roody or Roodee, an open place near the city; but this year (1540) the ball was changed into a silver bell, valued at three shillings and sixpence or more, to be given to him who shall run best and furthest on horseback before them on the same day, Shrove Tuesday; these bells were denominated St George's bells." In the reign of Elizabeth there is evidence from the poems of Bishop Hall (1597) that racing was in vogue, though apparently not patronized by the queen, or it would no doubt have formed part of the pastimes at Kenilworth; indeed, it seems then to have gone much out of fashion.

The accession of the Stuarts opened up an era of prosperity for the sport, for James I., who, according to Youatt, had encouraged if not established horse-racing in Scotland, greatly patronized it in England when he came to the throne. Not only did he run races at Croydon and Enfield, but he endeavoured to improve the breed of horses by the purchase for a high figure of Markham's Arabian, which little horse, however, was beaten in every race he ran.

In 1607, according to Camden's *Britannia*, races were run near York, the prize being a little golden bell. Camden also mentions as the prize for running horses in Gatherley Forest a little golden ball, which was apparently anterior to the bell. In 1609 Mr Robert Ambrye, sometime sheriff of the city of Chester, caused three silver bells to be made of good value, which bells he appointed to be run for with horses on St George's day upon the Roodee, the first horse to have the best bell and the money put in by the horses that ran—in other words, a sweepstake—the bells to be returned that day twelvemonth as challenge cups are now; towards the expenses he had an allowance from the city. In 1613 subscription purses are first mentioned. Nicholls, in his *Progress of James I.*, makes mention of racing in the years 1617 and 1619. Challenge bells appear to have continued to be the prizes at Chester, according to Randle Holme the younger, and Ormerod's *History of Chester*, until 1623 or 1624, when Mr John Brereton, mayor of Chester, altered the course and caused the horses to run five times round the Roodee, the bell to be of good value, £8 or £10, and to be a free bell to be held for ever,—in other words, a presentation and not a challenge prize.

During James's reign public race meetings were established at Gatherley or Garterley, near Richmond in Yorkshire, at Croydon in Surrey, and at Enfield Chase, the last two being patronized by the king, who not only had races at Epsom during his residence at Nonsuch, but also built a house at Newmarket for the purpose of enjoying hunting, and no doubt racing too, as we find a note of there having been horse-races at this place as early as 1605. Races are also recorded as having taken place at Linton near Cambridge, but they were probably merely casual meetings. The prizes were for the most part silver or gold bells, whence the phrase "bearing away the bell." The turf indeed appears to have attracted a great deal of notice, and the systematic preparation of running horses was studied, attention being paid to their feeding and training, to the instruction of jockeys,—although private matches between gentlemen who rode their own horses were very common,—and to the adjustment of weights, which were usually about 10 stone. The sport also seems to have taken firm hold of the people, and to have become very popular.

The reign of Charles I., which commenced in 1625, saw still more marked strides made, for the king not only patronized the racing at Newmarket, which we know was current in 1640, but thoroughly established it there, and built a stand house in 1667, since which year the races have been annual. Mention is likewise made in the comedy of the *Merry Beggars*, played in 1641, of races, both horse and foot, in Hyde Park, which were patronized by Charles I., who gave a silver cup, value 100 guineas, to be run for instead of bells. Butcher, in his survey of the town of Stamford (1646), also says that a race was annually run in that town for a silver and gilt cup and cover, of the value of £7 or £8, provided by the care of the aldermen for the time being out of the interest of a stock formerly made by the nobility and gentry of the neighbourhood.

In 1648 Clarendon tells us that a meeting of Royalists was held at Banstead Downs, as Epsom Downs were then called, "under the pretence of a horse-race," so that horse-racing at Epsom was not unknown early in the 17th century; Pepys, too, in his *Diary* of 1663, mentions his having intended to go to Banstead Downs to see a famous horse-race. Cromwell is said to have kept running horses in the year 1653, but in 1654 he appears to have gone so far as to forbid racing for six and eight months respectively. After the Restoration in 1660, a new impetus was given to horse-racing, which had languished during the civil wars, and the races at Newmarket, which had been suspended, were restored and attended by the king; and as an additional spur to emulation, according to Youatt, royal plates were given at each of the principal courses, and royal mares, as they were called, were imported from abroad. Charles II. rebuilt the house originally erected at Newmarket by James I., which had fallen into decay. The Round course was made in 1666, and racing at the headquarters of the turf was regulated in the most systematic way, as to the course, weights, and other conditions. Charles II. was the first monarch who entered and ran horses in his own name; and, besides being a frequent visitor at the races on Newmarket Heath, and on Burford Downs, near Stockbridge, where the Bibury Club meeting was held, he established races at Datchet. In the reign of James II. nothing specially noteworthy occurred, but William III. continued former crown donations and even added to them.

Anne was much devoted to horse-racing, and not only gave royal plates to be competed for, but ran horses for them in her own name. In 1703 Doncaster races were established, when 4 guineas a year were voted by the corporation towards a plate, and in 1716 the Town Plate was established by the same authority, to be run on Doncaster Moor. Nearly a century, however, elapsed before the St Leger was instituted. Matches at Newmarket had become common, for we find that Basto, one of the earliest race-horses of whom we have any authentic account, won several matches there in 1708 and 1709. In the latter year, according to Camden, York races were established, the course at first being on Clifton Ings, but it was subsequently removed to Knavesmire, on which the races are now run. In 1710 the first gold cup said to have been given by the Queen, of 60 guineas value, was run for by six year old horses carrying 12 stone each, the best of three 4-mile heats, and was won by Bay Bolton. In 1711 it was increased to 100 guineas. In 1712 Queen Anne's gelding Pepper ran for the Royal Cup of £100 at York, and her Mustard, a nutmeg grey horse, ran for the same prize in 1713. Again in 1714 her Majesty's bay horse Star won a sweepstake of 10 guineas added to a plate of £40 at the same place, in four heats, carrying 11 stone. In 1716 the Ladies' Plate at York for five year olds was won by Aleppo, son of the Darley Arabian. Racing and match making continued to be a regular sport at Newmarket, and at York and Hambleton, and we also find a record of a race at Lincoln in August 1717 for a silver tea-board, won by Brocklesby Betty, as was the Queen's Plate at Black Hambleton in the year before.

Between 1714 and 1720 there were races at Pontefract in Yorkshire for plates or money. The best of two out of three heats was to be the winner, provided the said horse was not distanced in the third heat—the distance post being 1 furlong from the winning post; and this appears to have been a usual condition. In or about the year 1721 Flying Childers is said to have run a trial against Almanzor and Brown Betty over the Round course at Newmarket (3 m. 4 f. 93 y.) in 6 m. 40 s., and another trial over the Beacon course (4 m. 1 f. 138 y.) in 7 m. 30 s.—which is fast even for a six year old; but it is just possible that in those days the art of time-taking was anything but perfect. In 1721 George I. gave 100 guineas in specie in lieu of the gold cup at York presented by Anne, and the king's or queen's plates have been given in cash ever since. In 1725 a ladies' plate was run for on September 14 by female riders on Ripon Heath in Yorkshire. In 1727 Mr John Cheney established the *Racing Calendar*—an historical list of all the horse matches run, and of all plates and prizes run for in England and Wales of the value of £10 or upwards in 1727, &c. No systematic records had till then been preserved of the running of the race-horses of the day, and it is only through the performances of certain celebrated horses and mares that we have any information of what actually took place, and even that is more or less of a fragmentary kind. At this time racing was thoroughly established as a national and popular sport, for there were upwards of a hundred meetings in England and Wales; but the plates or sweepstakes run for were for the most part of small value, as £10, £20, £30, £40, and sometimes £50. In 1727, according to Whyte, there were only a dozen royal plates run for in England:—one at Newmarket in April for six year old horses at 12 stone each, in heats over the Round course—first called the King's Plate course; one for five year old mares at 10 stone each, in one heat, and another in October for six year old horses at 12 stone, in heats over the same course; one at York (which commenced in 1711) for six year old horses, 12 stone each, 4-mile heats; one at Black Hambleton, Yorkshire (of which no regular account was kept until 1715), for five year old mares, 10 stone, 4 miles; one at each of the following places, Nottingham, Lincoln, Guildford, Winchester, Salisbury, and Lewes, for six year old horses, 12 stone each, 4-mile heats; and one at Ipswich for five year old horses, 10 stone each. A royal plate was also run for at Edinburgh in 1728 or 1729, and one at the Curragh of Kildare in 1741.

In 1739 an Act was passed to prevent racing by ponies and weak horses, 13 Geo. II. cap. 10, which also prohibited prizes or plates of less value than £50. At this period the best horses seldom ran more than five or six times, and some not so often, there being scarcely any plates of note except royal ones, and very few sweepstakes or matches of value except at Newmarket until after 1750; moreover, as the races were run in heats, best three out of four, over a course of several miles in length, the task set the horses before winning a plate was very severe, and by no means commensurate with the value of the prize. In 1751 the great subscription races commenced at York, the city also giving £50 added money to each day's racing. At Newmarket there were only two meetings, one in April and the other in October, but in 1753 a second spring meeting was established, and in that year the Jockey Club, which was founded in 1750, purchased the present racing ground. In 1762 a second October meeting was added, in 1765 the July meeting, in 1770 the Houghton meeting, and in 1771 the Craven meeting. In 1766 Tattersall's was established at Hyde Park Corner by Richard Tattersall for the sale of horses; it remained the great emporium of horses, and the rendezvous for betting on horse races, until 1865, when, the lease of the premises at the Corner having run out, it was removed to its present site at Knightsbridge.

We now come to a very important period—that at which the great three year old races were instituted.

The St Leger.

The St Leger was established in 1776 by Colonel St Leger, who resided at Parkhill, near Doncaster. On the 24th September, during the Doncaster races, which took place annually in the autumn, at his suggestion a sweepstake of 25 guineas each for three year old colts and fillies was run over a 2-mile course; there were six competitors, the property of as many subscribers,—a very small beginning, it must be owned. The race was won by a filly by Sampson, belonging to Lord Rockingham, which was afterwards named Allabaculia. In the following year the same stake had twelve subscribers and ten starters, and was won by Mr Sotheron's Bourbon. It was not, however, until the succeeding year, 1778, that it was named the St Leger, in complement to the founder, at the suggestion of the marquis of Rockingham, on which occasion it was won by Mr T. Gascoigne's Hollandaise, another filly; thus at the beginning, as well as a century later, the fillies, from Allabaculia and Hollandaise to Apology and Jannette, owing to the cool season of the year at which it is run, were found capable of taking their own part against the colts in the race. The stakes were increased in 1832 to 50 sovs. each, and the weights have been raised from time to time to keep pace with modern requirements. The Doncaster Cup, a weight for age race for three year olds and upwards, was established in 1801. The course is nearly flat, of an oval or kite shape, about $1\frac{3}{4}$ miles round the town-moor. It has been run in 3 m. 14 s. by three year old horses, carrying 8 st. 10 ℔, and fillies 8 st. 5 ℔.

The Derby and Oaks.

The Derby and Oaks were established in 1779 and 1780, the Oaks in the former and the Derby in the latter year. It is true that in 1730 Epsom races became annual, but the prizes were nothing more than the usual plates run for in heats, the money required being raised by voluntary subscriptions, as well by the owners of booths on the downs as by the parties more immediately interested, whence arose the custom of charges being made by the lord of the manor for permission to erect booths, &c., during the race meetings. On the 14th May 1779 the twelfth earl of Derby originated the Oaks stakes (named after his seat or hunting box "The Oaks" at Woodmansterne), a sweepstake for three year old fillies run on a course $1\frac{1}{2}$ miles long. The race on its inception was won by Lord Derby's bay filly Bridget, bred by himself—her sire being Herod and her dam Jemima. In the following year the earl established a sweepstake of 50 sovs. each, half forfeit, for three year old colts. The distance was then one mile, but it has since been altered to a mile and a half, and is now run on a new course starting on a higher level than before, and joining the old course on the top of the hill. Being a very hilly or up and down course, Epsom is excessively trying to horses not perfectly sound. On the first occasion of the Derby being run it was won by Sir C. Bunbury's chestnut colt Diomed by Florizel, son of Herod, who beat eight opponents, including the duke of Bolton's Bay Bolton and Lord Grosvenor's Diadem. These two races have since been run for regularly every year, the Derby, which before 1839 was run on the Thursday, now taking place on the Wednesday, and the Oaks on the Friday in the same week at the end of May. Two fillies only have won both races, viz., Sir C. Bunbury's Eleanor in 1801 and Mr W. I'Anson's Blink Bonny in 1857, but Deception ran second for the Derby in 1839, and subsequently won the Oaks. The course has been run in 2 m. 43 s. by colts and in 2 m. 44 s. by fillies.

Ascot races. Ascot races, which are held on Ascot Heath, on the confines of Windsor Park, close to the kennels of the royal buckhounds, were established by the duke of Cumberland, uncle of George III., and are patronized by royalty in state or semi-state. They are mentioned in the first *Racing Calendar*, published in 1727, but the races were for the most part plates and other prizes of small importance, though a royal plate for hunters appears to have been given in 1785. The Gold Cup was first given in 1807, and has been regularly competed for ever since, though from 1845 to 1853 inclusive it went by the designation of the Emperor's Plate, the prize being offered by the emperor of Russia. In 1854, during the Crimean war, the cup was again called the Ascot Gold Cup, and was given from the race fund. The Queen's Vase was first given in 1838, and the Royal Hunt Cup in 1843, while in 1865 a new long-distance race for four year olds and upwards was established, and named the Alexandra Plate, after the Princess of Wales.

Goodwood. Goodwood races were established by the duke of Richmond on the downs at the northern edge of Goodwood Park in 1802, upon the earl of Egremont discontinuing races in his park at Petworth. The course is situated in most lovely scenery, about 5 miles from Chichester, with downs and woodlands to the north, and the sea and the Isle of Wight to the south. The races take place at the end of July, on the close of the London season. The Goodwood Cup, the chief prize of the meeting, was first given in 1812; but from 1815 to 1824 inclusive there was no race for it, with the single exception of 1816. Since 1824 it has been competed for annually.

During the latter half of the 18th century horse-racing declined very much in England, and numbers of meetings were discontinued, the wars which took place necessarily causing the change. From the beginning of the 19th century, and especially after the conclusion of the French war in 1815, racing rapidly revived, and many new meetings were either founded or renewed after a period of suspension, and new races were from time to time established. Two Thousand, &c. Among others the Two Thousand Guineas at Newmarket for three year old colts and fillies, and the One Thousand Guineas for fillies, were established in 1809 and 1814 respectively, the Goodwood Stakes in 1823, the Chester Cup and Brighton Stakes in 1824, the Liverpool Summer Cup in 1828, the Northumberland Plate in 1833, the Manchester Cup in 1834, the Ascot Stakes and the Cesarewitch and Cambridgeshire Handicaps at Newmarket in 1839, the Stewards' and Chesterfield Cups at Goodwood in 1840, the Great Ebor Handicap at York in 1843, and, to omit others, the City and Suburban Handicap at Epsom in 1851, and the Lincoln Handicap in 1853. With the exception of the Two Thousand and One Thousand Guineas run for in the spring at Newmarket, which are as it were junior Derby and Oaks, or at any rate public trials for Handicaps. those events, all these races are handicaps, which came into fashion for the following reasons:—

In the early days of racing the plates or stakes were given for competition by horses of not less than five and generally of six years of age, all carrying the same weights, so that if a four year old, as sometimes happened, entered, it took no allowance from its older and more mature opponents, but had to compete with them on even terms, or at a material disadvantage considering the difference in age. We then find that weight for age races were introduced, a specified difference in weight for each year, where all were not of the same age, being conceded by the older horses. As time went on, however, it was found that when well-known winners entered for a race, other competitors withdrew, and sport was spoiled. A remedy was devised in handicapping, that is, in apportioning a table of weights to the competitors, placing the heaviest impost on the best public performers, and lighter weights in a descending scale upon those of lower calibre, in proportion to their known or assumed demerits. The object of course was in theory to place all, both good and bad, on an equal footing,—in other words, so to burden them that on paper they should all be equal and run a dead heat. In practice it is often far otherwise, for the real merits of a horse are frequently kept secret, and he is sent to run in public half trained, with the view of deceiving the handicapper, who then puts on him a lighter weight than he is capable of carrying, and the race and a large stake of money in bets are frequently so won. It is unnecessary to say that handicaps are thus responsible for much of the malpractice which prevails on the turf, and for keeping in training inferior horses otherwise valueless.

No horses of less than three years of age are allowed to run in handicaps, and at present the lowest weight is 5 st. 7 lb, although some years back it was as low as 4 stone, a weight carried to victory in the Chester Cup by Red Deer in 1844. It would be a step in the right direction to raise the minimum to 7 stone, which would not only tend to the improvement of the horses running, but permit abler and stronger jockeys than the present feather-weights to ride.

Two year old racing was established very shortly after the great three year old races, and on a similar footing, that is to say, the competitors carried the same weights, with the exception of a slight allowance for sex,—the July Stakes at the Newmarket midsummer meeting having been founded as early as 1786. The Woodcote Stakes at Epsom succeeded in 1807, the Champagne Stakes at Doncaster in 1823, the Criterion Stakes at the Houghton meeting in 1829, the Chesterfield Stakes at the Newmarket July meeting in 1834, the New Stakes at Ascot in 1843, the Middle Park Plate (or two year old Derby, as it is sometimes called) at the Newmarket second October meeting in 1866, the Dewhurst plate at the Houghton meeting in 1875, and the Richmond Stakes at Goodwood in 1877.

No race is now run over a shorter course than 5 furlongs.

Statistics of racing in Great Britain. The number of races in Great Britain in the year 1879, according to the *Racing Calendar*, was 1626, of which fifty-nine only were of 2 miles and upwards, ten of 3 miles and above, and two of 4 miles. The number of horses competing was 844 two year olds, 633 three year olds, 314 four year olds, and 322 of five years and upwards—in all 2113; and the value of the stakes run for amounted to £380,699. During the same period there were foaled 955 thoroughbred colts and 900 fillies, while 716 mares were barren, 98 slipped their foals, 152 were covered by halfbred horses or not covered at all, and 174 either died or were sent abroad before foaling—the total number of mares on the register being nearly 3000. The horses at the stud who sired the above foals amounted in round numbers to 350.

The following table will show the value of the principal two and three year old races for the last six years:—

	1874.	1875.	1876.	1877.	1878.	1879.
	£	£	£	£	£	£
Two Thousand Guineas	4200	4550	4100	5200	4650	6250
One Thousand Guineas	3050	2350	3100	4750	4500	4200
Derby	5350	4950	5575	6050	5825	7050
Oaks	4375	2925	4300	4150	5000	4425
St Leger	4625	4150	4825	5025	5750	6550
Middle Park Plate	3340	3430	3860	3610	3790	3470

Few handicaps ever reach £2000 in value; but to the Manchester Cup of 1880 the sum of £2000 added money was advertised, being the largest amount ever given to a single race, of course irrespective of the stakes of the individual entries.

In regard to the sums won by individual horses we may instance £18,681 won by Gladiateur as a three year old, and £18,025 by Lord Lyon, both of whom won Guineas, Derby, and St Leger; £17,850 by Formosa, who divided the Two Thousand Guineas, and won the One Thousand, Oaks, and St Leger; £11,755 by Achievement, who took the One Thousand and St Leger, after having won £10,387 as a two year old; and £12,074 by Wheel of Fortune, including the One Thousand and the Oaks, after having taken £7665 as a two year old.

Training. The treatment or training of racers is essentially a trade of itself, for horses intended to run for stakes are either sent, if few in number, to a public training stable, such as those at Newmarket and other places, or else, when numerous, are prepared for their engagements by a private trainer, the treatment in both cases being the same. The usual charge per horse in a public stable is from 2 to 2½ guineas a week, which includes feeding and grooming.

Foreign racing. Racing has made considerable progress in other countries besides Great Britain, notably in France, Germany, and Austria-Hungary, whither some of the very best bred English horses and mares have from time to time been exported to increase the numbers of thoroughbreds reared on the Continent. Thence have been sent to compete in England such horses as Jouvence, Baroncino, Monarque, Dollar, and Flageolet, winners of the Goodwood Cup in 1853, 1855, 1857, 1864, and 1873 respectively; Gladiateur, winner of the Two Thousand Guineas, Derby, and St Leger in 1865; Fille de l'Air, Reine, and Enguerrande, winners of the Oaks in 1864, 1872, and 1876; Mortemer, Henry, Boiard, and Verneuil, winners of the Ascot Cup in 1871, 1872, 1874, and 1878; Chamant, winner of the Two Thousand Guineas in 1877; Sornette and Dutch Skater, winners of the Doncaster Cup in 1870 and 1872; and Rayon d'Or, winner of the St Leger in 1879. From Austria-Hungary have come Kisber, winner of the Derby in 1876, and the unbeaten filly Kincsem, winner of the Goodwood Cup in 1878. In France especially, enormous strides have been made in racing, and, when the superiority of its climate over that of England is considered, it is not surprising that French horses have achieved a fair measure of success in the leading races of the English turf.

American horses have sometimes been sent over to compete in England, but on the whole they have not been very successful, as they have found the English horses too good for them. Their chief successes have been those of Prioress in the Cesarewitch in 1857, of Starke in the Goodwood Cup of 1861, and of Parole in the Newmarket Handicap and the City and Surburban and Metropolitan Stakes at Epsom in 1879.

Steeple-chasing and hurdle-racing. Steeple-chasing and hurdle-racing take place during the winter months, partly in amalgamated meetings of flat and cross-country races, and partly in meetings purely across country and over fences. The chief event is the Liverpool Grand National, run at Aintree towards the close of the hunting season. It dates from 1839, and, though formerly won by well-bred hunters, now commonly falls to thoroughbreds cast off from racing stables as too slow for the flat, as do nearly all the steeple-chases and hurdle-races. Its value averages from £1500 to £1700. There are many meetings in the provinces and in the London district at which steeple-chases and hurdle races are run, but the more important of them are at Croydon, Sandown Park near Esher, Lincoln, Rugby, Warwick, Bristol, &c. The prizes are nearly always won by thoroughbreds. (E. D. B.)

Horse-Racing and Trotting in the United States.

American racing. Horse-racing was indulged in to a limited extent in Maryland and Virginia as early as the middle of the 17th century, particularly in the latter colony. Most of the inhabitants of both were either from the British Isles or were descended from parents who had immigrated from them, and they inherited a taste for the sport. The animals used for this purpose, however, were not highly prized at the time, and the pedigree of not even one of them has been preserved. A horse called Bully Rock by the Darley Arabian out of a mare by the Byerly Turk, granddam by the Lister Turk, great-granddam a royal mare, foaled 1718, is the first recorded importation of a thoroughbred horse into America. He was imported into Virginia in 1730. In 1723 the duke of Bolton bred a mare named Bonny Lass by his celebrated horse Bay Bolton out of a daughter of the Darley Arabian. She became celebrated in England as a brood mare, and was the first thoroughbred mare, according to the records, that was carried to America. This is supposed to have been in or after 1740, as the *Stud-Book* shows she produced in England after 1739 a filly by Lord Lonsdale's Arabian, and subsequently became familiar to the public as the granddam of Zamora. The importations increased very rapidly from this period, and many valuable shipments were made before the war which resulted in a separation of the colonies from the mother country. This acquisition of thoroughbred stock increased the number and value of racing prizes, and extended the area of operations into the Carolinas in the South, and New Jersey and New York in the North. The first race run in South Carolina was in February 1734, for £20. It took place over "the Green," on Charleston Neck. This shows that the earlier races in America were actually on the turf, as they have always been in England. The next year a Jockey Club was organized at Charleston (1735), and a course was prepared, such as those which have since come into general use throughout the States, from which the turf is removed and the ground is made as nearly level as may be. They are generally oval in shape, and a mile in length, with posts a furlong apart. A race of greater distance than one mile is accomplished by traversing the track the necessary number of times to complete the distance prescribed by the conditions of the race.

After the establishment of the government of the United States (1776), the importation of thoroughbred horses from England became quite common, and selections were made from the best stocks in the United Kingdom. This continued and even increased as the country became developed, down to 1840. The following Derby winners, were among those carried into the States:—Diomed, who won the first Derby in 1780; Saltram, winner in 1783; John Bull, winner in 1792; Spread Eagle, winner in 1795; Sir Harry, winner in 1798; Archduke, winner in 1799; and Priam, who won in 1830. The most important and valuable importations, however, proved to be Jolly Roger, Fearnought, Medley, Traveller, and Diomed in the last century, and Glencoe, Leviathan, Tranby, Lexington, Margrave, Yorkshire Buzzard, Albion, and Leamington of the present century. The best results have been obtained from Diomed and Glencoe. Diomed sired one horse, Sir Archy, who founded a family to which nearly all the blood horses of America trace back. He was foaled in 1805, in Virginia, and became celebrated as a sire. The superiority of his progeny was so generally conceded, that they were greatly sought after. From this period, too, the number and value of races increased; still they were comparatively few in number, and could not compare in value with those of Great Britain. Up to 1860 the value of racing prizes was quite inadequate to develop large breeding establishments, or to sustain extensive training stables. During that year the number of races run was about 250, of the estimated value of $100,000 (£20,000). The institution, however, was in a healthy condition, and gained rapidly in public favour, when the civil war between the North and the South broke out, which raged for four years. Breeding establishments were broken up during that time; the horses were taken by the armies for cavalry purposes, for which service they were highly prized; and racing was completely paralysed for that period. It took some time to regain its strength; but an era of prosperity set in, about 1870, and it has since continued to grow and extend the area of its operations, until it has become the chief sport and amusement of the more populous cities of the States.

In 1874 there were 958 races run of the value of $496,772; in 1875, 866 races, of the value of $490,649; in 1876, 782 races, valued at $485,509; in 1877, 907 races, valued at $441,652; in 1878, 1058 races, valued at $461,395; and in 1879, 1221 races were run, of the value of $545,624. In 1877 as many as 1093 horses started; in 1878 there were 1382, and last year 1524. This increase in the value of racing events, and the consequent demand for horses of this class, have stimulated the breeding interests of the country. There are only four prominent breeding establishments which breed and sell the foals produced as yearlings to the public annually. There are, however, a large number of private breeding establishments, some of them nearly or quite as extensive as the public studs. The number of brood mares in the country is about 2100; the stallions number over 300, and the annual number of foals is estimated at about 1400. There are no official records of the produce.

One of the peculiar features of racing in America is that all events are officially timed, and the time is recorded by the clerks of the jockey clubs upon the books of the club. By it the value of different performances by the same or different horses is generally estimated. Of course other elements are considered, such as the weight carried, the age of the horses, the weather, the condition of the track, &c. If a horse of the same age and weight, and over courses of similar conditions, can run a mile a second quicker than another horse, he is regarded as faster at the distance than his rival. The artificial tracks of the country make time a reasonably accurate test when weighed in connexion with other circumstances. Each club has its official timer, who gives the time taken to the clerk as soon as the race is over. The following is the fastest time made at all distances in the United States, down to July 1, 1880:—

Half mile.—Two year olds, $47\frac{3}{4}$ s ; older horses have no record at this distance.
Three quarters of a mile.—Two year olds, 1 m. 15 s.; three year olds, 1 m. $15\frac{1}{4}$ s.; four year olds and upwards, 1 m. 15 s.
One mile.—Two year olds, 1 m. $43\frac{1}{4}$ s.; three year olds, 1 m. $41\frac{3}{4}$ s.; four years and upwards, 1 m. $39\frac{3}{4}$ s.
One mile and a furlong.—Three year olds, 1 m. 54 s.; four years and upwards, 1 m. $55\frac{1}{4}$ s.
One mile and a quarter.—Three year olds, 2 m. $8\frac{1}{2}$ s.; four years and upwards, 2 m. $8\frac{3}{4}$ s.
One mile and a half.—Three year olds, 2 m. 37 s.; four year olds and upwards, 2 m. $34\frac{3}{4}$ s.
One mile and five furlongs.—Three year olds, 2 m. $49\frac{1}{4}$ s.; four years and upwards, 2 m. 53 s.
One mile and three quarters.—Three year olds, 3 m. $5\frac{1}{4}$ s.; four years and upwards, 3 m. 4 s.
Two miles.—Three year olds, 3 m. $30\frac{1}{2}$ s.; four years and upwards, 3 m. $27\frac{1}{2}$ s.
Two miles and a furlong.—Three year olds, 3 m. 50 s ; four years and upwards, 3 m. $45\frac{1}{2}$ s
Two miles and a quarter.—Three year olds, 4 m. 2 s.; four years and upwards, 3 m. $56\frac{1}{4}$ s.
Two miles and a half.—Three year olds, 4 m. $31\frac{3}{4}$ s.; four years and upwards, 4 m. $27\frac{1}{2}$ s.
Two miles and three quarters.—Four year olds and upwards, 4 m. $58\frac{3}{4}$ s.
Three miles.—Three year olds, 5 m. 28 s.; four years and upwards, 5 m. $26\frac{1}{4}$ s.
Four miles.—Three year olds, 7 m. $31\frac{3}{4}$ s. · four years and upwards, 7 m. $15\frac{3}{4}$ s.

(J. R. H.)

American trotting.

Trotting.—The development of speed in the trotting-horse through systematic breeding and training is one of the great industries of the United States of America and the Dominion of Canada, and in no other portion of the world is it pursued to any great extent, except in Russia. This interest, which has attained vast proportions, is entirely the growth of a century, dating back to the importation to Philadelphia from England, in 1788, of the thoroughbred horse Messenger. This was a grey stallion, by Mambrino, 1st dam by Turf, 2d dam by Regulus, 3d dam by Starling, 4th dam by Fox, 5th dam Gipsey, by Bay Bolton, 6th dam by duke of Newcastle's Turk, 7th dam by Byerly Turk, 8th dam by Taffolet Barb, 9th dam by Place's White Turk. He was eight years old when imported to the United States. He was at the stud for twenty years, in the vicinity of Philadelphia and New York, serving a number of thoroughbred mares, but a far greater number of cold-blooded mares, and in the progeny of the latter the trotting instinct was almost invariably developed, while his thoroughbred sons, who became scattered over the country, were also noted for transmitting the trotting instinct. That Messenger was the fountain-head of American trotting is shown by the fact that almost every trotter of merit in that country, whose pedigree is reasonably well established, traces to him in one or more lines, and the more Messenger strains there are in a pedigree the greater is its esteemed value. It was years after the death of Messenger, however, before these facts became apparent ; the taste of the country in racing matters was confined to running contests, and systematic trotting breeding is of much later growth. The first public trotting race of which there is any account in the United States was in 1818, when the grey gelding Boston Blue was matched to trot a mile in 3 minutes, a feat deemed impossible, but he won, though the time of his performance has not been preserved. From about that date, interest in this gait began to increase ; breeders of trotters, in a small way, sprang up, and horses were trained for trotting contests. The problem of breeding trotters has been necessarily found to be a much more complex one than that of breeding the thoroughbred, as in the latter case pure blood lines of long recognized value could be relied upon, while in the former the best results were constantly being obtained from most unexpected sources. At the present day, the leading families are the Hambletonian, of which the modern head was Rysdyk's Hambletonian, a bay horse foaled in 1849, got by Abdallah (traced to imp. Messenger on the side of both sire and dam) out of the Charles Kent mare, by imp. (*i.e.*, imported) Bellfounder, with two crosses to imp. Messenger on her dam's side ; the Mambrinos, whose modern head was Mambrino Chief, foaled 1844, by Mambrino Paymaster, a grandson of imp. Messenger ; the Bashaws, founded by Young Bashaw, foaled 1822, by Grand Bashaw, an Arabian horse, dam Pearl, by First Consul; the Clays, springing from Henry Clay, a grandson of Young Bashaw through Andrew Jackson, and properly a branch of the Bashaw Family, but arbitrary usage, of which there is much in American trotting lineage, makes them distinct ; the Stars, springing from Stockholm's American Star, by Duroc, son of imp. Diomed ; the Morgans, whose founder was Justin Morgan, foaled 1793, by a horse called True Briton, or Beautiful Bay, who was probably thoroughbred ; the Black Hawks, a branch of the Morgan family ; the Blue Bulls, descended from Doyle's Blue Bull, foaled 1855, a pacer, sired by a pacer of the same name, dam by Blacknose, son of Medoc ; the Canadians, whose best representatives were St Lawrence and pacing Pilot, horses of unknown pedigree ; the Gold Dusts, another branch of the Morgan family ; and the Royal Georges, springing from Tippoo, a horse who was probably by Ogden's Messenger, son of imp. Messenger. There are many subordinate branches of these leading families not named here, and in some cases trotters of great speed have been produced which do not trace to any of the sources mentioned. It follows that the breeder has an extensive field before him, and the questions of in-breeding or out-crossing, of the value of thoroughbred crosses, pacing crosses, &c., have to be considered, and are abundantly discussed. There are many large and successful establishments for breeding trotters at the present day. All of them are extensive in acreage, while on several a hundred or more brood mares are kept, besides a number of stallions. As a rule, the stallions do service outside the farms of their owner, but in some cases they are reserved strictly for home use. Very large prices are frequently paid for youngsters, solely on the strength of their breeding. In 1876 $13,000 was paid for two two year old fillies, and $41,200 for a lot of thirteen, nearly all young. Steinway, a three year old colt, was sold in 1879 to go to California, for $13,000; and in 1878 $21,000 was paid for the four year old filly Maud S., after she had trotted a mile in public in 2 m. $17\frac{1}{4}$ s. Much larger sums have been paid, however, for matured trotters, such as $40,000 for the stallion Smuggler, $38,000 for Pocahontas, $35,000 for Dexter, $36,000 for Rarus, and long prices for many others ; St Julien, the trotter with the fastest record at the close of 1879, was held at $50,000, while Rysdyk's Hambletonian, Messenger, Duroc, and Volunteer were valued, in their prime, at $100,000 each.

Since the early days of American trotting, the advance has been rapid and the changes marked. After the performance of Boston Blue, mentioned above, more attention was paid to the gait, but for a long time the races were generally under saddle, and at long distances, 3 miles being rather the favourite. The best of the old time trotters were Edwin Forrest, who trotted a mile in 2 m. $31\frac{1}{2}$ s. in 1834; Dutchman, whose 3 miles under saddle, in 7 m. $32\frac{1}{2}$ s., is still the best on record ; Ripton ; Lady Suffolk, who trotted a mile in 2 m. $26\frac{1}{2}$ s. in 1843, and headed the list of performers; Mac, Tacony, &c. Since 1850, however, the taste of the people has settled upon the style of race called "mile heats, best three out of five, in harness," as the favourite, and nine out of ten contests are of this character. By "in harness" is meant that the horse draws a sulky, a light two-wheeled vehicle in which the driver sits close to the horse, with his legs on each side of his flanks. These sulkies often weigh less than 40 lb. The driver is required to weigh, with the blanket on which he sits, 150 lb, while for saddle races the regulation weight is 145 lb, or 10 st. 5 lb. Each heat of a mile is a separate race ; 20 minutes is allowed between heats ; and the horse that first places three heats to his credit wins the race. There are various penalties imposed upon a horse that breaks into a run in a trotting race. The driver is required to pull him to a trot as quickly as possible ; if the horse gains by running, the judges set him back at the finish twice the distance he has gained, in their estimation, by running ; and for repeated "breaks" they can declare him distanced. The first-class tracks are of oval shape, with long stretches and easy curves, measuring 1 mile at 3 feet distance from the "pole," as the inner railing of the track is called. The time in which the leading horse trots each heat is accurately kept, placed on a blackboard in front of the judges' stand for the information of the public, and also placed in the book of the course. The fastest time that any trotter has is thus entered as his "record." This is one of the distinctive features of trotting in America. The purses that are given by the association owning tracks are generally divided into classes, such as for horses that have never beaten 3 minutes, that have never beaten 2 m. 40 s., 2 m. 20s., &c. Hence it is an object, as a rule, for the record of a trotter to be kept as slow as possible, that he may be eligible to compete in slow classes, and as the purses are divided into three or four monies, and the second money is usually half as large as the first, drivers frequently "pull" a superior animal, and content themselves with an inferior portion of the purse for the sake of avoiding a record, which attaches only to the winner of a heat, and from this cause springs a great deal of dishonest racing. It is in the power of the judges, when they think that a horse is not being driven to win, to substitute another driver, and this is often done.

Prior to 1866 purses for trotters were small ; match races were more in vogue, and the trotting turf was in bad odour. In that year an association was formed at Buffalo, N.Y., which undertook to remedy the evil, and inaugurated its efforts by offering the then unprecedented sum of $10,500 for a trotting meeting of four days' duration. The experiment was successful ; other cities followed the example of Buffalo; larger and larger purses were given; and at Buffalo in 1872 the prizes amounted to $70,000. Twice at this point $20,000 has been given for a single race, a sum nearly equal to an average Derby winning. Other cities are also in the habit of giving large purses, and the amount offered in the United States and Canada, during a single year, has reached nearly $1,500,000. Individual trotters, in the course of a long turf career, earn enormous amounts. The most remarkable instance of this was the mare Goldsmith Maid, by Alexander's Abdallah (a son of Rysdyk's Hambletonian), out of an Abdallah mare. She began trotting in 1866, and left the turf in 1878, when twenty-one years old, and her winnings amounted to over $200,000.

In 1869 the organization now known as the National Trotting Association was formed, and it embraces in its membership all the principal tracks of the continent. All members of this association respect the penalties imposed by any other member, and exclusion from the privileges of one is exclusion from the privileges of all. This has had a great tendency to reform abuses on the trotting turf, enabling severe penalties to be inflicted for infractions of the rules, a very elaborate code of which has been published by the National Trotting Association, and is revised triennially.

In trotting races, it will be noted, the time test is supreme, differing from running races, in which time is of comparatively little consequence. The animal which has the fastest record for 1 mile in harness is, until deposed, the king or queen of the trotting turf. Lady Suffolk, with her record of 2 m. 26½ s., in 1843, held this honour until 1853, when Tacony trotted in 2 m. 25½ s. under saddle; Flora Temple wrested it from him in 1856 by trotting in 2 m. 24½ s. in harness. This latter mare, in 1859, trotted a mile in 2 m. 19¾ s., a feat which the best horsemen thought would never be repeated, but since that time forty-two trotters have beaten 2 m. 20 s. Dexter's record was 2 m. 17¼ s. in 1867, and Goldsmith Maid's in 1871 was 2 m. 17 s., which she reduced, by successive efforts, to 2 m. 16¾ s., 2 m. 16 s., 2 m. 15 s., 2 m. 14¾ s., and finally, in 1874, to 2 m. 14 s. In 1878 Rarus trotted a mile in 2 m. 13¼ s., and in October 1879 the bay gelding St Julien, by Volunteer, son of Rysdyk's Hambletonian, dam by Henry Clay, trotted a mile in California in 2 m. 12¾ s. There is a great diversity of opinion among the best informed horsemen as to the limit of trotting speed, but none fix it slower than 2 m. 10s., while the more sanguine believe that a mile will yet be made by a trotter in 2 minutes. The pacing gait, in which the front and hind legs on the same side are moved in the same direction simultaneously, is admitted to be faster than the trotting, in which the near fore leg and the off hind leg move together, but as pacing is not fashionable, and small purses are given for contests between pacers, a great deal of skill has been expended, of late years, in converting pacers to trotters. This is done by means of toe-weights on the forward feet, which are knobs of brass or iron screwed into the hoof or fastened to the shoe, by means of which a competent trainer can not only change a pacing into a trotting horse, but can correct any errors of gait in a natural trotter. With inveterate pacers very heavy weights have to be used, but these can gradually be lessened as the horse becomes accustomed to the trot. So effective are these weights found that there are very few fast trotters upon whom they are not used to some extent, unless the same object is effected by wearing a very heavy forward shoe.

The market for American trotters is by no means confined to those intending to use them for track purposes. While there are probably ten thousand in training, at least an equal number are used by gentlemen for road purposes; and there is great rivalry among millionaires with a taste for driving to secure the best stable, and especially the fastest double team. In September 1877 Mr W. H. Vanderbilt drove his team, composed of Small Hopes and Lady Mac, a full mile over Fleetwood Park track, near New York city, in 2 m. 23 s., which is 3½ seconds faster than the best record for a mile by a double team, the 2 m. 23 s. performance not being a technical record.

As an indication of the rapid advance that has been made in the general speed of the American trotter, a table recently published in the United States, giving the names of all horses that had trotted 1 mile in harness in 2 m. 25 s., or better, up to the close of 1879, includes 317 performers, and all these, except 25, were living when the table was published. This shows that a 2 m. 25 s. record was a very unusual occurrence only a horse generation since, while now an animal who cannot show that rate of speed is not considered a promising competitor in turf contests.

Every year a book is published containing summaries of all the trotting and pacing events of the preceding year. The record for 1875 showed 3304 events, amount of purses and stakes, $1,418,971; for 1876, 3484 races, $1,078,449; for 1877, 2802, $951,137; for 1878, 2737, $817,629; and for 1879, 2246 races, amount of purses and stakes, $750,000.

We give, in conclusion, a table of the fastest trotting and pacing records, at all distances, ages, and ways of going, complete up to July 1880:—

Trotting in Harness.

One mile—St Julien, Oakland Park, Cal., Oct. 25, 1879, 2 m. 12¾ s., in a first heat.
One mile (second heat)—Rarus, Hartford, Conn., August 23, 1878, 2 m. 13½ s.
One mile (third heat)—Rarus, Buffalo, N.Y., August 3, 1878, 2 m. 13¼ s.
One mile (fourth heat)—Lula, Rochester, N.Y., August 14, 1875, 2 m. 17 s.
One mile (fifth heat)—Smuggler, Cleveland, O., July 27, 1876, 2 m. 17½ s.
One mile (sixth heat)—Goldsmith Maid, Hartford, Conn., Aug 31, 1876, 2 m. 19¾ s.
One mile—Smuggler, Hartford, Conn., August 31, 1876, 2 m. 15¼ s., the fastest heat by a stallion.
Half-mile, by a yearling—Memento, Lexington, Ky., October 10, 1877, 1 m. 30½ s.
One mile, by a two year old—So-So, Lexington, Ky., October 12, 1877, 2 m. 31 s.
One mile, three year old—Jewett, Lexington, Ky., Oct. 15, 1879, 2 m. 23½ s.
One mile, four year old—Trinket, Louisville, Ky, July 10, 1879, 2 m. 19¾ s.
One mile, five year old—Santa Claus, Sacramento, Cal., Sept 11, 1879, 2 m. 18 s.
One mile, over half-mile track—Rarus, Toledo, O., July 20, 1878, 2 m. 16 s.
One mile, fastest two consecutive heats—Rarus, Hartford, Conn., August 23, 1878, 2 m. 13½ s., 2 m 13¾ s.
One mile, fastest three consecutive heats—Rarus, Hartford, Conn., August 23, 1878, 2 m. 15 s., 2 m. 13½ s., 2 m. 13¾ s.
One mile, fastest four consecutive heats—Gloster, Rochester, N.Y., August 14, 1874, 2 m. 18 s., 2 m. 17¾ s., 2 m. 17 s., 2 m. 19 s.,; and Goldsmith Maid, Hartford, Conn., August 31, 1876, 2 m. 16¾ s., 2 m. 17¼ s., 2 m. 18 s., 2 m. 19¾ s. The aggregate times of these two performances are equal.
Two miles—Flora Temple, Eclipse Course, L. I., August 16, 1859, 4 m. 50½ s.
Three miles—Huntress, Prospect Park, Brooklyn, N.Y., Sept 23, 1872, 7 m. 21¼ s.
Four miles—Trustee, Union Course, L. I., June 13, 1849, 11 m 6 s.
Five miles—Lady Mack, San Francisco, Cal., April 2, 1874, 13 m
Ten miles—Controller, San Francisco, Cal., November 23, 1878, 27 m. 28¼ s.
Fifteen miles—Girda, San Francisco, Cal., August 6, 1874, 47 m. 20 s.
Twenty miles—Capt. McGowan, Boston, Mass, 1865, 58 m. 25 s.
Fifty miles—Ariel, Albany, N.Y., 1846, 3 h 55 m. 40½ s.
One hundred miles—Conqueror, Long Island, November 12, 1853, 8 h. 55 m. 53 s.

Trotting to Waggon.

One mile—Hopeful, Chicago, Ill., October 12, 1878, 2 m. 16¾ s., in a first heat.
One mile (second heat)—Hopeful, Chicago, Ill., October 12, 1878, 2 m 17 s.
One mile (third heat)—Hopeful, Chicago, Ill., October 12, 1878, 2 m. 17 s.
One mile, drawing 2000 lb—Mountain Maid, Long Island, 1865, 3 m. 24½ s.
Two miles—Gen. Butler, Long Island, 1863, first heat, 4 m. 56¼ s.; Dexter, Long Island, October 27, 1865, second heat, 4 m. 56¼ s.
Three miles—Kemble, Jackson, June 1, 1853, 8 m. 3 s.
Four miles—Longfellow, California, December 31, 1869, 10 m. 34½ s.
Five miles—Little Mack, Fashion Course, L I., October 29, 1863, 13 m. 43½ s.
Twenty miles—Controller, San Francisco, Cal., April 20, 1878, 58 m. 57 s.
Fifty miles—Spangle, October 15, 1855, 3 h. 49 m. 4 s.

Trotting, Double Teams.

One mile—Gen. Cobb and Lulu May, San Francisco, Cal., 1877, 2 m. 26½ s., in a third heat
One mile, with running mate—Ethan Allen and mate, Fashion Course, L.I., June 21, 1867, 2 m. 15 s., in a first heat.
One hundred miles—Master Burke and Robin, 10 h. 17 m. 22 s.

Trotting under Saddle.

One mile—Great Eastern, Fleetwood Park, N.Y., September 22, 1877, 2 m. 15¾ s.
Two miles—Dexter, Long Island, 1865, 5 m. 0¾ s.
Three miles—Dutchman, Beacon Park, N J., August 1, 1839, 7 m. 32½ s.
Four miles—Dutchman, 1836, 10 m. 31 s.

Pacing.

One mile, in harness—Sleepy Tom, Chicago, Ill., July 25, 1879, 2 m. 12¼ s.
One mile, under saddle—Billy Boyce, Buffalo, N.Y., August 1, 1868, 2 m. 14½ s.
One mile, to waggon—Pocahontas, June 21, 1855, 2 m. 17½ s.
Two miles, under saddle—Bowery Boy, Long Island, 1839, 5 m. 4½ s.
Two miles, in harness—Hero, May 17, 1853, 4 m. 56½ s.
Three miles, under saddle—Oneida Chief, Beacon Park, N.J., 1843, 7 m. 44 s.
Three miles, in harness—Harry White, San Francisco, Cal., August 8, 1874, 7 m. 57¼ s. (W. T. C.)

HORSE-CHESTNUT, *Æsculus*, L. (Germ., *Rosskastanie*; Fr., *marronnier d' Inde*), a genus of trees or shrubs indigenous to North America and mountainous regions in Mexico, New Granada, Persia, North India, and the Malayan peninsula, of the natural order *Sapindaceæ* and suborder *Sapindeæ*, having exstipulate, opposite, digitate, 5- to 9-lobed leaves, an irregular campanulate or tubular 5-lobed calyx, 4 to 5 petals, 5 to 8 stamens, one style, a 3-celled ovary, with 6 ovules, of which 3 or more abort, exalbuminous seeds, and a smooth or echinate coriaceous capsule. The Common Horse-chestnut, *Æ. Hippocastanum*, L., has been stated to be a native of Thibet, and to have been brought thence to England in 1550; it is now, however, thought to be indigenous in the mountains of northern Greece, where it occurs wild at 3000 to 4000 feet above sea-level (*Gard. Chron.*, 1880, i. 488). Matthiolus, who attributes the origin of the name of the tree to the use of the nuts by the inhabitants of Constantinople for the relief of short-windedness and cough in horses,[1] remarks that no ancient writer appears

[1] *Opera quæ extant omnia*, "Comment.," lib. i. cap. cxxii. p. 184, Frankfort, 1598, fol.; *cf.* Gerard, *Herball*, p. 1443, 2d ed., 1633. For other derivations see *Notes and Queries*, 3d ser., x. 452, 523, and *Gard. Chron.*, 1878, ii. 53.

to have made mention of the horse-chestnut. Clusius (*Rariorum plantarum hist.*, lib. i. p. 8, 1601) describes it as a vegetable curiosity, of which in 1588 he had left in Vienna a living specimen, but of which he had not yet seen either the flowers or recent fruit. The dry fruit, he says, had frequently been brought from Constantinople into Europe. The tree grows rapidly; it flourishes best in a sandy, somewhat moist loam, and attains a height of 50 to 60 or more feet, assuming a pyramidal outline. Its boughs are strong and spreading. The buds, conspicuous for their size, are protected by a coat of a glutinous substance, which is impervious to water; in spring this melts, and the bud-scales are then cast off. The leaves are composed of 7 obovate-cuneate radiating leaflets (see vol. iv. p. 112, fig. 115); when young they are downy and drooping. From the early date of its leafing year by year, a horse-chestnut in the Tuileries is known as the "Marronnier du 20 Mars." The flowers of the horse-chestnut, which are white dashed with red and yellow, appear in May, and sometimes, but quite exceptionally, again in autumn (*Gard. Chron.*, 1868, p. 1116); they are very numerous on each rachis, and form a thyrse. Comparatively few of them afford mature fruit. The fruit is ripe in or shortly before the first week in October, when it falls to the ground, and the three-valved thorny capsule divides, disclosing the brown and at first beautifully glossy seeds or nuts, having a resemblance to sweet chestnuts, and commonly three or else two in number. For propagation of the tree, the nuts may be sown either when fresh, or, if preserved in sand or earth, in spring. Drying by exposure to the air for a month has been found to prevent their germination. The cotyledons do not rise to the surface of the soil. Rooks are wont to remove the nuts from the tree just before they fall, and to disperse them in various directions (R. Ellison, *Berwickshire Naturalist*, quoted in *J. of Forestry*, Apr. 1880, pp. 877, 878).

The bark of the horse-chestnut contains a greenish oil, resin, a yellow body, a tannin, $C_{26}H_{24}O_{12}$, existing likewise in the seeds and various parts of the tree, and decomposable into *phloroglucin* and *æsciglyoxalic acid*, $C_7H_6O_3$, also *æsculetin hydrate*, and the crystalline fluorescent compound *æsculin*, of the formula $C_{21}H_{24}O_{13}$ (Rochleder and Schwarz), with which occurs a similar substance *fraxin*, the *paviin* of Stokes (*Q. J. Chem. Soc.*, xi. 17, 1859; xii. 126, 1860), who suggests that its presence may perhaps account for the discrepancies in the analyses of æsculin given by different authors. From the seeds have been obtained starch (about 14 per cent.). gum, mucilage, a non-drying oil, phosphoric acid, salts of calcium, *saponin*, by boiling which with dilute hydrochloric or sulphuric acid *æsculic acid* is obtained, *quercitrin*, present also in the fully developed leaves, *æscigenin*, $C_{12}H_{20}O_2$, and *æsculetin*, $C_9H_6O_4$, which is procurable also, but in small quantity only, from the bark. Rochleder has described as constituent principles of the cotyledons *aphrodæscin*, $C_{52}H_{82}O_{23}$, a bitter glucoside, *argyræscin*, $C_{27}H_{42}O_{12}$, *æscinic acid*, $C_{24}H_{40}O_{12}$, and *queræscitrin*, $C_{41}H_{46}O_{25}$, found also in the leaves. To prepare pure starch from the seeds, Flandin (*Compt. Rend.*, xxvii. 391, 1848; xxviii. 138, 1849) recommends kneading them, when peeled and bruised, in an aqueous solution of $\frac{1}{100}$ to $\frac{1}{60}$ of their weight of sodium carbonate. E. Staffel (*Ann. d. Chem. u. Pharm.*, lxxvi., 1850, p. 379) after drying found, in spring and autumn respectively, 10·9 and 3·38 per cent. of ash in the wood, 8·68 and 6·57 in the bark, and 7·68 and 7·52 in the leaves of the horse-chestnut. The ash of the unripe fruit contains 58·77, that of the ripe kernel 61·74, and that of the green shell 75·91 per cent. of potash (E. Wolff).

The wood of the horse-chestnut is soft, and serves only for the making of water-pipes, for turner's work and common carpentry, as a source of charcoal for gunpowder, and as fuel. Newly cut it weighs 60 ℔, and dry 35 ℔ per cubic foot approximately. The bark has been employed for dyeing yellow and for tanning, and was formerly in popular repute as a febrifuge and tonic. The powder of the dried nuts was at one time prescribed as a sternutatory in the Edinburgh *Pharmacopœia*. It is stated to form with alum-water a size or cement highly offensive to vermin, and with two parts of wheaten flour the material for a strong bookbinder's paste. Infusion of horse-chestnuts is found to expel worms from soil, and soon to kill them if they are left in it (*The Garden*, xiii. 198, 1878). The nuts furthermore have been applied to the manufacture of an oil for burning, cosmetic preparations, and starch (*v. sup.*), and in Switzerland, France, and Ireland, when rasped or ground, to the bleaching of flax, hemp, silk, and wool. In Geneva horse-chestnuts are largely consumed by grazing stock, a single sheep receiving 2 ℔ crushed morning and evening. Given to cows in moderate quantity, they have been found to enhance both the yield and flavour of milk. Deer readily eat them, and, after a preliminary steeping in lime-water, pigs also. For poultry they should be used boiled, and mixed with other nourishment. The fallen leaves are relished by sheep and deer, and afford a good litter for flocks and herds.

One variety of the horse-chestnut has variegated leaves, and another double flowers. Darwin has observed that *Æ. Pavia*, L., the Red Buckeye of North America, exhibits a special tendency, under unfavourable conditions, to be double-blossomed (*Anim. and Pl.*, ii. 168). The seeds of this species are used to stupefy fish. The Scarlet-flowered Horse-chestnut, *Æ. rubicunda*, is a handsome tree, less in height, and having a rounder head than the common form. Another species, possessing flowers with the lower petals white with a red tinge, and the upper yellow and red with a white border, and fruit unarmed, is *Æ. indica*. Among the North American species are the Fœtid or Ohio Buckeye, *Æ. glabra*, Willd., and *Æ. flava*, Ait., the Sweet Buckeye. *Æ. californica*, Nutt., when full-grown and in flower, is a beautiful tree, but its leaves often fall before midsummer.

See Loudon, *Arboretum*, i. 147, 462; *Gard. Chron.*, 1843, pp. 7, 737; 1878, i. 768, 828, and ii. 53; *Technologist*, 1865, p. 3; Asa Gray, *Man. of Bot.*, p. 117, 5th ed., 1872; Brewer and Watson, *Geol. Surv. Calif.*, "Bot." i. 106; ARBORICULTURE, vol. ii. p. 319; and, for the chemistry, Rochleder and Schwarz, *Ann. d. Chem. u. Pharm.*, lxxxvii., 1853, p. 186, and lxxxviii. 356; C. Zwenger, *Ib.*, xc., 1854, p. 63; and Rochleder, *Wien. Akad. Sitzungsber.*, xl., 1860, xlv., 1862, xlviii., 1863, liv.-lvii., 1866-68. (F. H. B.)

HORSE-MACKEREL is the name applied to a genus of fishes (*Caranx*) found in abundance in almost all temperate and especially in tropical seas. The designation "cavalli," given to them by the early Portuguese navigators, and often met with in the accounts of the adventures of the buccaneers, is still in frequent use among the sailors of all nations. Some ninety different kinds are known,—the majority being wholesome food, and some of the species attaining a length of 3 feet and more. The fish to which the name horse-mackerel is applied in Great Britain is *Caranx trachurus*, distinguished by having the lateral line in its whole length armed with large but narrow bony plates. Horse-mackerel are found singly on the coast all the year round, but sometimes they congregate in shoals of many thousands. Although well-flavoured, they are much more frequently used for bait than for food. This species has a most extraordinary range, being found almost everywhere within the temperate and tropical zones of the northern and southern hemispheres.

HORSEMANSHIP. See HORSE, p. 195.

HORSENS, a seaport town of Denmark, in the province of Aarhuus and amt of Skanderborg, is situated at the head of the Horsens-fiord on the east coast of Jutland, and on the railway from Fridericia to Langaa, 25 miles south-west of Aarhuus. It is a well-built town, and contains a Latin school and two market-places. In the neighbourhood there is a large prison. The town possesses a large foundry, machine shops, shipbuilding yards, lime-works, and manufactures of cloth and of woodwares; it has also a good harbour. It is the birthplace of the navigator Vitus Bering or Behring, the discoverer of Behring Straits. The population in 1870 was 10,501.

HORSE-POWER is the name given to the unit in terms of which engineers measure the power of steam-engines, water-wheels, and other prime movers. It is defined to be the rate at which an engine works when it does 33,000 foot-pounds of work per minute, a foot-pound being the amount of work necessary to raise a pound weight a foot high. We must go back to the early history of the steam-engine to discover the reason why this number was adopted. The first steam-engines were employed to drive mills, pumps, and other machinery which had previously been driven by horses; and it seemed natural to express their working-power in terms of the number of horses whose work they were got to accomplish. This led to experiments being made in order to get an estimate of the average working-power of a horse. Several such estimates have been given, all differing considerably from each other; but the one adopted whereby to express horse-power is that obtained by Boulton and Watt from observations on the strong dray horses employed at the London breweries working eight hours a day. They found that a horse was able to go at the rate of $2\frac{1}{2}$ miles per hour and at the same time raise a weight of 150 ℔ by means of a rope led over a pulley. This is easily seen to be equivalent to 33,000 ℔ raised one foot per minute, and hence the number given above. In connexion with this subject it is necessary to distinguish clearly between "horse-power indicated" and "horse-power nominal" as applied to steam-engines. The horse-power indicated is got from an examination of the indicator diagram (see DIAGRAMS, vol vii. p. 152). The area of the closed curve traced on the diagram, or "card" as it is technically called, gives the work done by the steam on the piston during each complete stroke. This divided by the difference between the extreme abscissæ gives the average pressure (p) on the piston. If we multiply this by the area of the piston (A) and by the length of stroke (x), we get the number of foot-pounds of work done during each stroke, and this multiplied by the number (n) of strokes per minute and divided by 33,000 gives the indicated horse-power. Thus—

$$\text{Indicated H.P.} = \frac{pAnx}{33,000}.$$

Nominal horse-power is a purely conventional term adopted by makers of steam-engines, and has no fixed relation to indicated horse-power. The method of calculating it dates from the time of Boulton and Watt. In their engines they supposed the average pressure on the piston to be 7 ℔ on the square inch, and the velocity of the piston in feet per minute to be 128 times the cube root of the length of stroke in feet. Computing from these supposed data, we get the nominal horse-power. Thus—

$$\text{Nominal H.P.} = \frac{7 \times A \times 128 \times \sqrt[3]{x}}{33,000}.$$

The British Admiralty rule for nominal horse-power differs from this in using the actual velocity of the piston instead of the above supposed velocity. These rules only apply to low-pressure engines; for high-pressure engines it is usual, after Bourne, to assume 21 ℔ as the average pressure on the piston, the other data remaining as before. See Rankine's *Steam-Engine*.

HORSE-RACING. See HORSE, p. 199.

HORSERADISH (Ger., *Meerrettig*; Fr., *raifort = racine forte, cran de Bretagne*; Swed., *Peppar-rot*; Russ., *chren*), *Cochlearia Armoracia*, L., a perennial plant of the natural order *Cruciferæ* and tribe *Alyssineæ*, having radical leaves on long stalks, ovate or oval-oblong, 4 to 6 inches broad, about a foot in length, subcoriaceous, crenate or serrate, and coarsely veined; stem-leaves short-stalked or sessile, elongate, and tapering to their attachment, the lower ones often deeply toothed; flowers, which appear in May and June, $\frac{3}{8}$-inch in width, in flat-topped panicles, with sepals purplish, and petals white; and fruit a small silicula, which in the climate of England seldom bears seed. The horseradish is indigenous to eastern Europe. Into western Europe and Great Britain, where it is to be met with on waste ground, it was probably introduced from Russia (De Candolle, *Géogr. Botan.*, ii. 654, 1855). It was wild in various parts of England in Gerard's time. The root, the *armoraciæ radix* of pharmacy, is $\frac{1}{2}$ to 2 inches or more in diameter, and commonly a foot, sometimes 3 feet in length; the upper part is enlarged into a crown, which is annulated with the scars of fallen leaves; and from the numerous irregular lateral branches are produced vertical stolons, and also adventitious buds, which latter render the plant very difficult of extirpation. From the root of ACONITE (*q. v.*, vol. i. p. 98), which has occasionally been mistaken for it, horseradish root differs in being more or less cylindrical from a little below the crown, and in its pale yellowish (or brownish) white hue externally, acrid and penetrating odour when scraped or bruised, and pungent and either sweetish or bitter taste (see Bentley, *Pharm. Journ.*, 1st ser., xv. 449, 1856). The fresh root yields on distillation with water about ·05 per cent. of a volatile oil identical with that of black mustard, resulting from the mutual reaction of sinigrin (potassium myronate) and myrosin in the presence of the water. After drying, the root has been found to afford 11·15 per cent. of ash. Horseradish root is an ingredient in the *spiritus armoraciæ compositus* of the British Pharmacopœia. It possesses stomachic, diaphoretic, and diuretic properties, and hence is administered in atonic dyspepsia, chronic rheumatism, and dropsies. As a masticatory, or in the form of syrup or infusion, it is used for hoarseness. Gerard speaks of it as anthelmintic and emetic. Externally applied it acts as a rubefacient; and the juice with vinegar is a popular remedy for freckles. In common with other species of *Cochlearia*, the horseradish was formerly in high repute as an antiscorbutic. The root was, as well as the leaves, taken with food by the Germans in the Middle Ages, whence the old French name for it, *moutarde des Allemands*; and Coles, writing in 1657, mentions its use with meat in England, where it is now chiefly employed as a condiment with beef. For the successful cultivation of the horseradish, a light and friable damp soil is the most suitable; this having been trenched 3 feet deep in autumn, and the surface turned down with a liberal supply of farm-yard manure, a second dressing of decomposed manure should in the ensuing spring be dug in 2 feet deep, and pieces of the root 6 inches in length may then be planted a foot apart in narrow trenches. During summer the ground requires to be kept free of weeds; and the application of liquid manure twice or thrice in sufficient quantity to reach the lowest roots is an advantage. When dug the root may be long preserved in good condition by placing it in sand. The horseradish tree is the *Moringa pterygosperma* of Gärtner.

See Gerard, *Herball*, p. 240, ed. Johnson, 1636; Syme, *Sowerby's Eng. Bot.*, i. 183, pl. cxxix., 1863; *Florist*, 1875, p. 191; *Floral World*, 1879, p. 149; Flückiger and Hanbury, *Pharmacographia*, p. 71, 2d ed., 1879; Bentley and Trimen, *Med. Pl.*, i. 21, 1880.

HORSETAIL, *Equisetum*, the sole genus of the natural order *Equisetaceæ*, consists of a group of vascular cryptogamous plants remarkable for its resemblance in general appearance to the phanerogamic genera *Casuarina* and *Ephedra*. The stem is jointed, consisting of numerous easily separable tubular sheaths toothed at the apex, and is generally furnished with whorls of similar but more slender branches. The fructification is borne at the apex of the stem in the form of a dense oval, oblong, or cylindrical spike, consisting of a number of shortly-stalked peltate scales, each of which has attached to its under surface a circle of spore cases. These open by a longitudinal slit on their inner side. The spores differ from those of ferns in their outer coat being split up into four club-shaped hygroscopic threads or elaters, which are curled when moist, but become straightened when dry. The apparent roots consist of underground stems, any portion of which broken off is capable of producing a new plant; hence the difficulty of eradicating them when once established. There are 25 known species of the horsetail, and the genus is universally distributed.

The Corn Horsetail, *E. arvense*, L., one of the commonest species, is a troublesome weed in clayey cornfields. The fructification appears in March and April, terminating in short unbranched stems. It is said to produce diarrhœa in such cattle as eat it. The Bog Horsetail, *E. palustre*, is said to possess similar properties. It grows in marshes, ditches, pools, and drains in meadows, and sometimes obstructs the flow of water with its dense matted roots. The fructification in this species is cylindrical, and in that of *E. limosum*, L., which grows in similar situations, it is ovate in outline. The largest British species, *E. maximum*, L., grows in wet sandy declivities by railway embankments or streams, &c., and is remarkable for its beauty, due to the abundance of its elegant branches and the alternately green and white appearance of the stem. In this species the fructification is conical or lanceolate, and is found in the month of April, on short stout unbranched stems, which have large loose sheaths. Horses appear to be fond of this species, and in Sweden it is stored for use as winter fodder. *E. hyemale*, L., commonly known as the Dutch rush, is much more abundant in Holland than in Britain; it is used for polishing purposes, and also in medicine by homœopathic practitioners. *E. variegatum*, Sch., grows on wet sandy ground, and serves by means of its fibrous roots to bind the sand together. The horsetails are remarkable for the large quantity of silica they contain, which often amounts to half the weight of the ash yielded by burning them, and the roots contain a quantity of starch.

HORSHAM, a parliamentary borough and market-town of Sussex, England, is pleasantly situated in the midst of a fertile country near the source of the Arun and on the Mid-Sussex Railway, 37½ miles south of London. It consists chiefly of two streets crossing each other at right angles, and a picturesque causeway leading to the church, adorned with rows of trees. Within recent years the town has undergone great improvements, and it now possesses well-paved streets and some handsome buildings. In the vicinity there are several fine mansions. Works were erected in 1865 for supplying the town with water from a well in the neighbourhood. The principal buildings are the parish church, often repaired, and in 1865 entensively restored, a very ancient structure in the Early English style, with the remains of Norman work, having a lofty tower surmounted by a spire, and containing several fine monuments and tombs, and two brasses; the grammar school, founded in 1540 and rebuilt in 1840, recommended to be used as a middle class school by the Endowed Schools Commission; the corn exchange, erected in 1766 in the Italian style, with a room for assemblies and public meetings; the Roman Catholic chapel of St John in the Early English style, erected in 1866 at the cost of the duchess of Norfolk. A school board was formed in 1873, which, besides having the management of most of the schools previously existing, has erected new buildings in the east end of the town, at a cost of above £4000. There are a number of small charities, and almshouses were founded in 1842 by the Rev. Jarvis Kenrick. The town possesses a tannery, a foundry, a carriage factory, and several flour-mills. The area of the parish and parliamentary borough is 10,741 acres, and the population in 1871 was 7831.

There is a tradition which derives the name of Horsham from Horsa the brother of Hengist, who is said to have been slain in the vicinity; others derive it from *horsham*, the horses' meadow; but the most probable derivation is Hurst-Ham or the Ham (village) in the Hurst (forest). The town is a borough by prescription, and returned two members to parliament from the 23d year of the reign of Edward I. to the 2d of William IV., when it was deprived of one of its members. It has never been incorporated, and it is now governed by a local board.

HORSLEY JOHN (*c.* 1685–1732), a distinguished antiquary of the last century, the date and place of whose birth as well as his parentage are uncertain. The late Rev. John Hodgson, the historian of Northumberland, in a short memoir of him published in 1831, countenances the belief that he was born in 1685, at Pinkie, in the parish of Inveresk and county of Midlothian. This statement he reconciles with Horsley's subsequent history, by supposing that his father was a Northumberland Nonconformist, who had migrated to Scotland during the reign of Charles II. or James II., but returned to England soon after the Revolution of 1688. On the other hand, Mr J. H. Hinde, in "Notes" on the life of Horsley, printed in the *Archæologia Æliana* for February 1865, leans to the opinion that he was a native of Newcastle-on-Tyne, and the son of Charles Horsley, a member of the Tailors' Company of that town, an opinion to which colour is given by some expressions of Horsley's own in the *Britannia Romana*.

Horsley undoubtedly received his early education at the grammar school of Newcastle, and completed it at the university of Edinburgh, where he was admitted to the degree of master of arts on the 29th of April 1701. For years afterwards nothing seems to be known of him, though some of them must have been given to the study of theology in connexion with the body of dissenters to which he belonged. There is some evidence tending to show that Horsley "was settled in Morpeth as a Presbyterian minister as early as 1709." Mr Hodgson, however, thinks that up to 1721, at which time he was residing at Widdrington, "he had not received ordination, but preached as a licentiate." Even if he was ordained then his stay at the latter place was probably prolonged beyond that date; for he communicated to the *Philosophical Transactions* notes on the rainfall there in the years 1722 and 1723. Mr Hinde also shows that during these years, in addition to his other duties, whatever their nature, "he certainly followed a secular employment as agent to the York Buildings Company, who had contracted to purchase and were then in possession of the Widdrington estates." Soon after settling at Morpeth, Horsley began to supplement his professional income, probably slender, by opening a private school. The enterprise was successful. Respect for his character and abilities attracted pupils irrespective of religious connexion, one of them becoming afterwards Dean of Westminster. He likewise found time to give courses of lectures on mechanics and hydrostatics in Morpeth, Alnwick, and Newcastle; and it was doubtless in recognition of his scientific tastes and attainments that he was elected on the 23d April 1730 a Fellow of the Royal Society.

It is, however, in connexion with his archæological researches that John Horsley is now so well and so honourably known, though strangely enough no place appears to have been hitherto found for his name in such works as the present. Among those who have investigated the traces left by the Romans of their presence in Britain he stands, and must ever stand, as in many respects the foremost. His great work, *Britannia Romana, or the Roman Antiquities of Britain* (London, 1732), one of the scarcest and most valuable of its class, contains the result of an amount of patient labour in this extensive field that in the case of a man in his position is truly marvellous. Nor was the acuteness of his intellectual powers less remarkable; for so accurately were his researches conducted and so solid was the judgment he brought to bear upon them that a century and a half of subsequent inquiry has invalidated only a few of the conclusions he came to.

Horsley died suddenly, of apoplexy, on the 12th of January 1732, his constitution having been in all likelihood prematurely worn out by the toil he had undergone in the composition of the *Britannia Romana*, then on the eve of publication. The following extract from the burial register of the parish of Morpeth gives the date of his interment: "173½, Jan. 15, Mr John Horsley;" but the site of his grave is unknown. Besides the *Britannia Romana*, Horsley published two sermons and a hand-book to his lectures on mechanics, &c. He also projected a history of Northumberland and Durham, collections for which were found among his papers. By his wife, a daughter of the Rev. William Hamilton, D.D., minister of Cramond, afterwards professor of divinity in the university of Edinburgh, he had one son and two daughters.

HORSLEY, Samuel (1733–1806), a learned Anglican prelate, was born in London in 1733. Entering Trinity College, Cambridge, he became LL.B. in 1758 without graduating in arts, and in the following year succeeded his father in the living of Newington Butts in Surrey. Horsley was elected a Fellow of the Royal Society in 1767; but, in consequence of a difference with the president, he withdrew from it in 1784. He had been secretary since 1773. In 1768 he attended the eldest son of the earl of Aylesford to Oxford as private tutor; and, after receiving through the earl and Bishop Lowth various minor preferments, which by dispensations he combined with his first living, he was installed in 1781 as archdeacon of St Albans. In 1774 the university of Oxford conferred on him the degree of LL.D. Whilst archdeacon, Horsley entered upon his famous controversy with the Socinian, Dr Priestley, who denied that the early Christians held the doctrine of the Trinity. In this controversy, conducted on both sides in the fiercest polemical spirit, Horsley showed the superior learning and ability. His aim was to lessen the influence which the prestige of Priestley's name gave to his views, by proving from his writings the latter's incompetence through ignorance to form an authoritative judgment on the disputed points. For the energy displayed in the contest Horsley was rewarded by Lord Chancellor Thurlow with a prebendal stall at Gloucester; and in 1788 the same patron procured his promotion to the episcopal see of St David's. As a bishop, Horsley was energetic both in his diocese and in parliament. The efficient support which he afforded the Government in the latter place was acknowledged by his successive translations to Rochester in 1793, and to St Asaph in 1802. With the bishopric of Rochester he held the deanery of Westminster. He died at Brighton on October 4, 1806.

Besides the controversial *Tracts*, which appeared in 1783-84-86, and were republished in 1789 and 1812, Horsley's more important works are:—*Apollonii Pergæi Inclinationum Libri duo*, 1770; *Remarks on the Observations . . . for determining the acceleration of the Pendulum in Lat.* 70° 51′, 1774; *Isaaci Newtoni Opera quæ extant Omnia*, with a commentary, 5 vols. 4to, 1779–84; *On the Properties of the Greek and Latin Languages*, 1796; *Disquisitions on Isaiah* xviii., 1796; *Hosea, translated from the Hebrew, with Notes*, 1801; *Elementary Treatises on . . . . Mathematics*, 1801; *Euclidis Elementorum Libri priores XII.*, 1802; *Euclidis Datorum Liber*, 1803; *Virgil's Two Seasons of Honey*, &c., 1805; and papers in the *Philosophical Transactions* from 1767 to 1776. Since his death have appeared—*Sermons*, 1810–12; *Speeches in Parliament*, 1813; *Book of Psalms, translated with Notes*, 1815; *Biblical Criticism*, 1820; *Collected Theological Works*, 6 vols. 8vo, 1845. See Nichol's *Literary Anecdotes*, vol. iv.

HORSLEY, William (1774–1858), an English musician of considerable reputation, was born November 15, 1774, and became in 1790 the pupil of Theodore Smith, an indifferent musician of the time, who, however, taught him sufficient to obtain the position of organist at Ely Chapel, Holborn. This post he resigned in 1798, to become organist at the Asylum for Female Orphans, as assistant to Dr Callcott, with whom he had long been on terms of personal and artistic intimacy, and whose eldest daughter he married. In 1802 he became his friend's successor upon the latter's resignation. Besides holding this appointment he became in 1812 organist of Belgrave Chapel, Halkin Street, and in 1837 of the Charter House. He died June 12, 1858. Horsley's compositions are numerous, and include amongst other instrumental pieces three symphonies for full orchestra. Infinitely more important are his glees, of which he published five books, besides contributing many detached glees and part songs to various collections. Mr Barrett, in his lecture on "English glee and madrigal writers," calls Horsley "one of the princes amongst glee writers," and attributes to him "a fine and powerful dramatic aim and an elegant taste." Horsley's compositions are moreover distinguished by a remarkable purity of style, which sometimes verges on pedantry. His glees, "By Celia's arbour," "O nightingale," "Now the storm begins to lower," and others, are amongst the finest specimens of this peculiarly English class of compositions. Horsley's son (Charles Edward), born in 1822, enjoyed a certain reputation as a musician. He studied in Germany under Hauptmann and Mendelssohn, and on his return to England composed several oratorios and other pieces, none of which had permanent success. In 1868 he emigrated to Australia. He died March 2, 1876, at New York.

HORTEN (Karljohanswærn), a seaport town of Norway, in the amt of Jarlsberg-Laurvig, is beautifully situated on the west bank of the Christiania fjord, opposite Moss, and 32 miles south of Christiania. It is defended by strong fortifications, is the headquarters of the Norwegian fleet, and possesses an arsenal and shipbuilding yards, as well as a real school, a national school of the higher grade, an observatory, a nautical museum, and an infirmary. It also carries on a considerable shipping trade. The population, which in 1836 did not exceed 200, was 5457 in 1875.

HORTENSE (1783–1837), queen of Holland, is familiarly known as La Reine Hortense. Her proper name was Eugénie Hortense de Beauharnais, and she was the only daughter of Alexandre de Beauharnais and Josephine Tascher de la Pagerie. She was born on the 10th of April 1783. When four years old she accompanied her mother to Martinique, and returned with her three years later to be subjected to all the dangers of the Revolution. For a time she was sent with her brother to England, but soon returned. The marriage of her mother to Napoleon Bonaparte naturally altered her prospects altogether, and, as she grew to woman's estate, several marriages of more or less importance were proposed for her. It suited the first consul, however, that she should marry his brother Louis, and despite her tears and entreaties the marriage was concluded. In one of his moments of brutal frankness Napoleon confessed that his brother as a husband was "insupportable," though he characteristically proceeded to charge Hortense with having been the cause of his own misfortunes in not agreeing with her husband. Louis it appears was sincerely anxious to please his young wife. But his health was bad and his temper gloomy, while Hortense was exceptionally lively and fond of gaiety. The natural consequence was an infinity of scandal, some of it of a very grave character. The recent publication of Madame de Rémusat's memoirs has, however, gone far to exonerate Hortense. The writer, equally outspoken and well informed, gives instances of the most fantastic and disgusting exercise of conjugal tyranny on Louis's part, and denies that his wife in any way misconducted herself, the malignant jealousy of the Bonaparte sisters being credited with the accusation. Within seven years of her marriage Hortense had three children, whose nomenclature, unless carefully studied, is somewhat puzzling. The eldest, Napoleon-Louis-Charles, was born in 1802 and died in 1807. The next, Napoleon-Louis, was born in 1804 and died in 1831. The third, Charles-Louis-Napoleon, was born in 1807, and lived to be the late emperor Napoleon III. When Napoleon distributed crowns to his relations Hortense was very anxious that her husband should receive that of Italy. Holland, however, fell to his share, and the ill-matched pair retired thither. The death of her eldest son made Holland intolerable to Hortense, and before long she returned to Paris and established herself in the Rue Cerutti. Nor did she from that time forward ever live in any regular fashion with her husband, whose forced abdication of his crown soon followed. In Paris she was more popular than respected, and her leisure time was filled up with many quasi-literary and artistic employments. It was there that she signalized herself by composing among other airs the famous melody of *Partant pour la Syrie.* The ineffable silliness of the words of this song is not due to her, but to a certain M. de Laborde; and it is only fair to say that it took Frenchmen twenty years to find out that the air was ugly, and that it was possibly stolen. Hortense continued even after her mother's divorce to exercise a certain influence over her stepfather. At the first Restoration she was confirmed in her title and possessions as Duchesse de Saint-Leu. But she ardently welcomed the returning emperor, and thenceforward France was hardly a residence for her, while her private life was disturbed by constant and indecent bickerings with her husband about the custody of her children. She bought a house at Arenenberg on the Lake of Constance and another at Augsburg, for the sake of educating her sons, and from time to time she undertook various journeys in the hope of furthering their interests. The Revolution of July gave her some chance of returning to France, but immediately afterwards grave misfortunes overtook her. Her sons took part in the Italian risings, and the elder died of measles. Scarcely had she recovered from this when the Strasburg attempt was made against her advice. She lived long enough to see the future emperor return from America, and died at Arenenberg on the 3d October 1837. Generally speaking, Hortense appears to have been an amiable woman, whose life was spoilt by the tyrannical egotism of her stepfather. She seems, however, to have been unduly given to intrigue; and she herself admitted that she might have lived on better terms with her husband, upon whom she was forced almost as much as he was forced on her.

HORTENSIUS, Quintus, was one of the first and most famous orators at the Roman bar in the latter days of the republic, when the orator's art was particularly flourishing and was diligently cultivated. His father had been governor of Sicily, and had left behind him a good name for justice and uprightness. He was himself born in 114 B.C., and he lived to the year 50 B.C., so that his life and career ran parallel to that of Cicero, whose senior he was by only eight years. He had the best possible introductions into public life, and at the age of nineteen he made his first speech at the bar, and shortly afterwards successfully conducted the defence of a petty king of Bithynia, one of Rome's many dependants in the East. From that time his reputation as an eloquent advocate was decisively established. As the son-in-law of Catulus he was attached to the aristocratical party of which Sulla was the head, and among his clients he numbered several of its most eminent members. During Sulla's ascendency the courts of law were under the control of the senate, the judges being themselves senators. To this circumstance perhaps as well as to his own merits Hortensius may have been indebted for much of his success. Many of his clients were the governors of provinces which they were accused of having plundered, and such men were generally sure to find themselves brought before a somewhat lenient or even friendly tribunal, one, too, which was shamefully accessible to corruption. Hortensius himself, according to Cicero, was not ashamed to avail himself of this disgraceful weakness, and a good deal of the plunder which his clients had got from the provincials went into the pockets of the judges. Cicero made this statement in open court, and we are thus driven to assume that it must have had some foundation.

Hortensius, like other eminent Roman citizens, passed through the regular succession of public offices, rising from the quæstorship in 81 to the consulship in 69 B.C. In the year before his consulship he came into collision with the now rapidly rising eloquence of Cicero in the memorable case of Verres, and from that time his supremacy at the bar was shaken. In fact his younger rival stepped into his position. Cicero's success against a man who was backed up by all the influence of Sulla's party was a splendid triumph, and it must have been a heavy blow to Hortensius. Shortly afterwards he was again pitted against Cicero, and again failed. In 67 a proposal was made to supersede Lucullus in his command in the East against Mithradates in favour of Pompeius. This was supported by Cicero, and was successfully carried in face of the opposition of Hortensius. From the year 63 B.C., the famous year of Cicero's consulship and of the Catiline conspiracy, we find the two great rivals often associated together as counsel in the same case. The fact was that Cicero was now himself drawn towards the aristocratical party,—the party of Hortensius. Consequently, in the many cases which had more or less of a political complexion as arising out of the disorder and turbulence incident to party quarrels, it was natural that the two men should have the same sympathies and be engaged on the same side. So it happened, for example, in the case of Licinius Murena, whom Cicero defended along with Hortensius against a charge of bribery in canvassing for the consulship. And so strongly declared was his sympathy with Milo against Cicero's bitter enemy Clodius that he was nearly murdered by some of Clodius's gang. After Pompeius's return from the East in 61 B.C., and the political revolution which for a time united him with Cæsar, Hortensius withdrew from public life and devoted himself exclusively to his profession. For nine more years he was in continual employment as an advocate, and won a number of verdicts. In 50 B.C., the last year of his life, he defended successfully one Appius Claudius against Dolabella, Cicero's son-in-law, who prosecuted the man on a serious charge of bribery.

None of Hortensius's speeches have come down to us; and it was, it seems, only on special occasions that he wrote them. Almost all our knowledge of him is derived from Cicero. He was undoubtedly a highly-gifted and accomplished man, and though of course he owed his very early success to his great connexions, yet he was perfectly well able to stand on his own conspicuous merits. His eloquence perhaps was not quite of the highest order;—it was not for the most part what Cicero called "gravis," weighty, dignified, impressive; there was, it may be presumed, an absence of those appeals to great moral principles which give such grandeur to the best speeches of Cicero and Demosthenes, and of our own Burke. His oratory, according to his great rival, was of the Asiatic style, by which appears to be meant a florid rhetoric, better to hear than to read. He had the gift of a marvellously tenacious memory, and could retain every single point in his opponent's argument. His action was highly artificial, and even his manner of folding his toga was noted by eminent tragic actors of the day, and is left on record by Macrobius. He had, too, a fine musical voice, which he could skilfully command.

Cicero sometimes speaks of Hortensius very favourably, and even almost affectionately, though it would appear from some passages in his letters that he never quite trusted him. He could not have thought him a high-principled man, as he openly charged him with bribery, and as he actually mentions a case in which he claimed property under a will which he knew to be a forgery (*De Officiis*, iii. 18). Hortensius, in fact, seems to have been a lax, easygoing, clever man, with very little noble ambition and very little real moral worth. "An amiable Epicurean" is a phrase which describes him not unfairly. The anecdotes we have about him all point to a man of luxurious tastes and a great capacity for enjoyment. The vast wealth he had accumulated during forty-four years of successful practice he spent after the fashion of rich Roman nobles, in splendid villas, in parks, in fish ponds, and costly entertainments. He left his heir an unusually well-stocked cellar of wine, and his park at Laurentum abounded in every variety of game. He was also a great buyer of pictures and works of art. With true consistency he opposed Pompeius and Crassus when they proposed their sumptuary law. He is said to have spoken wittily on the occasion; he was at any rate successful.

There is a good account of Hortensius in Dunlop's *Roman Literature* (ii. 222), and in Smith's *Dictionary of Greek and Roman Biography* his life and career are traced as thoroughly as the materials at our disposal allow. (W. J. B.)

HORTICULTURE

HORTICULTURE embraces both the art and the science of the cultivation of garden plants, whether for utilitarian or for decorative purposes. The subject naturally divides itself into two sections, which we here propose to treat separately, commencing with the science, and passing on to the practice of the cultivation of flowers, fruits, and vegetables as applicable to the home garden.

Part I.—Principles or Science of Horticulture.

Horticulture, apart from the mechanical details connected with the maintenance of a garden and its appurtenances, may be considered as the application of the principles of vegetable physiology to the cultivation of plants. The lessons derived from the abstract principles enunciated by the physiologist, the chemist, and the physicist require, however, to be modified to suit the special circumstances of plants under cultivation. The necessity for this modification arises from the fact that such plants are subjected to conditions more or less unnatural to them, and that they are grown for special purposes which are at variance, in degree at any rate, with their natural requirements.

The life of the plant makes itself manifest in the processes of growth, development, and reproduction. By growth is here meant mere increase in bulk, and by development the series of gradual modifications by which a plant originally simple in its structure and conformation becomes eventually complicated, and endowed with distinct parts or organs. The reproduction of the higher plants takes place either asexually by the formation of buds or organs answering thereto, or sexually by the production of an embryo plant within the seed. The conditions requisite for the growth, development, and reproduction of plants are, in general terms, exposure, at the proper time, to suitable amounts of light, heat, and moisture, and a due supply of appropriate food. The various amounts of these needed in different cases have to be adjusted by the gardener, according to the nature of the plant, its "habit" or general mode of growth in its native country, and the influence to which it is there subjected, as also in accordance with the purposes for which it is to be cultivated, &c. It is but rarely that direct information on all these points can be obtained; but inference from previous experience, especially with regard to allied vegetable forms, will go far to supply such deficiencies. Moreover, it must be remembered that the conditions most favourable to plants are not always those to which they are subjected in nature, for, owing to the competition of other vegetable forms in the struggle for existence, liability to injury from insects, and other adverse circumstances, plants may actually be excluded from the localities best suited for their development. The gardener therefore may, by modifying, improve upon the conditions under which a plant naturally exists. Thus it frequently happens that in our gardens flowers have a beauty and a fragrance, and fruits a size and savour denied to them in their native haunts. It behoves the judicious gardener, then, not to be slavish in his attempts to imitate natural conditions, and to bear in mind that such attempts must sometimes necessarily be failures. The most successful gardening is that which turns to the best account the plastic organization of the plant, and enables it to develop and multiply as perfectly as possible. Experience, coupled with observation and reflexion, as well as the more indirect teachings of tradition, are therefore of primary importance to the practical gardener.

We propose here to notice briefly the several parts of a flowering plant, and to point out the rationale of the cultural procedures connected with them.

The Root.—The root, though not precluded from access of air, is not directly dependent for its growth on the agency of light. The efficiency of drainage, digging, hoeing, and like operations is accounted for by the manner in which they promote aeration of the soil, raise its temperature, and remove its stagnant or superfluous moisture. Owing to their growth in length at, or rather in the immediate vicinity of, their tips, roots are enabled to traverse long distances by surmounting some obstacles, penetrating others, and insinuating themselves into narrow crevices. As they have no power of absorbing solid materials, their food must be of a liquid or gaseous character. It is taken up from the interstices between the particles of soil exclusively by the finest subdivisions of the fibrils, and in many cases by the extremely delicate thread-like cells which project from them, and which are known as root-hairs. The number and density of these latter are in direct proportion to the abundance and suitability of the food of the plant. The importance of the root-fibres, or "feeding roots," justifies the care which is taken by every good gardener to secure their fullest development, and to prevent as far as possible any injury to them in digging, potting, and transplanting, such operations being therefore least prejudicial at seasons when the plant is in a state of comparative rest.

Root-Pruning and Lifting.—In apparent disregard of the general rule just enunciated is the practice of root-pruning fruit trees, when, from the formation of wood being more active than that of fruit, they bear badly. The contrariety is more apparent than real, as the operation consists in the removal of the coarser roots, a process which results in the development of a leash of fine feeding roots. Moreover, there is a generally recognized quasi-antagonism between the vegetative and reproductive processes, so that, other things being equal, anything that checks the one helps forward the other.

Watering.—So far as practical gardening is concerned, feeding by the roots after they have been placed in suitable soil is confined principally to the administration of water and, under certain circumstances, of liquid manure; and no operations demand more judicious management. The amount of water required, and the times when it should be applied, vary greatly according to the kind of plant and the object for which it is grown, the season, the supply of heat and light, and numerous other conditions, the influence of which is to be learnt by experience only. The same may be said with respect to the application of manures. The watering of pot-plants requires especial care. Water should as a rule be used at a temperature not lower than that of the surrounding atmosphere, and preferably after exposure for some time to the air.

Bottom-Heat.—The "optimum" temperature, or that best suited to promote the general activity of roots, and, indeed, of all vegetable organs, necessarily varies very much with the nature of the plant, and the circumstances in which it is placed, and is ascertained by practical experience. Artificial heat applied to the roots, called by gardeners "bottom-heat," is supplied by fermenting materials, dung, tan, flues, or hot-water pipes. In some cases solar heat is as it were entrapped by placing beneath the roots substances such as bricks, the heat previously absorbed by which is slowly radiated. In winter the temperature of the soil, out of doors, beyond a certain depth is usually higher than that of the atmosphere, so that the roots are in a warmer and more uniform medium than are the upper parts of the plant. Often the escape of heat from the soil is prevented by "mulching," *i.e.*, by depositing on it a thick layer of litter, straw, dead leaves, and the like.

The *Stem* and its subdivisions or branches lengthen, not only near the tip, but also lower down, by intercalary growth. They upraise to the light and air the leaves and flowers, and serve as channels for the passage to them of fluids from the roots, and they act as reservoirs for nutritive substances. Their functions in annual plants cease after the ripening of the seed, whilst in plants of longer duration layer after layer of strong woody tissue is formed, which enables them to bear the strains which the weight of foliage and the exposure to wind, &c., entail. The gardener aims usually at producing stout, robust, short-jointed stems, instead of long lanky growths defective in woody tissue. To secure these conditions free exposure to light and air is requisite, but in the case of coppice woods, or where long straight spars are needed by the forester, plants are allowed to grow thickly so as to ensure development in an upward rather than in a lateral direction. This and like matters will, however, be more fitly considered in dealing hereafter with the buds and their treatment.

Leaves.—The work of the leaves may briefly be stated to consist in the processes of nutrition and of respiration. Nutrition by the leaves includes the inhalation of air, and the combination, under the influence of light and in the presence of chlorophyll, of carbon from the carbonic acid gas in the air with hydrogen from the watery vapour it contains, oxygen being exhaled. There is also a process of true respiration, in which atmospheric oxygen unites with a portion of the carbon in the plant, and is evolved as carbonic acid gas.

Syringing, &c.—In certain circumstances water is absorbed by the surface of leaves, especially when the supply of moisture at the root is defective, and when by too long exposure to drought the watery constituents of the plant have evaporated. A certain amount of evaporation of superfluous watery fluid or vapour is a necessary accompaniment of nutrition, but this may easily become excessive, especially where the plant cannot readily recoup itself. In these circumstances such operations as "syringing" and "damping down" are of special value. Evaporating basins or tanks in houses for orchid and other plants are beneficial for like reasons. Following Boussingault and Henslow, by whom the absorption of water by leaves has been proved, we may sum up the advantages of syringing as follows:—it washes off dust and insects from the leaves, and by moistening the cuticle promotes respiration and the absorption of water; it checks loss by transpiration, and so enables terminal shoots and young leaves to receive a sufficiency of sap from the stem; it keeps the air cool by evaporation; and lastly, as moisture is actually imbibed by the green parts of plants, it helps to compensate for any loss from within, and thus supplements root absorption.

In accordance with the facts just cited it is found that the preservation of cut flowers is promoted by inserting some of their leaves as well as their stalks in water. By cutting an herbaceous stem under water, so that the severed end is never exposed to the air, withering can to a large extent be prevented; and a bouquet may be kept fresh for a long time either by immersing the whole in water, or by simply covering the vase of water in which it is placed with a bell-glass. In the case of "cuttings" excessive transpiration is obviated by means of bell-glasses and by shading, and sometimes by burying a portion of the cutting with a leaf attached.

Carnivorous Plants.—Before leaving the subject of nutrition by leaves, reference may be made to the so-called carnivorous plants, *e.g.*, *Drosera*. Substances, particularly such as contain nitrogen, as insects or fragments of meat, when brought into contact with the surface of the leaves, or with certain glands on the leaves, become dissolved by the agency of a digestive ferment secreted therein, are then absorbed and serve as nutriment. See INSECTIVOROUS PLANTS.

Respiration, already alluded to, is not directly connected with exposure to light, since it goes on by night as freely as by day. It is a process requisite for the health of the plant, and contributes to maintain its heat, to perfect its structure, to eliminate some of its secretions, and to destroy effete or impure matters. Chlorophyll, according to Pringsheim, acts as a regulator of the respiration of plants by absorbing some of the luminous rays, and thereby favouring the function of assimilation.

As a result of the processes carried on in the leaves under the influence of light, many of the secretions, as starch, sugar, oils, and colouring and odoriferous matters are formed. These either at once subserve the nutrition of the plant or are stored in its tissues, as in the case of tubers and many seeds. Usually before it can be rendered available as nourishment the stored matter has to undergo a change from a more or less insoluble to a soluble form. The changes which they undergo within the plant require very careful study, and indeed constitute a department of physiology still very greatly in need of elucidation. Pringsheim's recent researches on the action of light on chlorophyll, prosecuted with the aid of a small lens and observed under the microscope, bid fair, if confirmed, materially to change the views of chemists as to the processes which go on in leaves as a consequence of exposure to light; but, although they may change or even reverse our notions as to the mode of action of chlorophyll, they will not detract from its importance.

Buds.—The recognition of the various forms of buds, and their modes of disposition in different plants, on which see BOTANY, vol. iv. pp. 95–99, 118, 119, is a matter of the first consequence in the operations of pruning and training. Flower-buds may be produced on the old wood, *i.e.*, the shoots of the past year's growth, or on a shoot of the present year. The pear and rhododendron develop flower-buds for the next season speedily after blossoming, and these may be stimulated into premature growth. The peculiar short stunted branches or "spurs" which bear the flower-buds of the pear, apple, and their allies, and of the laburnum, deserve special attention. In the rose, in which the flower-buds are developed at the ends of the young shoot of the year, we have an example of a plant destitute of flower-buds during the winter.

Propagation by Buds.—The detached leaf-buds (*gemmæ* or *bulbils*) of some plants are capable under favourable conditions of forming new plants. The edges of the leaves of *Bryophyllum calycinum* (see vol. iv. p. 98, fig. 67) and of *Cardamine pratensis*, and the axils of the leaves of *Lilium bulbiferum* (iv. 99, fig. 71), produce buds of this character. It is a matter of familiar observation that the ends of the shoots of brambles take root when bent down to the ground. In rare instances buds form on the roots, and may be used for purposes of propagation, as in the Japan quince. Of the tendency in buds to assume an independent existence gardeners avail themselves in the operations of striking "cuttings," and making layers and "pipings," as also in budding and grafting. In taking a slip or cutting the gardener removes from the parent plant one or more buds or "eyes," in the case of the vine one only, attached or not to a short shoot, and places them in a moist and sufficiently warm situation, where, as previously mentioned, undue evaporation from the surface of the leaf or leaves is prevented. For some cuttings pots filled with light soil, with the protection of the propagating house and of bell-glasses, are requisite; but for many, such as willows, no such precautions are necessary, and the thrusting of the end of a shoot into moist ground suffices to ensure its growth. In the case of the more delicate plants, the formation of roots is preceded by the production from the cambium of the cuttings of a succulent mass of tissue, the *callus*. It is important in some cases to retain on the cutting some of its leaves, so as to supply the requisite food for storage in the callus. In other cases, where the buds themselves contain a sufficiency of nutritive matter for the young growths, the retention of leaves is not necessary. In the tissues of willow-stakes just referred to there exists an abundance of material available for the supply of the young roots. The most successful mode of forming roots is to place the cuttings in a mild bottom-heat, which expedites their growth, even in the case of many hardy plants whose cuttings strike roots in the open soil. With some hard-wooded trees, as the common white-thorn, roots cannot be obtained without bottom-heat. It is a general rule throughout plant culture that the activity of the roots shall be in advance of that of the leaves. Cuttings of deciduous trees and shrubs succeed best if planted early in autumn while the soil still retains the solar heat absorbed during summer. For evergreens April or May and August or September, and for greenhouse and stove-plants the spring and summer months, are the times most suitable for propagation by cuttings. The great object to be attained is to secure the formation of active roots before the approach of winter.

Layering consists simply in bending down a branch and keeping it in contact with or buried to a small depth in the soil until roots are formed; the connexion with the parent plant may then be severed. Many plants can be far more easily propagated thus than by cuttings.

Grafting or "*working*" consists in the transfer of a branch, the "graft" or "scion," from one plant to another, which latter is termed the "stock." The operation must be so performed that the growing tissues, or cambium-layer of the scion, may fit accurately to the corresponding layer of the stock. In *budding*, as with roses and peaches, a single bud only is implanted. *Inarching* is essentially the promotion of the union of one shoot to another of a different plant. The outer bark of each being removed, the two shoots are kept in contact by ligature until union is established, when the scion is completely severed from its original attachments. This operation is varied in detail according to the kind of plant to be propagated, but it is essential in all cases that the affinity between the two plants be near, that the union be neatly effected, and that the ratio as well as the season of growth of stock and scion be similar.

The selection of suitable stocks is a matter still requiring much scientific experiment. The object of grafting is to expedite and increase the formation of flowers and fruit. Strong-growing pears, for instance, are grafted on the quince stock in order to restrict their tendency to form "gross" shoots, and a superabundance of wood in place of flowers and fruit. Apples, for the same reason, are "worked" on the "paradise" or "doucin" stocks, which from their influence on the scion are known as dwarfing stocks. Scions from a tree which is weakly, or liable to injury by frosts, are strengthened by engrafting on robust stocks. Lindley has pointed out that, while in Persia, its native country, the peach is probably best grafted on the peach, or on its wild type the almond, in England, the summer temperature of whose soil is much lower than that of Persia, it might be expected, as experience has proved, to be most successful on stocks of the native plum.

The soil on which the stock grows is a point demanding attention. From a careful series of experiments made in the Horticultural Society's Garden at Chiswick, it was found that where the soil is loamy, or light and slightly enriched with decayed vegetable matter, the apple succeeds best on the doucin stock, and the pear on the quince; and where it is chalky it is preferable to graft the apple on the crab, and the pear on the wild pear. For the plum on loamy soils the plum, and on chalky and light soils the almond, are the most desirable stocks, and for the cherry on loamy or light rich soils the wild cherry, and on chalk the "mahaleb" stock.

The form and especially the quality of fruit is more or less affected by the stock upon which it is grown. The Stanwick nectarine, so apt to crack and not to ripen when worked in the ordinary way, is said to be cured of these propensities by being first budded close to the ground, on a very strong-growing Magnum Bonum plum, worked on a Brussels stock, and by then budding the nectarine on the Magnum Bonum about a foot from the ground. The fruit of the pear is of a higher colour and smaller on the quince stock than on the wild pear; still more so on the medlar. On the mountain ash the pear becomes earlier.

The effects produced by stock on scion, and more particularly by scion on stock, are as a rule with difficulty appreciable. Nevertheless, in exceptional cases modified growths, termed "graft-hybrids," have been obtained which have been attributed to the commingling of the characteristics of stock and scion. Of these the most remarkable example is *Cytisus Adami*, a tree which year after year produces some shoots, foliage, and flowers like those of the common laburnum, others like those of the very different looking dwarf shrub *C. purpureus*, and others again intermediate between these. We may hence infer that *C. purpureus* was grafted or budded on the common laburnum, and that the intermediate forms are the result of graft-hybridization. Numerous similar facts have been recorded. Among gardeners the general opinion is against the possibility of graft-hybridization. The wonder, however, seems to be that it does not occur more frequently, seeing that fluids must pass from stock to scion, and matter elaborated in the leaves of the scion must certainly to some extent enter the stock. It is clear, nevertheless, from examination that as a rule the wood of the stock and the wood of the scion retain their external characters year by year without change. Still, as in the laburnum just mentioned, in the variegated jasmine and in *Abutilon Darwinii*, in the copper beech and in the horse-chestnut, the influence of a variegated scion has occasionally shown itself in the production from the stock of variegated shoots. At a meeting of the Scottish Horticultural Association (see *Gard. Chron.*, Jan. 10, 1880, fig. 12-14) specimens of a small roundish pear, the "Aston Town," and of the elongated kind known as "Beurré Clairgeau," were exhibited. Two more dissimilar pears hardly exist. The result of working the Beurré Clairgeau upon the Aston Town was the production of fruits precisely intermediate in size, form, colour, speckling of rind, and other characteristics. Similar, though less marked, intermediate characters were obvious in the foliage and flowers.

Double grafting (French, *greffe sur greffe*) is sufficiently explained by its name. By means of it a variety may often be propagated, or its fruit improved in a way not found practicable under ordinary circumstances. For its successful prosecution prolonged experiments in different localities and in gardens devoted to the purpose are requisite.

Planting.—By removal from one place to another the growth of every plant receives a check. How this check can be obviated or reduced, with regard to the season, the state of atmosphere, and the condition and circumstances of the plant generally, is a matter to be considered by the practical gardener.

As to season, it is now admitted with respect to deciduous trees and shrubs that the earlier in autumn planting is performed the better; although some extend it from the period when the leaves fall to the first part of spring, before the sap begins to move. If feasible, the operation should be completed by the end of November, whilst the soil is still warm with the heat absorbed during summer. Attention to this rule is specially important in the case of rare and delicate plants. Early autumn planting enables wounded parts of roots to be healed over, and to form fibrils, which will be ready in spring, when it is most required, to collect food for the plant. Planting late in spring should, as far as possible, be avoided, for the buds then begin to awaken into active life, and the draught upon the roots becomes great. It has been supposed that because the surface of the young leaves is small transpiration is correspondingly feeble; but it must be remembered, not only that their newly-formed tissue is unable without an abundant supply of sap from the roots to resist the excessive drying action of the atmosphere, but that, in spring, the lowness of the temperature at that season in Great Britain prevents the free circulation of the sap. The comparative dryness of the atmosphere in spring also causes a greater amount of transpiration then than in autumn and winter. Another fact in favour of autumnal planting is the production of roots in winter.

The best way of performing transplantation depends greatly on the size of the trees, the soil in which they grow, and the mechanical appliances made use of in lifting and transporting them. The smaller the tree the more successfully can it be removed. The more argillaceous and the less siliceous the soil the more readily can balls of earth be retained about the roots. All planters lay great stress on the preservation of the fibrils; all indeed admit them to be indispensable for the absorption of nutriment. The point principally disputed is to what extent they can with safety be allowed to be cut off in transplantation. Trees and shrubs in thick plantations, or in sheltered warm places, are ill fitted for planting in bleak and cold situations. During their removal it is important that the roots be covered, if only to prevent desiccation by the air. Damp days are therefore the best for the operation; the dryest months are the most unfavourable. Though success in transplanting depends much on the humidity of the atmosphere, the most important requisite is warmth in the soil; humidity can be supplied artificially, but heat cannot.

Pruning, or the removal of superfluous growths, is practised in order to equalize the development of the different parts of trees, or to promote it in particular directions so as to secure a certain form, and, by checking undue luxuriance, to promote enhanced fertility. In the rose-bush, for instance, in which, as we have seen, the flower-buds are formed on the new wood of the year, pruning causes the old wood to "break," *i.e.*, to put forth a number of new buds, some of which will produce flowers at their extremities. The manner and the time in which pruning should be accomplished, and its extent, vary with the plant, the objects of the operation, *i.e.*, whether for the production of timber or fruit, the season, and various other circumstances. So much judgment and experience does the operation call for that it is a truism to say that bad pruning is worse than none. The removal of weakly, sickly, overcrowded, and gross infertile shoots is usually, however, a matter about which there can be few mistakes when once the habit of growth and the form and arrangement of the buds are known. Winter pruning is effected when the tree is comparatively at rest, and is therefore less liable to "bleeding" or outpouring of sap. Summer pruning or pinching off the tips of such of the younger shoots as are not required for the extension of the tree, when not carried to too great an extent, is preferable to the coarser more reckless style of pruning. The injury inflicted is less and not so concentrated; the wounds are smaller, and have time to heal before winter sets in. The effects of badly-executed pruning, or rather hacking, are most noticeable in the case of forest trees, the mutilation of which often results in rotting, canker, and other diseases. Judicious and timely thinning so as to allow the trees room to grow, and to give them sufficiency of light and air, will generally obviate the need of the pruning-saw, except to a relatively small extent.

Training is a procedure adopted when it is required to grow plants in a limited area, or in a particular shape, as in the case of many plants of trailing habit. Judicious training also may be of importance as encouraging the formation of flowers and fruit. Growth in length is mainly in a vertical direction, or at least at the ends of the shoots; and this should be encouraged, in the case of a timber tree, or of a climbing plant which it is desired should cover a wall quickly; but where flowers or fruit are specially desired, then, when the wood required is formed, the lateral shoots may often be trained more or less downward to induce fertility. The refinements of training, as of pruning, may, however, be carried too far; and not unfrequently the symmetrically trained trees of the French excite admiration in every respect save fertility.

Sports or Bud Variations.—Here we may conveniently mention certain variations from the normal condition in the size, form, or disposition of buds or shoots on a given plant. An inferior variety of pear, for instance, may suddenly produce a shoot bearing fruit of superior quality; a beech tree, without obvious cause, a shoot with finely divided foliage; or a camellia an unwontedly fine flower. When removed from the plant and treated as cuttings or grafts, such sports may be perpetuated. Many garden varieties of flowers and fruits have thus originated. The cause of their production is very obscure. In certain instances where plants have been "crossed" or hybridized, perhaps for generations, the phenomenon may be explained on the supposition of a dissociation of previously mixed elements, or of a reversion to some ancestral conditions.

Formation of Flowers.—Flowers, whether for their own sake or as the necessary precursors of the fruit and seed, are objects of the greatest concern to the gardener. As a rule they are not formed until the plant has arrived at a certain degree of vigour, or until a sufficient supply of nourishment has been stored in the tissues of the plant. The reproductive process of which the formation of the flower is the first stage being an exhaustive one, it is necessary that the plant, as gardeners say, should get "established" before it flowers. Moreover, although the green portions of the flower do indeed perform the same office as the leaves, the more highly coloured and more specialized portions, which are further removed from the typical leaf-form, do not carry on those processes for which the presence of chlorophyll is essential; and the floral organs may, therefore, in a rough sense, be said to be parasitic upon the green parts. A check or arrest of growth in the vegetative organs seems to be a necessary preliminary to the development of the flower. The flower itself is always the modified extremity of a shoot or stalk, which only exceptionally lengthens beyond the flower, as, for example, in "proliferous" roses. See BOTANY, vol. iv. p. 119, fig. 145.

A diminished supply of water at the root is requisite, so as to check energy of growth, or rather to divert it from leaf-making. Partial starvation will sometimes effect this; hence the grafting of free-growing fruit trees upon dwarfing stocks, as before alluded to, and also the "ringing" or girdling of fruit trees, *i.e.*, the removal from the branch of a ring of bark, or the application of a tight cincture, in consequence of which the growth of the fruits above the wound or the obstruction is enhanced. On the same principle the use of small pots to confine the roots, root-pruning and lifting the roots, and exposing them to the sun, as is done in the case of the vine in some countries, are resorted to. A higher temperature, especially with deficiency of moisture, will tend to throw a plant into a flowering condition. This is exemplified by the fact that the temperature of the climate of Great Britain is too low for the flowering, though sufficiently high for the growth of many plants. Thus the Jerusalem artichoke, though able to produce stems and tubers abundantly, only flowers in exceptionally hot seasons.

Forcing.—The operation of forcing is based upon the facts just mentioned. By subjecting a plant to a gradually increasing temperature, and supplying water in proportion, its growth may be accelerated; its season of development may be, as it were, anticipated; it is roused from a dormant to an active state. Forcing therefore demands the most careful adjustment of temperature and supplies of moisture and light.

Deficiency of light is less injurious than might at first be expected, because the plant to be forced has stored up in its tissues, and available for use, a reserve stock of material formed through the agency of light in former seasons. The intensity of the colour of flowers and the richness of flavour of fruit are, however, deficient where there is feebleness of light. Recent experiments of Dr Siemens have shown that the gardener may avail himself of the electric light, which is proved to exercise on chlorophyll the same kind of influence as do the solar rays, and that he may thus supply the deficiencies of natural illumination. The employment of that light for forcing purposes would seem to be at present a question of expense. The great advantage hitherto obtained from its use has consisted in the rapidity with which flowers have been formed and fruits ripened under its influence, circumstances which go towards compensating for the extra cost of production.

Double Flowers.—The taste of the day demands that "double flowers" should be largely grown. Though in some instances, as in hyacinths, they are decidedly less beautiful than single ones, they always present the advantage of being less evanescent. Under the vague term "double" many very different morphological changes are included. The flower of a double dahlia, *e.g.*, offers a totally different condition of structure from that of a rose or a hyacinth. The double poinsettia, again, owes its so-called double condition merely to the increased number of its scarlet involucral leaves, which are not parts of the flower at all. It is reasonable, therefore, to infer that the causes leading to the production of double flowers are varied. A good deal of difference of opinion exists as to whether they are the result of arrested growth or of exuberant development, and accordingly whether restricted food or abundant supplies of nourishment are the more necessary for their production. It must suffice here to say that double flowers are most commonly the result of the substitution of brightly-coloured petals for stamens or pistils or both, and that a perfectly double flower where all the stamens and pistils are thus metamorphosed is necessarily barren. Such a plant must needs be propagated by cuttings. It rarely happens, however, that the change is quite complete throughout the flower, and so a few seeds may be formed, some of which may be expected to reproduce the double-blossomed plants. By continuous selection of seed from the best varieties, and "roguing" or eliminating plants of the ordinary type, a "strain" or race of double flowers is gradually produced.

Formation of Seed—Fertilization.—In fertilization—the influence in flowering plants of the sperm-cell, or its contents upon the germ-cell (see BOTANY, vol. iv. 147, and BIOLOGY, vol. iii. 695)—there are many circumstances of importance horticulturally, to which therefore brief reference must be made. Flowers, generally speaking, are either self-fertilized, cross-fertilized, or hybridized. Self-fertilization occurs when the pollen of a given flower affects the germ-cell of the same individual flower. Such a flower is hermaphrodite functionally as well as structurally. In self-fertilizing flowers the structure is such that the pollen inevitably comes in contact with the stigma; but fertilization is also dependent on the simultaneous maturity of pollen and stigma. Cross-fertilization varies both in manner and degree. In the simplest instances the pollen of one flower fertilizes the ovules of another on the same plant, owing to the stamens arriving at maturity in any one flower earlier or later than the pistils. Such flowers though structurally hermaphrodite are, at any given time, functionally unisexual. In many plants a polymorphic condition occurs: thus, in the same species of primrose some flowers have the stamens short, and within the tube of the corolla, with the style projecting beyond the mouth, giving the appearance termed "pin-eyed," while others, known as "thrum-eyed," present exactly reverse conditions of stamens and style. In the common loose-strife, *Lythrum Salicaria*, the stamens are of three lengths, and the styles differ correspondingly. In such di- or tri-morphic flowers, as Mr Darwin's experiments have shown, the most complete fertility occurs when a cross is effected between a flower having short stamens and one with short styles. It is asserted that, not only is such a union more fertile than when pollen from a short stamen is placed on a long style, or *vice versa*, but the seedling plants are as a rule more vigorous.

Cross-fertilization must of necessity occur when the flowers are structurally unisexual, as in the hazel, in which the male and female flowers are monoecious, or separate on the same plant, and in the willow, in which they are diœcious, or on different plants. A conspicuous example of a diœcious plant is the common aucuba, of which for years only the female plant was known in Britain. When, through the introduction of the male plant from Japan, its fertilization was rendered possible, ripe berries, before unknown, became common ornaments of the shrub.

The conveyance of pollen from one flower to another in cross-fertilization is effected naturally by the wind, or by the agency of insects and other creatures. Flowers that require the aid of insects usually offer some attraction to their visitors in the shape of bright colour, fragrance, or sweet juices. The colour and markings of a flower often serve to guide the insects to the honey, in the obtaining of which they are compelled either to remove or to deposit pollen. The reciprocal adaptations of insects and flowers demand attentive observation on the part of the gardener concerned with the growing of grapes, cucumbers, melons, and strawberries, or with the raising of new and improved varieties of plants. Scarcely less remarkable, though not so important in the present connexion, are the means by which the visits of such insects as are useless for the purpose of fertilization, or even injurious to the plant, as preying without advantage to it on its secretions, are prevented or rendered ineffective. In wind-fertilized plants the flowers are comparatively inconspicuous and devoid of much attractions for insects; and their pollen-cells are smoother and smaller, and better adapted for transport by the wind, than those of insect-fertilized plants, the roughness of which adapt them for attachment to the bodies of insects.

Although the general facts with respect to fertilization are as above stated, it must be remembered that probably self-fertilization is not constant in any plant under all circumstances, and that it certainly does sometimes take place in flowers which are usually cross-fertilized. It may be that, while continued self-fertilization ensures the perpetuation of certain qualities, cross-fertilization induces beneficial variation. Some botanists doubt the injurious effects attributed to self-fertilization, and, so long as a plant is healthy, it can be attended with but little disadvantage; but after a time in any case a cross is probably useful, and sometimes fertility is found to be much greater, and, in rare instances, only possible, when impregnation is effected by pollen not produced by a flower's own stamens.

It is very probable that the same flower at certain times and seasons is self-fertilizing, and at others not so. The defects which cause gardeners to speak of certain vines as "shy setters," and of certain strawberries as "blind," may be due either to unsuitable conditions of external temperature, or to the non-accomplishment, from some cause or other, of cross-fertilization. In a vinery or a peach-house it is often good practice at the time of flowering to tap the branches smartly with a stick so as to ensure the dispersal of the pollen. Sometimes more delicate and direct manipulation is required, and the gardener has himself to convey the pollen from one flower to another, for which purpose a small camel's-hair pencil is generally suitable. The degree of fertility varies greatly according to external conditions, the structural and functional arrangements just alluded to, and other causes which may roughly be called constitutional. Thus, it often happens that an apparently very slight change in climate alters the degree of fertility. Certain plants which seem almost sterile with their own pollen become fertile if grafted on some others. In a particular country or at certain seasons one flower will be self-sterile or nearly so, and another just the opposite. The influence of conditions on the formation of "races," and the consequent importance to the horticulturist seeking to obtain new and improved strains of crossing-plants grown in different localities, have been specially insisted on by Darwin. The advantages of this practice are analogous to those accruing from what gardeners call "change of seed," *i.e.*, the sowing of seed or the planting of tubers, say of potatoes, in localities and on soils other than those in which they themselves were produced.

Hybridization.—Some of the most interesting results and many of the gardener's greatest triumphs have been obtained by hybridization, *i.e.*, the crossing two individuals, not of the same but of two distinct species of plants, as, for instance, two species of rhododendron or two species of orchid. It is obvious that hybridization differs more in degree than in kind from cross-fertilization. The occurrence of hybrids in nature explains the difficulty experienced by botanists in deciding on what is a species, and the widely different limitations of the term adopted by different observers in the case of willows, roses, brambles, &c. The artificial process is practically the same in hybridization as in cross-fertilization, but usually requires more care. To prevent self-fertilization, or the access of insects, it is advisable to remove the stamens and even the corolla from the flower to be impregnated, as its own pollen or that of a flower of the same species is often found to be "prepotent." There are, however, cases, *e.g.*, some passion-flowers and rhododendrons, in which a flower is more or less sterile with its own, but fertile with foreign pollen, even when this is from a distinct species. It is a singular circumstance that reciprocal crosses are not always or even often possible; thus, one rhododendron may afford pollen perfectly potent on the stigma of another kind, by the pollen of which latter its own stigma is unaffected. With respect to the relations of the hybrid offspring, which partakes sometimes more of the characteristics of the male or pollen parent, sometimes more of those of the female or seed-parent, the opinions of practical experimenters are so diverse that at present no general rule can be established. A valuable essay on the subject is the presidential address read by Mr Anderson-Henry at the annual meeting of the Botanical Society of Edinburgh in 1867. A general *résumé* of the facts will be found in Darwin's *Origin of Species*, his *Variations of Animals and Plants under Domestication*, and his works on the fertilization of flowers. See also HYBRIDISM.

The object of the hybridizer is to obtain varieties exhibiting improvements in hardihood, vigour, size, shape, colour, fruitfulness, or other attributes. His success depends not alone on skill and judgment, for some seasons, or days even, are found more propitious than others. Although promiscuous and hap-hazard procedures no doubt meet with a measure of success, the best results are those which are attained by systematic work with a definite aim. To secure early and free-flowering varieties, Mr Henry advises "violent" crosses, *i.e.*, crosses between varieties or species as distantly related as is practicable. Careful experiments are still greatly needed for the elucidation of the mysteries and the development of the resources of hybridization. It is difficult to understand why some very closely-related species, *e.g.*, the apple and pear, the currant and gooseberry, refuse to intercross, while much more remote species, or even members of different genera, can be made to do so, as in the case of the hybrid *Philageria* (see *Gardeners' Chronicle*, 1872, p. 358), which is the result of a cross between the climbing plant *Lapageria rosea* and the dwarf bush *Philesia buxifolia*.

Hybrids are usually less fertile than pure-bred species, and are occasionally quite sterile. Some hybrids, however, are as fertile as pure-bred plants. Hybrid plants may be again crossed, or even re-hybridized, so as to produce a progeny of very mixed parentage. This is the case with many of our roses, dahlias, begonias, pelargoniums, and other long or widely cultivated garden plants.

Reversion.—In modified forms of plants there is frequently a tendency to "sport" or revert to parental or ancestral characteristics. So markedly is this the case with hybrids that in a few generations all traces of a hybrid origin may disappear. The dissociation of the hybrid element in a plant must be obviated by careful selection.

Germination.—The length of the period during which seeds remain dormant after their formation is very variable. The conditions for germination are much the same as for growth in general. Access to light is not required, because the seed contains a sufficiency of stored-up food. The temperature necessary varies according to the nature and source of the seed. Some seeds require prolonged immersion in water to soften their shells; others are of so delicate a texture that they would dry up and perish if not kept constantly in a moist atmosphere. Seeds buried too deeply receive a deficient supply of air. As a rule, seeds require to be sown more deeply in proportion to their size and the lightness of the soil.

The time required for germination in the most favourable circumstances varies very greatly, even in the same species, and in seeds taken from one pod. Thus the seeds of *Primula japonica*, though sown under precisely similar conditions, yet come up at very irregular intervals of time. Germination is often slower where there is a store of available food in the perisperm or albumen, or in the embryo itself, than where this is scanty or wanting. In the latter case the seedling has early to shift for itself, and to form roots and leaves for the supply of its needs.

Selection.—Supposing seedlings to have been developed, it is found that a large number of them present considerable variations, some being especially robust, others peculiar in size or form. Those most suitable for the purpose of the gardener are carefully selected for propagation, while others not so desirable are destroyed; and thus after a few generations a fixed variety, race, or strain superior to the original form is obtained. Many garden plants have originated solely by selection; and it is certain that, quite independently of cross-breeding, much could still be done to improve our breeds of vegetables, flowers, and fruit by more systematic selection. The remarkable results obtained in the case of Major Hallett's pedigree wheat and Mr Bennett's hybrid tea-roses are instances in point. Two robust-growing varieties of potato, the "Magnum Bonum" and the "Champion," have been found to resist better than others the attacks of fungus to which the plant is liable. Whatever may be the cause, whether the possession by the tuber of a more than ordinarily thick skin, or other peculiarity, it is obvious that selection with a view to the development of this quality might be productive of the most important results. Darwin recommends, as a means of improving health and fertility by intercrossing without loss of purity of race, to sow in alternate rows seeds grown under as different conditions as possible.

Large and well-formed seeds are to be preferred for harvesting. The seeds should be kept in sacks or bags in a dry place, and if from plants which are rare, or liable to lose their vitality, they are advantageously packed for transmission to a distance in bottles or jars filled with earth or sphagnum moss, without the addition of moisture. Cuttings and entire plants may be transported in wide-mouthed bottles.

It will have been gathered from what has been said that seeds cannot always be depended on to reproduce exactly the characteristics of the plant which yielded them; for instance, seeds of the greengage plum or of the Ribston pippin will produce a plum or an apple, but not these particular varieties, to perpetuate which grafts or buds must be employed. (M. T. M.)

Part II.—The Practice of Horticulture.

The details of horticultural practice naturally range under the three heads of flowers, fruits, and vegetables. There are, however, certain general aspects of the subject which will be more conveniently noticed apart, since they apply alike to each department. We shall therefore first treat of these under four headings:—formation and preparation of the garden, garden structures and edifices, garden materials and appliances, and garden operations.

I. *Formation and Preparation of the Garden.*

1. *Site.*—The site chosen for the mansion will more or less determine that of the garden, the pleasure grounds and flower garden being placed so as to surround or lie contiguous to it, while the fruit and vegetable gardens, either together or separate, should be placed on one side or in the rear, according to fitness as regards the nature of the soil and subsoil, the slope of the surface, or the general features of the park scenery. In the case of villa gardens there is usually little choice: the land to be occupied is cut up into plots, usually rectangular, and of greater or less breadth, and in laying out these plots there is generally a smaller space left in the front of the villa residence and a larger one behind, the front plot being usually devoted to approaches, shrubbery, and plantations, flower beds being added if space permits, while the back or more private plot has a piece of lawn grass with flower beds next the house, and a space for vegetables and fruit trees at the far end, this latter being shut off from the lawn by an intervening screen of evergreens. Between these two classes of gardens there are many gradations, but our remarks will chiefly apply to those of larger extent. Site.

The almost universal practice is to have the fruit and vegetable gardens combined; and the flower garden may sometimes be conveniently placed in juxtaposition with them. When the fruit and vegetable gardens are combined, the smaller and choicer fruit trees only should be admitted, such larger-growing hardy fruits as apples, pears, plums, cherries, &c., being relegated to the orchard.

Ground possessing a gentle inclination toward the south is desirable for a garden. On such a slope effectual draining is easily accomplished, and the greatest possible benefit is derived from the sun's rays. It is well also to have an open exposure towards the east and west, so that the garden may enjoy the full benefit of the morning and evening sun, especially the latter; but shelter is desirable on the north and north-east, or in any direction in which the particular locality may happen to be exposed.

2. *Soil and Subsoil.*—A hazel-coloured loam, moderately light in texture, is well-adapted for most garden crops, whether of fruits or culinary vegetables, especially a good warm deep loam resting upon chalk; and if such a soil occurs naturally in the selected site, but little will be required in the way of preparation. If the soil is not moderately good and of fair depth, the situation is not an eligible one for gardening purposes. Wherever the soil is not quite suitable, but is capable of being made so, it is best to remedy the defect at the outset; and as it will be found easier to render a light soil sufficiently retentive than to make a tenacious clay sufficiently porous, a light soil is to be preferred to one which is excessively stiff and heavy. It is advantageous to possess a variety of soils; and if the garden be on a slope, it will often be practicable to render the upper part light and dry, while the lower remains of a heavier and damper nature. Soil.

Natural soils consist of substances derived from the decomposition of various kinds of rocks, the bulk consisting of clay, silica, and lime, in various proportions. As regards preparation, draining is of course of the utmost importance.

The ground should also be trenched to the depth of 3 feet at least, but the deeper the better, provided the good soil be not buried under a mass of inferior quality. In this operation all stones larger than a man's fist must be taken out, and all roots of trees and of perennial weeds carefully cleared away. When the whole ground has been thus treated, a moderate liming will, in general, be useful. After this, supposing the work to have occupied most of the summer, the whole may be laid up in ridges, to expose as great a surface as possible to the action of the winter's frost.

Argillaceous or clay soils are those which contain a large percentage (45–50) of clay, and a small percentage (5 or less) of lime. These are unfitted for garden purposes until improved by draining, liming, trenching, and the addition of porous materials, such as ashes, burnt ballast, or sand, but when thoroughly improved they are very fertile and less liable to become exhausted than most other soils. Loamy soils contain a considerable quantity (30–45 per cent.) of clay, and smaller quantities (5 or less) of lime and humus. Such soils properly drained and prepared are very suitable for orchards, and when the proportion of clay is smaller (20–30 per cent.) they form excellent garden soils, in which the better sort of fruit trees luxuriate. Marly soils are those which contain a considerable percentage (10–20) of lime, and are called clay marls, loamy marls, and sandy marls, according as these several ingredients preponderate. The clay marls are, like clay soils, too stiff for garden purposes until ameliorated; but loamy marls are fertile and well suited to fruit trees, and sandy marls are adapted for producing early crops. Calcareous soils, which may also be heavy, intermediate, or light, are those which contain more than 20 per cent. of lime, their fertility depending on the proportions of clay and sand which enter into their composition; they are generally cold and wet. Vegetable soils or moulds, or humus soils, contain a considerable percentage (more than 5) of humus, and embrace both the rich productive garden moulds and those known as peaty soils.

Subsoil. The nature of the subsoil is of scarcely less importance than that of the surface soil. If an unsuitable subsoil has to be dealt with, it must be removed or ameliorated. An uneven subsoil, especially if retentive, is most undesirable, as water is apt to collect in the hollows, and thus affect the upper soil. The remedy is to make the plane of its surface agree with that of the ground. When there is a hard pan this should be broken up, and if of bad quality the material should be removed altogether. When there is an injurious preponderance of metallic oxides or other deleterious substances, the roots of trees would be affected by them, and they must therefore be removed. When the subsoil is too compact to be pervious to water, effectual drainage must be resorted to; when it is very loose, so that it drains away the fertile ingredients of the soil as well as those which are artificially supplied, the compactness of the stratum must be increased. The best of all subsoils is a dry bed of clay overlying sandstone.

Size. 3. *Size and Form.*—The general size of a garden adjoining a mansion is from 4 to 6 acres; but in many places the extent varies from 12 to 20 or even 30 acres. A garden of 2 to 3 acres, enclosed by walls and surrounded by slips, will, however, suffice for the supply of a moderate establishment.

Plan. In laying out the garden, the plan should be prepared in minute detail before commencing operations. The form of the kitchen and fruit garden should be square or oblong, rather than curvilinear, since the working and cropping of the ground can thus be more easily carried out. The whole should be compactly arranged, so as to facilitate working, and to afford convenient access for the carting of the heavy materials. This access is especially desirable as regards the store-yards and framing ground, where fermenting manures and tree leaves for making up hot beds, coals or wood for fuel, and ingredients for composts, together with flower pots and the many necessaries of garden culture, have to be accommodated. In the case of villas or picturesque residences, gardens of irregular form may be permitted; when adapted to the conditions of the locality, they associate better with surrounding objects, but in such gardens wall space is usually limited.

The distribution of the garden area in walks, borders, and compartments must be partly regulated by the outline of the ground. In general, a gravel walk, 6 or 8 feet broad, is led quite round the garden, both within and without the walls. A walk of similar dimensions is often constructed in the centre of the garden in the direction of the glazed houses, and this is sometimes crossed by another at right angles, which is far preferable to having the walks led diagonally from the corners, since this throws the enclosed plots out of the square. The space between the wall and the walk that skirts it is called the wall-border, and is commonly from 15 to 20 feet broad. On the interior of the walk there is usually another border 5 or 6 feet broad, which is generally occupied by fruit trees, trained either as espaliers, as dwarfs, or as pyramids. The middle part of the garden is divided into rectangular compartments for raising the various culinary crops. It is advantageous to have several small beds, in which to cultivate the less bulky subjects, such as basil, sage, tarragon, &c., which, in large spaces, are apt to be overlooked or neglected.

A considerable portion of the north wall is usually covered in front with the glazed structures called forcing-houses, and to these the houses for ornamental plants are sometimes attached; but a more appropriate site for the latter is the flower garden, when that forms a separate department. It is well, however, that everything connected with the forcing of fruits or flowers should be concentrated in one place. The frame ground, including melon and pine pits, should occupy some well-sheltered spot in the slips, or on one side of the garden, and adjoining to this may be found a suitable site for the compost ground, in which the various kinds of soils are kept in store, and in which also composts may be prepared.

As the walls afford valuable space for the growth of the choicer kinds of hardy fruits, the direction in which they are built is of considerable importance. In the warmer parts of the country the wall on the north side of the garden should be so placed as to face the sun at about an hour before noon, or a little to the east of south; in less favoured localities it should be made to face direct south, and in still more unfavourable districts it should face the sun an hour after noon, or a little west of south. The east and west walls should run parallel to each other, and at right angles to that on the north side, in all the most favoured localities; but in colder or later ones, though parallel, they should be so far removed from a right angle as to get the sun by eleven o'clock. On the whole, the form of a parallelogram with its longest sides in the proportion of about five to three of the shorter, and running east and west, may be considered the best form, since it affords a greater extent of south wall than any other. Mr Thompson, in the *Gardener's Assistant*, gives a figure which is nearly in this proportion (fig. 1), representing a small garden 272¼ feet by 160, and therefore containing exactly an acre. This figure admits of nearly double the number of trees on the south aspect as compared with the east and west; it allows a greater number of espalier or pyramid trees to face the south; and it admits of being divided into equal principal compartments, each of which forms nearly a square. The size of course can be increased to any requisite extent. That of the royal gardens at Frogmore,

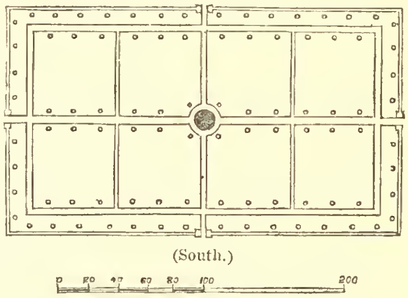

Fig. 1.—Plan of Garden an acre in area.

760 feet from east to west, and 440 feet from north to south, is nearly of the same proportions.

Slips. The spaces between the walls and the outer fence are called slips. A considerable extent is sometimes thus enclosed, and utilized for the growth of such vegetables as potatoes, winter greens, and sea-kale, for the small bush fruits, and for strawberries. The slips are also convenient as affording a variety of aspects, and thus helping to prolong the season of particular vegetable crops.

Shelter. 4. *Shelter.*—A screen of some kind to temper the fury of the blast is absolutely necessary. If the situation is not naturally well sheltered, the defect may be remedied by masses of forest trees disposed at a considerable distance so as not to shade the walls or fruit trees. They should not be nearer than say 50 yards, and may vary from that to 100 or 150 yards distance according to circumstances, regard being had especially to peculiarities occasioned by the configuration of the country, as for instance to aerial currents from adjacent eminences. Care should be taken, however, not to hem in the garden by crowded plantations, shelter from the prevailing strong winds being all that is required, while the more open it is in other directions the better. The trees employed for screens should include both those of deciduous and of evergreen habit, and should suit the peculiarities of local soil and climate. Of deciduous trees the sycamore, wych-elm, horse-chestnut, beech, lime, plane, and poplar may be used,—the *Populus canadensis nova* being one of the most rapid-growing of all trees, and, like other poplars, well-suited for nursing other choicer subjects; while of evergreens, the holm oak, holly, laurel (both common and Portugal), and such conifers as the Scotch, Weymouth, and Austrian pines, with spruce and silver firs and yews, are suitable. The conifers make the most effective screens.

Extensive gardens in exposed situations are often divided into compartments by hedges, so disposed as to break the force of high winds. Where these are required to be narrow as well as lofty, holly, yew, or beech is to be preferred; but, if there is sufficient space, the beautiful laurel and the bay may be employed where they will thrive. Smaller hedges may be formed of evergreen privet, or of tree-box. These subordinate divisions furnish, not only shelter, but also shade, which, at certain seasons, is peculiarly valuable.

Belts of shrubbery may be placed round the slips outside the walls; and these may in many cases, or in certain parts, be of sufficient breadth to furnish pleasant retired promenades, at the same time that they serve to mask the formality of the walled gardens, and are made to harmonize with the picturesque scenery of the pleasure ground.

Water Supply. 5. *Water Supply.*—Although water is one of the most important elements in vegetable life, we do not find one garden in twenty where even ordinary precautions have been taken to secure a competent supply. Rain-water is the best, next to that river or pond water, and last of all that from springs; but a chemical analysis should be made of the last before introducing it, as some spring waters contain mineral ingredients injurious to vegetation. Iron pipes are the best conductors; they should lead to a capacious open reservoir placed outside the garden, and at the highest convenient level, in order to secure sufficient pressure for effective distribution, and so that the wall trees also may be effectually washed. Stand pipes should be placed at intervals beside the walks and in other convenient places from which water may at all times be drawn; and short flexible tubes should be made to fit on to them, to which a garden hose can be attached, so as to permit of the whole garden being readily and when necessary profusely watered. The mains should be placed under the walks for safety, and also that they may be easily reached when repairs are required. Pipes should also be laid having a connexion with all the various greenhouses and forcing-houses, each of which should be provided with a cistern for aerating the daily supplies. In fact, every part of the garden, including the working sheds and offices, should have water supplied without stint. At the same time it is not expedient to admit of large basins or ponds, and far less of a running stream in a garden.

Entrance. 6. *Approach and Fence.*—The entrance to the garden from without is a matter requiring the exercise of some taste and of sound judgment. If possible, it should be from the south and front, so that the pleasing effect of the range of glazed houses may be realized by the visitor on entering. Sometimes a lateral entrance, leading from the flower-garden through an intermediate shrubbery, and coming upon the hot-houses in flank, may be necessary. The worst of all entrances is from the back or north, everything being then viewed in reverse.

Enclosure. All gardens of large extent should be encircled by an outer boundary, which is often formed by a sunk wall or ha-ha surrounded by an invisible wire fence to exclude ground game, or consists of a hedge with low wire fence on its inner side. Occasionally this sunk wall is placed on the exterior of the screen plantations, and walks lead through the trees, so that views are obtained of the adjacent country. Although the interior garden receives its form from the walls, the ring fence and plantations may be adapted to the shape and surface of the ground. In smaller country gardens the enclosure or outer fence is often a hedge, and there is possibly no space enclosed by walls, but some divisional wall having a suitable aspect is utilized for the growth of peaches, apricots, &c., and the hedge merely separates the garden from a paddock used for grazing. The still smaller gardens of villas are generally bounded by a wall or wood fence, the inner side of which is appropriated to fruit trees. For the latter, walls are much more convenient and suitable than a boarded fence, but in general these are too low to be of much value as aids to cultivation, and they are best covered with bush fruits or with ornamental plants of limited growth.

Walks. 7. *Walks and Edgings.*—The best material for the construction of garden walks is good binding gravel. The ground should be excavated to the depth of a foot or more,—the bottom being made firm and slightly concave, so that it may slope to the centre, where a drain should be introduced; or the bottom may be made convex and the water allowed to drain away at the sides. The bottom 9 inches should be filled in compactly with hard coarse materials, such as stones, brickbats, clinkers, burned clay, &c., on which should be laid two or three inches of coarse gravel, and then an inch or two of firm binding gravel on the surface. The surface of the walks should be kept well rolled, for nothing contributes more to their elegance and durability.

All the principal lines of walk should be broad enough to allow at least three persons to walk abreast; the others may be narrower, but a multitude of narrow walks has a puny effect. Much of the neatness of walks depends upon the material of which they are made. Gravel from an inland pit is to be preferred; though occasionally very excellent varieties are found upon the sea-coast. The gravels of Kensington and Blackheath have attained considerable celebrity, and have been frequently employed in remote parts of the kingdom, the expense being lessened by their being conveyed to different sea-ports as ballast for ships. Gravel walks must be kept free from weeds, either by hand weeding, by occasionally salting the surface, or by watering with boiling salt water. In some parts of the country the available material does not bind to form a close even surface, and such walks are kept clean by hoeing.

Grass walks were common in English gardens during the prevalence of the Dutch taste, but, owing to the frequent humidity of the climate, they have in a great measure been discarded. Their disuse is perhaps to be regretted, as in some situations, particularly behind lengthened screens of trees, they form very agreeable promenades in dry, hot weather. Grass walks were made in the same way as grass lawns. When the space to be thus occupied had been prepared, a thin layer of sand or poor earth was laid upon the surface, and over this a similar layer of good soil. This arrangement was adopted in order to prevent excessive luxuriance in the grass.

Edgings.—Walks are separated from the adjoining beds and borders in a variety of ways. If a living edging is adopted, by far the best is afforded by the dwarf Dutch box planted closely in line. It is of extremely neat growth, and, when annually clipped, will remain in good order for many years. Very good edgings, but of a less durable character, are formed by thrift (*Statice Armeria*), double daisy (*Bellis perennis*), gentianella (*Gentiana acaulis*), and London pride (*Saxifraga umbrosa*); or by some of the finer grasses very carefully selected, such as the sheep's fescue (*Festuca ovina*) or its glaucous-leaved variety. Indeed, any low-growing herbaceous plant, susceptible of minute division, is suitable for an edging. Edgings may also be formed of narrow slips of sandstone flag, slate, fire-clay tiles, bricks, glass, or cast-iron. An excellent form of edging tile is that invented by Mr Stevens of Trentham Gardens (fig. 2), which is made of a very durable kind of clay, and is remarkably neat in appearance. It is 18 inches long, 5 inches deep, and 5 inches broad, and, resting on the broad base, is held firmly by the gravel used for filling up the walk. One advantage of using edgings of this kind, especially in kitchen gardens, is that they do not harbour slugs and similar vermin, which all live edgings do, and often to a serious extent, if they are left to grow large. In shrubberies and large flower-plots, verges of grass-turf, from 1 to 3 feet in breadth, according to the size of the border and width of the walk, make a very handsome edging, but they should not be allowed to rise more than an inch and a half above the gravel, the grass being kept short by repeated mowings, and the edges kept trim and well-defined by frequently clipping with shears, and cutting once a year with an edging iron.

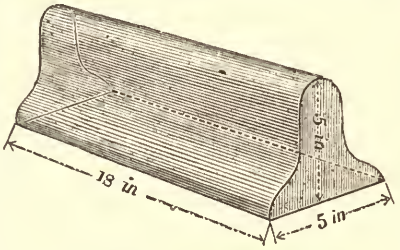

FIG. 2.—Stevens's Edging Tile.

II. *Garden Structures.*

8. *Gardener's Residence.*—The gardener's residence and the apartments for the workmen should be within convenient distance of each other and of the forcing-houses. The gardener's house may stand in the centre of the range of hot-houses, or it may be placed in one corner of the walled garden. In either case it should communicate on the one side with the best part of the garden, and on the other with the yard in which the garden offices are placed.

9. *Walls.*—The position to be given to the garden walls has been already referred to under par. 3. The shelter afforded by a wall, and the increased temperature secured by its presence, are indispensable in the climate of Great Britain, for the production of all the finer kinds of outdoor fruits; and hence, the inner side of a north wall, having a southern aspect, is appropriated to the more tender kinds. It is, indeed, estimated that such positions enjoy an increased temperature equal to 7° of latitude; that is to say, the mean temperature within a few inches of the wall is equal to the mean temperature of the open plain 7° farther south. The eastern and western aspects are set apart for fruits of a somewhat hardier character.

Where the inclination of the ground is considerable, and the presence of high walls would be objectionable, the latter may be replaced by sunk walls. These should not rise more than 3 feet above the level of the ground behind them. As dryness is favourable to an increase of heat, such walls should be either built hollow, or packed behind to the thickness of 3 or 4 feet with rubble stones, flints, brickbats, or similar material, thoroughly drained at bottom. For mere purposes of shelter a height of 6 or 7 feet will generally be sufficient for the walls of a garden, but for the training of fruit trees it is found that an average height of 12 feet is most suitable. In gardens of large size the northern or principal wall may be 14 feet, and the side walls 12 feet in height; while smaller areas of an acre or so should have the principal walls 12 and the side walls 10 feet in height. As brick is more easily built hollow than stone, it is to be preferred for garden walls. A 14-inch hollow wall will take in its construction 12,800 bricks, while a solid 9-inch one, with piers, will take 11,000; but the hollow wall, while thus only a little more costly, will be greatly superior, being drier and warmer, as well as more substantial. Bricks cannot be too well burnt for garden walls; the harder they are the less moisture will they absorb. The darker colour they acquire when the process of burning is prolonged is also more in harmony with the surrounding objects. At one time brick walls were preferred on account of the facility they afforded for training trees, but now cast-iron studs (fig. 3) or sometimes nails are placed in the wall during its erection, being pushed into the joints before the mortar becomes set, and ranged in straight lines, both vertically and horizontally; for peaches, &c., they are placed 9 inches apart, and for pears, &c., 15 inches. The trees are fastened to them by soft ligatures of twine or matting, which should be twisted after being tied to the stud or nail, so as to prevent contact between the branch and the metal. Many excellent walls are built of stone. The best is dark-coloured whinstone, because it absorbs very little moisture, or in Scotland Caithness pavement 4 inches thick. The stones can be cut (in the quarries) to any required length, and built in regular courses. Stone walls should always be built with thin courses for convenience of training over their surface. Concrete walls, properly coped and provided with a trellis, may in some places be cheapest, and they are very durable. Common rubble walls are the wors of all.

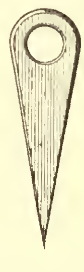

FIG. 3.—Cast-Iron Wall Stud.

The coping of garden walls is important, both for the preservation of the walls and for throwing the rain-water off their surfaces. It should not project less than from 2 to 2½ inches, but in wet districts may be extended to 6 inches. Stone copings are best, but they are costly, and Portland cement is sometimes substituted. Temporary copings of wood, which may be fixed by means of permanent iron brackets just below the stone coping, are extremely useful in spring for the protection of the blossoms of fruit trees. They should be 9 inches or a foot wide, and should be put on during spring before the blossom buds begin to expand; they should have attached to them scrim cloth (a sort of thin canvas), which admits light pretty freely, yet is sufficient to ward off ordinary frosts; this canvas is to be let down towards evening, and drawn up again in the morning. These copings should be removed when they are of no further utility as protectors, so that the foliage may have the full benefit of rain and dew. Any contrivance that serves to interrupt radiation, though it may not keep the temperature much above freezing, will be found sufficient. Standard fruit trees must be left to take their chance; and, indeed from the lateness of their flowering, they are generally more injured by blight, and by drenching rains, which wash away the pollen of the flowers, than by the direct effects of cold.

[H]ot [w]alls. Hot walls, whether constructed to be warmed by flues or hot-water pipes, are nearly or quite obsolete. Their chief use is to assist in ripening the young wood and the crops of the later varieties of tender fruits by the aid of artificial heat, but the expenditure would be more usefully directed to the construction of a glazed house for that purpose.

[E]spalier [ra]ils. *Espalier Rails.*—Subsidiary to walls as a means of training fruit trees, espalier rails were formerly much employed, and are still used in many gardens. In their simplest form, they are merely a row of slender stakes of larch or other wood driven into the ground, and connected by a slight rod or fillet at top. The use of iron rails has now been almost wholly discontinued on account of metallic substances acting as powerful conductors of both heat and cold in equal extremes. Trees trained to espalier rails have some advantages, as they are easily got at for all cultural operations, space is saved, and the fruit, while freely exposed to sun and air, is tolerably secure against wind. They form, moreover, neat enclosures for the vegetable quarters, and, provided excess of growth from the centre is successfully grappled with, they are productive in soils and situations which are suitable.

[Pl]ant [h]ouses. 10. *Plant Houses.*—These include all those structures which are more intimately associated with the growth of ornamental plants and flowers, and comprise conservatory, plant stove, greenhouse, and the subsidiary pits and frames. They should be so erected as to present the smallest extent of opaque surface consistent with stability. With this object in view, the early improvers of hot-house architecture substituted metal for wood in the construction of the roofs, and for the most part dispensed with back walls; but the conducting power of the metal caused a great irregularity of temperature, which it was found difficult to control; and, notwithstanding the elegance of metallic houses, this circumstance, together with their greater cost, and some doubt as to their durability, has induced most recent authorities to give the preference to wood. The combination of the two, however, as in the Crystal Palace at Sydenham, shows clearly that, without much variation of heat or loss of light, any extent of space may be covered, and houses of any altitude constructed.

The earliest notice we have of such structures is given in the Latin writers of the 1st century (Mart., *Epigr.*, viii. 14 and 68); the Ἀδώνιδος κῆποι, to which allusion is made by various Greek authors, have no claim to be mentioned in this connexion. Columella (xi. 3, 51, 52) and Pliny (*H.N.*, xix. 23) both refer to their use in Italy for the cultivation of the rarer and more delicate sorts of plants and trees. Seneca has given us a description of the application of hot water for securing the necessary temperature. The botanist Jungermann had plant houses at Altdorf in Switzerland; those of Loader, a London merchant, and the conservatory in the Apothecaries' Botanic Garden at Chelsea, were the first structures of the kind erected in British gardens. These were, however, ill adapted for the growth of plants, as they consisted of little else than a huge chamber of masonry, having large windows in front, with the roof invariably opaque. The next step was taken when it became fashionable to have conservatories attached to mansions, instead of having them in the pleasure grounds. This arrangement brought them within the province of architects, and for nearly a century utility and fitness for the cultivation of plants were sacrificed, as still is often the case, to the unity of architectural expression between the conservatory and the mansion.

Plant houses must be as far as possible impervious to wet and cold air from the exterior, provision at the same time being made for ventilation, while the escape of warm air from the interior must also be under control. The most important part of the enclosing material is necessarily glass. But as the rays of light, even in passing through transparent glass, lose much of their energy, which is further weakened in proportion to the distance it has to travel, the nearer the plant can be placed to the glass the more perfectly will its functions be performed; hence the importance of constructing the roofs at such an angle as will admit the most light, especially sunlight, at the time it is most required. Plants in glass houses require for their fullest development more solar light probably than even our best hot-houses transmit,—certainly much more than is transmitted through the roofs of houses as generally constructed.[1]

Plant houses should be constructed of the best Baltic pine timber, as being the most durable, but the whole of the parts should be kept as light as possible. In many houses, especially those where ornament is of no consequence, the rafters are now omitted, or only used at wide intervals, somewhat stouter sash-bars being adopted, and

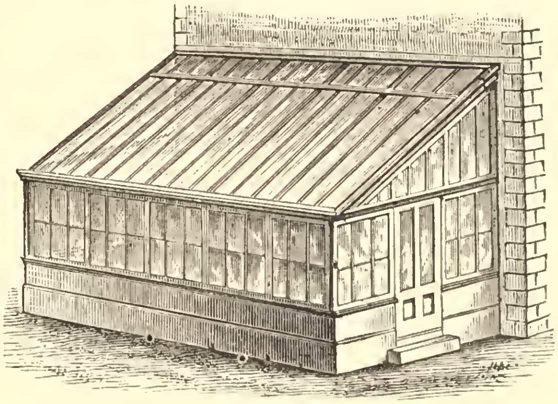

Fig. 4.—Lean-to Plant House.

stout panes of glass, 8 to 12 inches wide, made use of. Such houses are very light; being also very close, they require careful ventilation. The glass roof is commonly designed so as to form a uniform plane or slope from back to front in lean-to houses (fig. 4), and from centre to sides in span-roofed houses. In some cases, however, the roof sashes are fitted up on the ridge-and-furrow principle invented by Sir Joseph Paxton, shown in fig. 5, which represents the original ridge-and-furrow house erected by him at Chatsworth. To secure the greatest possible influx of light, some scientific horticulturists recommend curvilinear roofs; but the superiority of these is largely

[1] Mr Knight, an unquestionable authority, proposed a general pitch or elevation of 34° for the latitude of London, the angle at which the rays of the mid-day sun are perpendicular to the surface on the 20th of May and 21st of July. This would afford four months, from the 20th of April to the 21st of August, during which the angle of incidence at mid-day would not at any time amount to 9°, while the deviation at the winter solstice would be 43°, and the loss of light from reflexion would be little more than $\frac{1}{30}$. The angle of 45° has been recommended as a pitch extremely suitable for early vineries and pine stoves, in which case the midsummer deviation would be 19°, and the loss $\frac{1}{40}$, and the winter deviation 30°, the loss being nearly the same. Greater exactness, however, has been sought in this matter than is at all necessary. The reduction of the opacity of the roof arising from the breadth and depth of rafters and astragals is of much more consequence. The massive rafters, framed sashes, and inferior glass inserted in small fragments, with numerous overlaps liable to be choked with dirt, intercept a large proportion of the solar light and heat in ordinary glass houses.

due to the absence of rafters, which may also be dispensed with in plain roofs. Span and ridge-and-furrow roofs, the forms now mostly preferred, are exceedingly well adapted for the admission of light, especially when they are glazed to within a few inches of the ground. They can be made, too, to cover in any extent of area without sustaining walls. Indeed, it has been proposed to support such roofs to a great extent upon suspension principles, the internal columns of support being utilized for conducting the rain-water off the roof to underground drains or reservoirs. The lean-to is the least desirable form, since it scarcely admits of elegance of design, but it is necessarily adopted in some cases.

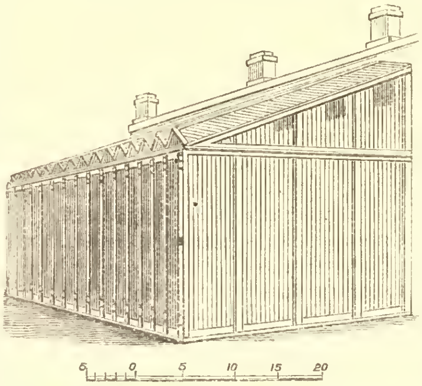

FIG. 5.—Ridge-and-Furrow Plant House.

azing. In glazing, the greater the surface of glass, and the less space occupied by rafters and astragals as well as overlaps, the greater the admission of light. Some prefer that the sash-bars should be grooved instead of rebated, and this plan exposes less putty to the action of the weather. The simple bedding of the glass, without the use of over putty, seems to be widely approved; but the glass may be fixed in a variety of other ways, some of which are patented. In Beard's method (a very good one) the glass is fixed between strips of felt, the covering bar being held in position by white metal nuts tightly screwed. Good results have also been obtained from the system introduced and improved by Rendle, which covers all the framework of the roof, so that the timber is not exposed to the vicissitudes of weather.

nser-tory. The *Conservatory* is often built in connexion with the mansion, so as to be entered from the drawing-room or boudoir. But when so situated it is apt to suffer from the shade of the building, and is objectionable on account of admitting damp to the drawing-room. Where circumstances will admit, it is better to place it at some distance from the house, and to form a connexion by means of a glass corridor. In order that the conservatory may be kept gay with flowers, there should be a subsidiary structure to receive the plants as they go out of bloom. The conservatory may also with great propriety be placed in the flower garden, where it may occupy an elevated terrace, and form the termination of one of the more important walks.

Great variety of design is admissible in the conservatory, but it ought always to be adapted to the style of the mansion of which it is a prominent appendage. Some very pleasing examples are to be met with which have the form of a parallelogram with a lightly rounded roof; others of appropriate character are square or nearly so, with a ridge-and-furrow roof. Whatever the form, there must be light in abundance; and the shade both of buildings and of trees must be avoided. A southern aspect, or one varying to south-east or south-west, is preferable; if these aspects cannot be secured, the plants selected must be adapted to the position. The central part of the house may be devoted to permanent plants; the side tables and open spaces in the permanent beds should be reserved for the temporary plants.

The kind of plants adapted for planting out in conservatories are palms, cycads, dracænas, aralias, luculias, camellias, &c., with fuchsias, habrothamnus, plumbago, strong-growing scarlet pelargoniums, &c., on the pillars, and tacsonias, passifloras, lapagerias, &c., on the roof.

reen-use. The *Greenhouse* is a structure designed for the growth of such exotic plants as require to be kept during winter in a temperature considerably above the freezing-point. The best form is the span-roofed, a single span being better even than a series of spans such as form the ridge-and-furrow roof. For plant culture, houses at a comparatively low pitch are better than higher ones where the plants have to stand at a greater distance from the glass, and therefore in greater gloom. Fig. 6 represents a form of house adopted by a most successful cultivator, Mr B. S. Williams, of Holloway. It is 20 feet wide and 12 feet high, the length in this case being 50 feet, but of course any other convenient length could be adopted. The side walls are surmounted by short upright sashes which open outwards by machinery *a*, and the roof is provided with sliding upper sashes for top ventilation. In the centre is a two-tier stage for plants, 6 feet wide, with a pathway on each side 3 feet wide, and a side table 4 feet wide, the side tables being flat, and the centre stage having the middle portion one-third of the width elevated 1 foot above the rest, so as to lift up the middle row of plants nearer the light. Span-roofed houses of this character should run north and south so as to secure an equalization of light, and should be warmed by two 4-inch hot-water pipes carried under the side tables along each side and across each end. Where it is desired to cultivate a large number of plants, it is much better to increase the number of such houses than to provide larger structures. The smaller houses are far better for cultural purposes, while the plants can be classified, and the little details of management more conveniently attended to. Pelargoniums, cinerarias, calceolarias, cyclamens, camellias, heaths, Australian plants, roses, and other specialities might thus have to themselves either a whole house or part of a house, the conditions of which could then be more accurately fitted to the wants of the inmates.

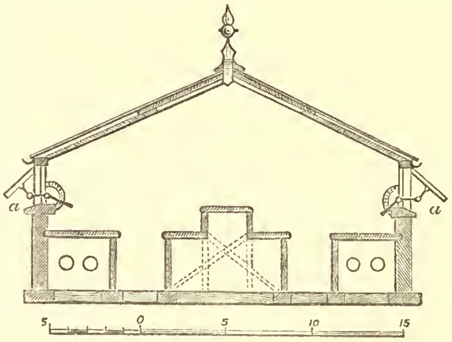

FIG. 6.—Section of Greenhouse.

The lean-to house is in most respects inferior to the span-roofed; one of the latter could be converted into two of the former of opposite aspects by a divisional wall along the centre. Except where space does not permit a span-roofed building to be introduced, a lean-to is not to be recommended; but a house of this class may often be greatly improved by adopting a half-span or hipped roof (as in fig. 9), that is, one with a short slope behind and a longer in front.

Where the cultivation of large specimens of heaths, Australian plants, Indian azaleas, &c., has to be carried on, a span-roofed house of greater height and larger dimensions may sometimes prove useful; but space for this class of plants may generally be secured in a house of the smaller elevation, simply by lowering or removing altogether the staging erected for smaller plants, and allowing the larger ones to stand on or nearer the floor.

The *Plant Stove* differs in no respect from the greenhouse except in having a greater extent of hot-water pipes for the purpose of securing a greater degree of heat, although, as the plants in stove houses often attain a larger size, and many of them require a tan bed to supply them with bottom heat, a somewhat greater elevation may perhaps be occasionally required in some of the houses. For the smaller plants, and for all choicer subjects, the smaller size of house already recommended for greenhouses, namely, 20 feet wide and 12 feet high, with a side table of 4 feet on each side, a pathway of 3 feet, and a central stage on two levels of 6 feet wide, will be preferable, because more easily managed as to the supply of heat and moisture. Mr Williams's plant stove (fig. 7), which is a very good model, is of the foregoing dimensions. It has, however, a different arrangement from the greenhouse as to ventilation. It will be seen that along the ridge of the roof a raised portion or lantern light *b*, *b* is introduced, which permits of the fixing of two continuous ventilators, one along each side, for the egress of heated and foul air, openings *a*, *a* being also provided in the side walls opposite the hot-water pipes for the admission of pure cold air. Plant stove.

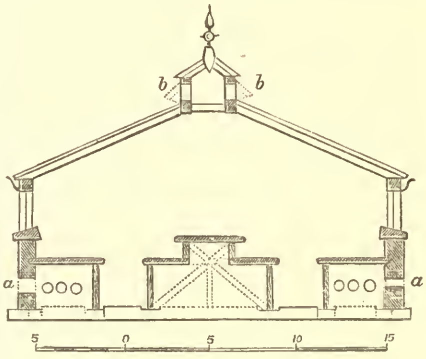

FIG. 7.—Section of Plant Stove.

Three or four rows of pipes will be required on each side, according to the heat proposed to be maintained.

In their interior fittings plant stoves require more care than greenhouses, which are much drier, and in which consequently the staging does not so soon decay. In stoves the tables should always be of slate or stone, and the supports of iron; slate is now most commonly used. This should be covered with a layer of 2 or 3 inches of some coarse gritty material, such as pounded spar, or the shell sand obtained on the sea-coast, on which the pots are to stand; its use is to absorb moisture and gradually give it out for the benefit of the plants. The pathways should be paved, or made of concrete and cement, and the surface should be gently rounded so that the water required for evaporation may drain to the sides while the centre is sufficiently dry to walk upon; they should also have brick or stone edgings to prevent the water so applied soaking away at the sides and thus being wasted.

sition plant uses. The greenhouses, if large and ornamental, should be contiguous to the flower garden or pleasure ground; but if of the simple character employed only for growing decorative plants, it is better to associate them with similar houses set apart for other purposes, in an enclosed portion of the grounds contiguous to the potting sheds, where fuel and other materials required can be conveniently stored, and where all the untidiness of the workshops may be masked. For this reason it is a very convenient plan to place side by side a series of small span-roofed houses for growing plants, where they can be connected by a glazed passage-way at the back. The glazed way may be utilized for the cultivation of plants requiring less light than others, such as ferns, camellias, &c.; it should communicate with the workmen's offices, which are commonly placed on the north side of the garden wall, so that potting and other cultural operations may be carried on without creating a block or confusion in the several houses. Wherever placed, it is imperative that all plant houses should have a free and abundant admission of light.

uit uses. 11. *Fruit Houses.*—The principal of these are the vinery, pinery, peach house, cucumber and melon house, and orchard house. These or a portion of them, especially the vineries and peacheries, are frequently brought together into a range along the principal interior or south wall of the garden, where they are well exposed to sun and light, an ornamental plant house being sometimes introduced into the centre of the range in order to give effect to the outline of the buildings. When thus associated, the houses are usually of the lean-to class, which have the advantage of being more easily warmed and kept warm than buildings having glass on both sides, a matter of great importance for forcing purposes.

ery. The *Vinery* is a house devoted to the culture of the grape-vine, which is by far the most important exotic fruit cultivated in English gardens. When forming part of a range a vinery would in most cases be a lean-to structure, with a sharp pitch (45°–50°) if intended for early forcing, and a flatter roof (40°) with longer rafters if designed for the main or late crops. Mr A. F. Barron, a recognized authority on grape growing, recommends in the *Florist and Pomologist* (1879, p. 37) three classes of

FIG. 8.—Lean-to Vinery.

vineries, namely, *early* for the production of early or forced grapes, *general-crop* for all unheated grape houses, and *late* for producing and keeping grapes till late in the season, each requiring its own special arrangements. The following are the three forms of houses recommended by him. (1) The *lean-to* (fig. 8) is the simplest form, often erected against some existing wall, and the best for early forcing, being warmer on account of the shelter afforded by the back wall. In this house the principal part of the roof is a fixture, ventilation being provided for by small lifting sashes against the back wall, and by the upright front sashes being hung on a pivot so as to swing outwards on the lower side. The necessary heat is provided by four 4-inch hot-water pipes, which would perhaps be best placed if all laid side by side, while the vines are planted in front, and trained upwards under the roof. A second set of vines may be planted against the back wall, and will thrive there until the shade of the roof becomes too dense. (2) The *hipped-roofed* or three-quarter span (fig. 9) is a combination of the lean-to and the span-roofed, uniting to a great degree the advantages of both, being warmer than the span and lighter than the lean-to. The heating and ventilating arrangements are much the same as in the lean-to, only the top sashes which open are on the back slope, and therefore do not interfere so much with the vines on the front slope. In both this and the lean-to the aspect should be as nearly due south as possible. Houses of this form are excellent for general purposes, and they are well adapted both for muscats, which require a high temperature, and for late-keeping grapes. (3) The *span-roofed* (fig. 10), the most elegant and ornamental

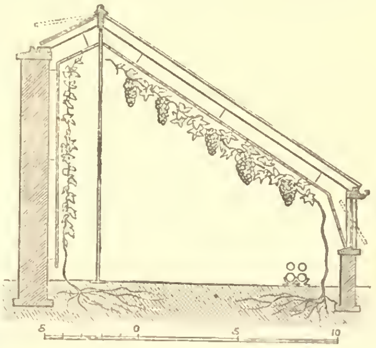

FIG. 9.—Hipped-Roofed Vinery.

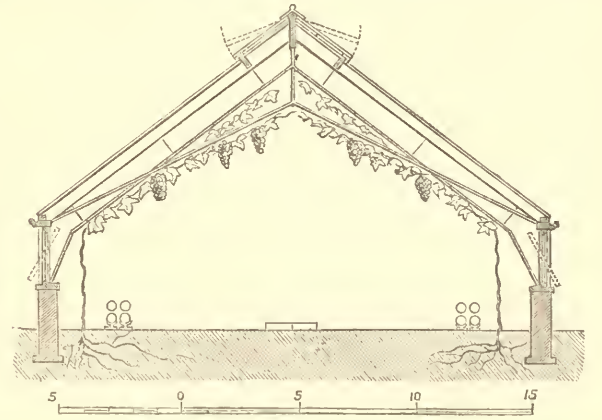

FIG. 10.—Span-Roofed Vinery.

form, is especially adapted for isolated positions; indeed, no other form affords so much roof space for the development of the vines. The amount of light admitted being very great, these houses answer well for general purposes and for the main crop. The large amount of glass or cooling surface, however, makes it more difficult to keep up a high and regular temperature in them, and from this cause they are not so well adapted for very early or very late crops. They are best, nevertheless, when grapes and ornamental plants are grown in the same house, except, indeed, in very wet and cold districts, where, in consequence of its greater warmth, the lean-to is to be preferred.

The *Pinery* is a house devoted to the cultivation of the pine-apple. The pineries or pine stoves of former times were generally large lofty structures of the lean-to vinery fashion, and heated by smoke flues; but these were superseded by buildings of more compact form, such as that of Baldwin, a noted pine grower of his day, in which the low roof was hipped, the short or northern slope being of slate, and the glazed sashes being fixtures. These were again improved by the substitution of glass for slate in the back slope, and of hot-water pipes for smoke flues as the heating medium, openings being provided at back and front, as at *a*, *a* (fig. 11), for ventilation. Such houses as these are low, and therefore are more economically kept at the high temperature necessary for pine growing. The best form of pinery is a low structure of this kind, but somewhat wider, so as to permit of the utilization of the front and back Pinery.

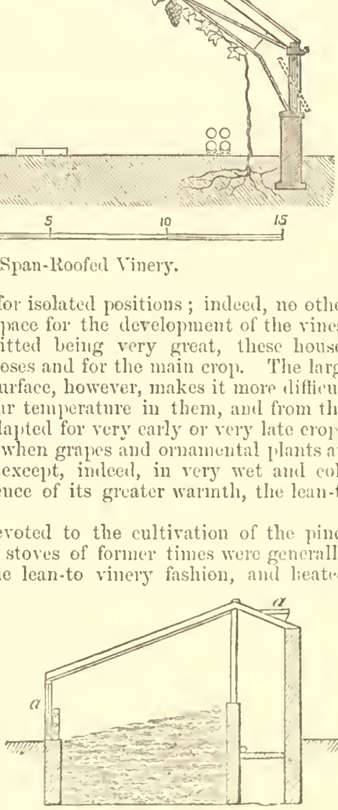

FIG. 11.—Section of Pinery.

spaces for general forcing purposes (fig 12). Such a house might be 14 feet wide, consisting of a plunging bed for bottom heat 8 feet wide, a back path of 2 feet provided with a shelf for strawberries near the glass, a front path of 2 feet, and between that and the front wall a stage for pots, which might be used for forcing French beans, and which should be on the same level as the front curb of the centre pit, and about 2½ feet from the glass. The height of the back wall should be 15 feet. The house should be heated by three or four hot-water pipes placed beneath the front stage, and two placed close to the wall in the back path; and the

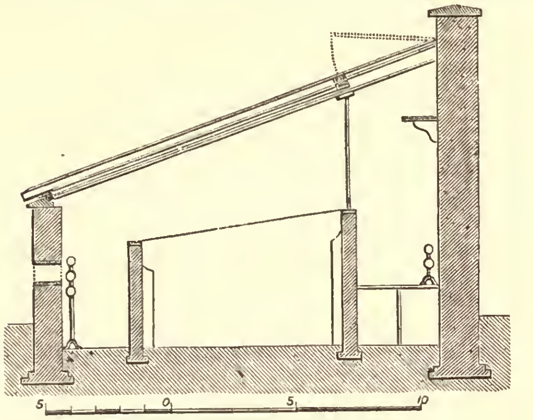

FIG. 12.—Modern Pinery.

necessary bottom heat should be provided by fermenting tan or leaves, or by hot-water pipes or a hot-water tank placed beneath the plunging bed. Ventilators should be fixed at short intervals in the front wall beneath the stage and opposite the heating pipes; and the alternate upper sashes should be made to open, or corresponding ventilators close to the top of the back wall should be provided.

If the stock of pine plants is not extensive, certain and abundant crops of fruit cannot be expected; and it is therefore necessary to have not only fruiting pineries but pineries for succession plants. These are generally called *pine pits*, and differ little from the pits used for accommodating other tender plants. Two or three succession pits are required to provide a stock of plants to keep the fruiting-house filled. Low-roofed pits are to be preferred, not only on account of their appearance, but because the pine can only be cultivated in its highest state of perfection when grown in pits just sufficient for the full development of the foliage and crown of the fruit. These pits, if span-roofed, should be provided with a central path under the ridge, just high enough for a workman to stand upright, and a plunging-pit on each side; but any ordinary well-constructed pit will answer the purpose if sufficiently heated.

Peach house.

The *Peach House* is a structure in which the ripening of the fruit is accelerated by the judicious employment of artificial heat. For early forcing, as in vineries, the lean-to form is to be preferred, and the house may have a tolerably sharp pitch. A width of 7 or 8 feet, with the glass slope continued down to within a foot or two of the ground, and without any upright front sashes, will be suitable for such a house, which may also be conveniently divided into compartments of from 30 to 50 feet in length according to the extent of the building, small houses being preferable to larger ones. As a very high temperature is not required, two or three pipes running the whole length of the house will suffice. The front wall should be built on piers and arches to allow the roots to pass outwards into a prepared border, the trees being planted just within the house. Abundant means of ventilation should be provided.

For more general purposes the house represented in fig. 13 will be found more useful. One set of trees is planted near the front, and trained to an arched trellis *b*. Another set is planted at the back, and trained on a trellis *c*, which is nearly upright, and leans against the back wall; or the back wall itself may be used for training. There are no upright front sashes, but to facilitate ventilation there are ventilators *d* in the front wall, and the upper roof sashes are made to move up and down for the same object. Two or three hot-water pipes are placed near the front wall. The back wall is usually planted with dwarf and standard trees alternately, the latter being temporary, and intended to furnish the upper part of the trellis, while the permanent dwarfs are gradually filling up the trellis from below. In any case the front trellis should stop conveniently short of the top of the sashes if there are trees against the back wall, in order to admit light to them. They would also be better carried up nearly parallel to the roof, and at about 1 foot distant from it, supposing there were no trees at the back.

A span-roofed house, being lighter than a lean-to, would be so much the better for peach culture, especially for the crop grown just in anticipation of those from the open walls, since a high temperature is not required. A low span, with dwarf side walls, and a lantern ventilator along the ridge, the height in the centre being 9 feet, would be very well adapted for the purpose. The trees should be planted inside and trained up towards the ridge on a trellis about a foot from the glass, the walls being arched to permit the egress of the roots. A trellis path should run along the centre, and movable pieces of trellis should

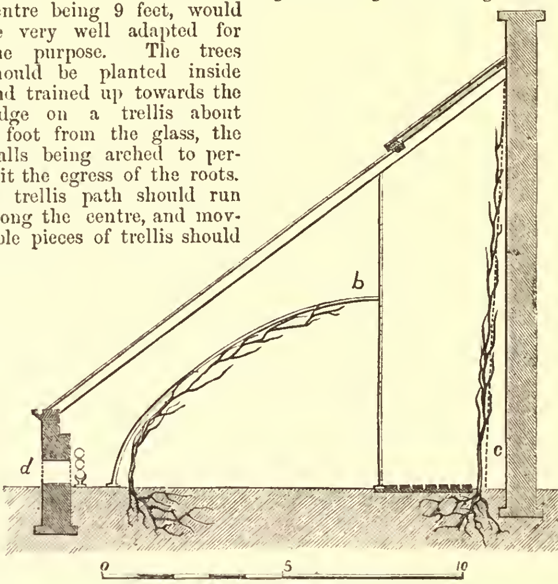

FIG. 13.—Peach House.

be provided to prevent trampling on the soil while dressing and tying in the young wood.

Cucumber and melon house.

The Cucumber and Melon House.—Wherever a continuous supply of cucumbers and a considerable number of melons are required, it is found most convenient to grow them in houses, the attention required and the risk of failures being much less than when hot-beds and pits heated by fermenting materials are employed. The best form of house is a narrow span (fig. 14), on account of the much greater amount of light which it admits. The width should be 12 feet, the height about 10 feet, and the length divided into short portions so as to be worked in succession; a 60-feet house divided into three 20-feet portions would be found very useful, as

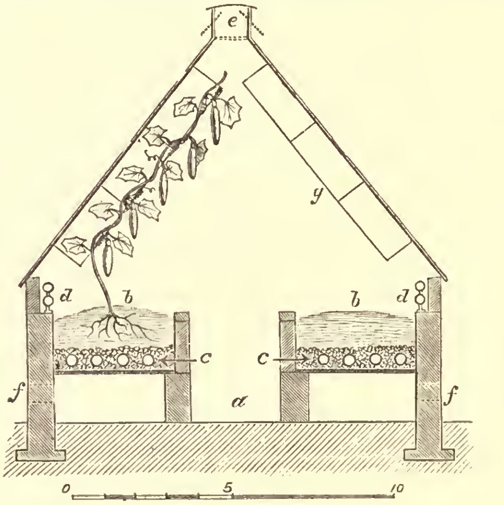

FIG. 14.—Span-Roofed Cucumber House.

one or more could be taken for either crop according to the demand. The inside arrangements should include a pathway *a* of 3 feet in the centre, two beds *b*, *b* provided with hot-water pipes *c*, *c* or hot-water tank for bottom heat, two pipes *d*, *d* on each side for warming the atmosphere, a lantern ventilator *e* at the ridge, and openings in the wall *f* beneath the beds to admit fresh air, and a trellis *g* for training the plants, fixed at 12 or 18 inches from the roof.

Where the house is built against a wall, the hipped form of roof is to be preferred, as it will admit more light, and also allows more space for the cucumber or melon vines. Fig. 15, from Moore's *Treatise on the Cucumber*, shows such a structure, in which *b* is the pathway, *c* front ventilator, *d* back ventilator, *e* hot-water pipes, and *f* tank for bottom heat. The cold air admitted at *c* enters a chamber *g*; thence it passes into the space *h* over the water in the tank, and is admitted through a tube *m*, which passes up through the bed of soil, into the house near the front; similar tubes *n*, inserted at intervals along the front of the bed, are intended for supplying water amongst the rubble, to keep the soil about the roots constantly moistened.

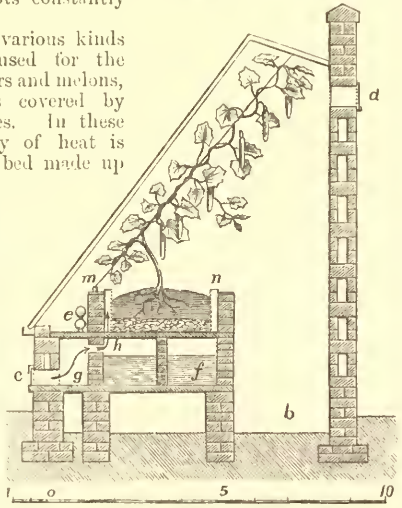

FIG. 15.—Moore's Cucumber House.

Pits and frames of various kinds are also frequently used for the cultivation of cucumbers and melons, as well as hot beds covered by ordinary garden frames. In these cases the first supply of heat is derived from the hot bed made up within the pit (fig. 17, *a*), which is all the better for having a layer or two of faggot-wood worked into it to facilitate the distribution of the heat from the linings later on. When the heat of the original bed subsides, linings of fermenting dung *b, b* must be added, and these must be kept active by occasional turnings and the addition of fresh material as often as required. Figs. 16 and 17 show different forms of pits of this character. It is, however, a vast improvement upon the old system to effect both top and bottom heating by hot-water pipes (fig. 16, *a, a*), in which case the width of the pits may be increased by at least 2 feet. Where there is much forcing carried on, the judicious arrangement of the several structures, permitting of their being worked from one boiler, should be carefully seen to.

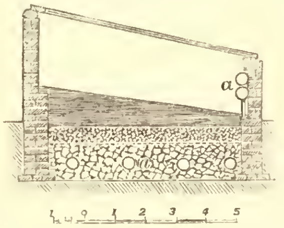

FIG. 16.—Cucumber Pit heated by Hot Water.

Orchard Houses. *Orchard Houses* are the invention of the late Mr Rivers of Sawbridgeworth. In all the more genial portions of England and Scotland they may be used without fire-heat, and chiefly for potted fruit trees; and if the trees are well managed, a very large quantity and variety of fruit can be produced, of excellent if not first-rate quality. These houses will be found useful adjuncts to

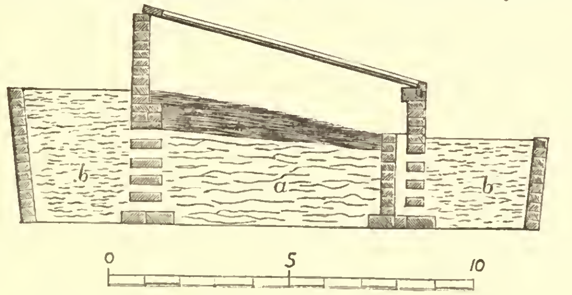

FIG. 17.—Cucumber Pit heated by Fermenting Dung.

other structures even in large gardens, while they are of the utmost value to amateurs, who would otherwise be dependent on outdoor crops. They are, moreover, exceedingly economical, and may be turned to a variety of uses, being just as suitable for the growth of half-hardy flowers as for our less hardy fruits. For fruit trees the orchard houses are of most value in spring, not to excite but to protect the blossom buds, and in autumn to assist in ripening both fruit and wood. While peaches, nectarines, and apricots are the permanent occupants of the house, except in late autumn, when they may be set out of doors, plums, pears, and apples may all by this means be assisted to produce good crops. During winter and spring (when they should be kept cool) the trees may be stored as closely as possible, and in this state they may remain until after blooming is over and the fruits are set, when the hardier kinds should be gradually drawn out and hardened in sheltered spots, and eventually plunged in the open garden to swell their fruits, this thinning out affording room for the tenderer kinds.

The orchard house may be of the lean-to form or a span; but the latter is much to be preferred. Fig. 18 is a sketch of Mr Rivers's small span-roofed orchard house, which is built of wood and glass. Two rows, 14 feet apart, of oak posts *a, a*, 5 by 3 inches and 9 feet long, or of deal posts set in cast-iron sockets, are firmly fixed 3 feet in the ground and 5 feet apart. On each of these should be firmly nailed the plate *b*, 4 inches by 3, to receive the ends of the rafters *c, c*, which should be 8 feet long and 3 inches by $1\frac{1}{2}$. The ridge board *d* should be 3 inches by 1, to which the upper ends of the rafters, after being sloped, should be nailed. At the lower end a drip board, 5 inches by 1, placed sloping to receive the lower ends of the glass, must be fixed on the plate the full length of the house; and on the ridge board a small ledge must be nailed for the upper ends of the glass panes to rest upon. On the upper edge of the ridge board a cap, 3 inches by 1, shaped thus ∧, should be nailed, to shoot off the water and prevent its entrance at the ridge. The sides *i* are boarded, and the roof is of 21 oz. glass, the rafters (stout sash-bars) being 20 inches apart, and the panes 15 inches long, set end to end in glazing. Under the glass *g* on each side is a ventilating shutter *h*, $\frac{3}{4}$ inch broad and 1 foot wide, hinged and opening downwards. The roof is stayed by irons screwed to every fourth rafter. The angular space over the door forms a ventilator. A house of this form should have a central path *e*, the two beds or spaces on each side *f, f* accommodating the fruit trees either planted out or grown in pots. These beds may be raised above the path if used for dwarf trees.

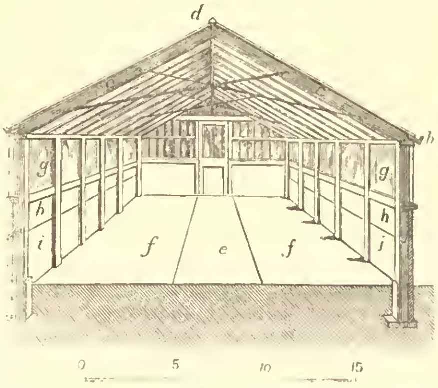

FIG. 18.—Rivers's Span-Roofed Orchard House.

As a larger house, one of 24 feet width (fig. 19) might be recommended. The oak posts or deal posts in sockets, 6 inches by 4, must be set in two rows *a, a*, 24 feet asunder, 6 feet apart in the rows, and the plates, rafters, ridge board, and drip board should be as described above. The apex of the ridge *d* should be 12 feet from the surface. The roof itself *c* is supported and steadied by two rows of iron pillars *k* connected by tie rods, and glazed with 21 oz. glass,

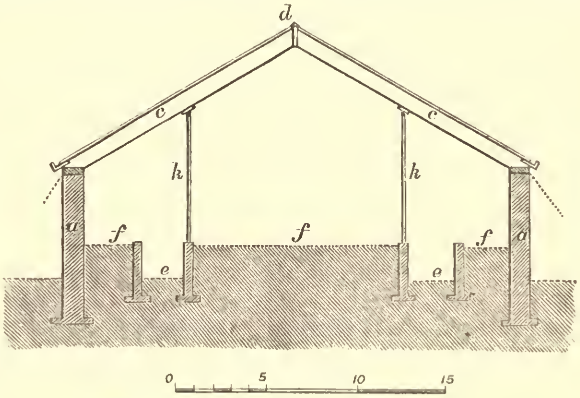

FIG. 19.—Orchard House with Raised Beds.

the rafters being 20 inches apart. The sides and ends are boarded, and provided with hinged ventilators as in the smaller house. The floor may be level with the ground, and with a central path or two side paths *e, e*. For dwarfer and more bushy plants, and for general purposes, the beds may be slightly raised, as *f, f, f* in fig. 19. When the trees are planted out the raised beds would be objectionable as diminishing the available height, but for potted plants they are an advantage, raising the trees nearer to the light.

In the north of England, and in all moist and cold districts of Scotland or Ireland, Mr Rivers recommends the introduction of a hot-water pipe or two into houses in which peaches, nectarines, and apricots are to be grown, not to force them, but to ensure the ripening of both wood and fruit.

12. *Pits and Frames.*—These are used both for the summer growth and winter protection of various kinds of ornamental plants, for the growth of such fruits as cucumbers, melons, and strawberries, and for the forcing of vegetables. When heat is required, it is sometimes supplied by means of fermenting dung, or dung and leaves, or Pits.

tanner's bark, but it is much more economically provided, on the score of labour at least, by hot-water pipes. Pits of many different forms have been designed, but it may be sufficient here to describe one or two which can be recommended for general purposes.

Fig. 20 represents a simple and useful form of pit designed for the Chiswick garden by Mr Sibthorpe, and published by Mr R. Thompson (*Gardener's Assistant*, 499). It is 7 feet wide, the front wall 2 feet high, the back wall 3½ feet. The walls are one brick thick, or 4½ inches, with a 4-inch pier *a* at every third rafter, the

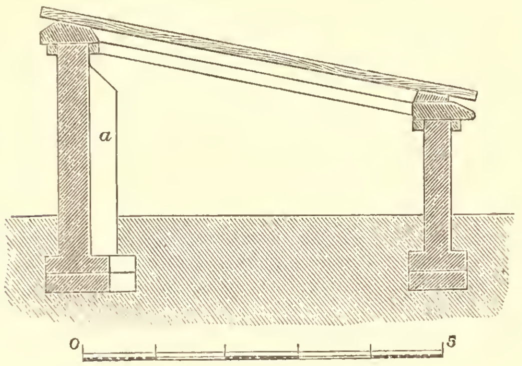

Fig. 20.—Sibthorpe's Plant Pit.

foundations being respectively 9 and 14 inches. The wall plates both at front and back project so as to allow the drip to fall clear of the walls; and fillets of wood fixed to their under surfaces and close up to the wall on each side serve to maintain both the wall plate and top of the wall steadily in their positions. Such a pit used for cucumbers or melons might be excavated slightly below the ground level to admit of bottom heat being supplied by a bed of fermenting dung, over which the soil should be placed in the usual way, bringing the plants up near to the glass; or the bottom heat might be supplied by the tank system of heating or by hot-water pipes. For small store plants of any kind the interior might be filled up with any porous materials, finishing off with a surface of fine coal-ashes at a suitable height, or larger plants might be accommodated by using it as shown, without any filling up. Heat can easily be supplied by one or two 4-inch pipes, front and back, according to the temperature required; but if fermenting material be used for this purpose, the lower portion of the walls, as far up as will be covered by the interior filling, should be pigeon-holed.

An excellent pit for wintering bedding-out plants or young greenhouse stock is shown at fig. 21. It is built upon the pigeon-hole principle as high as the ground level *a*, *a*, and above that in 9-inch brickwork. At a distance of 9 inches retaining walls *b*, *b* are built up to the ground level, and the spaces between the two are covered by thick boarding, which is to be shut down as shown at *c* in cold weather to exclude frost, and opened as shown at *d* in mild weather to promote a free circulation of air through the pit. The height of the pit might be reduced according to the size of the plants; and, to secure the interior against frost, a flow and return hot-water pipe *e* should pass along beneath the staging, which

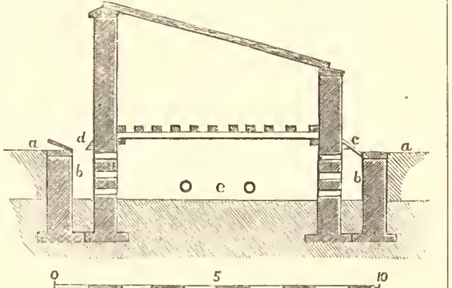

Fig. 21.—Ventilated Plant Pit.

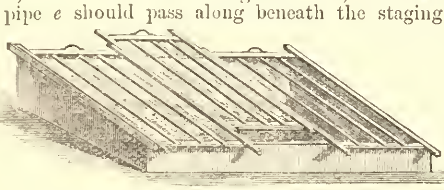

Fig. 22.—Hot-Bed Three-Light Frame.

should be a strong wooden trellis supported by projections in the brickwork. The water which drains from the plants or is spilt in watering would fall on the bottom, which should be made porous to carry it away. For many plants this under current of ventilation would be exceedingly beneficial, especially when cold winds prevented the sashes from being opened. A pit of this character may be sunk into the ground deeper than is indicated in the figure if the subsoil is dry and gravelly, but in the case of a damp subsoil it should rather be more elevated, as the soil could easily be sloped up to meet the retaining wall.

For all useful purposes these two forms of pits will suffice, but there will always be found occupation for some of the common hot-bed frames (fig. 22). They should be made of the best red deal, 1¼ inch thick. A convenient size is 6 feet wide, 24 inches high at the back and 15 in front; and they are usually 12 feet long, which makes three lights and sashes, though they can be made with two lights or one light for particular purposes. Indeed, a one-light frame (fig. 23) is often found very convenient for many purposes. The lights should be 2 inches thick, and glazed with 21 oz. sheet glass, in broad panes four or five to the breadth of a light, and of a length which will work in conveniently and economically, very long panes being undesirable from the havoc caused by accidents, and very short ones being objectionable as multiplying the chances of drip; panes of from 6 or 8 to 12 inches long are of convenient size for garden lights of this character. In all gardens the frames and lights should be of one size so as to be interchangeable, and a good supply of extra lights (sashes) may always be turned to good account for various purposes. Fran

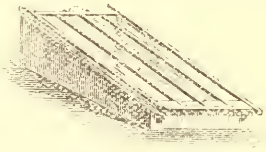

Fig. 23.—One-Light Frame.

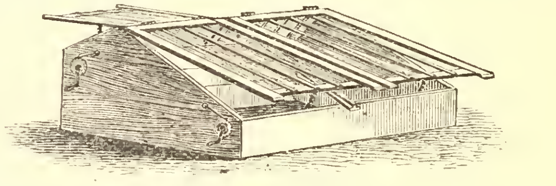

Fig. 24.—Span-Roof Frame.

Boulton and Paul's span-roof garden frame (fig. 24) may under some circumstances be useful as a substitute for the three-light frame. It is adapted for storing plants in winter, for nursing small plants in summer, and for the culture of melons and other crops requiring glass shelter. These frames are made 11 inches high in front, 22 at the back, and 32 at the ridge, with ends of 1½-inch red deal; the sashes, which are 2 inches thick, open by gearing, the front and back separately. The lights are hinged so that they can be turned completely back when necessary. This more direct and ready access to the plants within is one of the principal recommendations of this form of pit.

13. *Mushroom House.*—Mushrooms may be grown in sheds and cellars, or even in protected ridges in the open ground, but a special structure is usually devoted to them. A lean-to against the north side of the garden wall will be found suitable for the purpose, though a span-roofed form may also be adopted, especially if the building stands apart. Mus room hous

The internal arrangement of a lean-to mushroom house is shown in fig. 25. The length may vary from 30 feet to 60 feet; a convenient width is 10 feet, which admits of a 3½ feet central path, and beds 3 feet wide on each side. The shelves should be of slate *a*, *a*, supported by iron uprights *b*, *b*, each half having a front ledge of bricks set on edge in cement *c*, *c*. The slabs of slate forming the shelves should not be too closely fitted, as a small interval will prevent the accumulation of moisture at the bottom of the bed. They may be supported

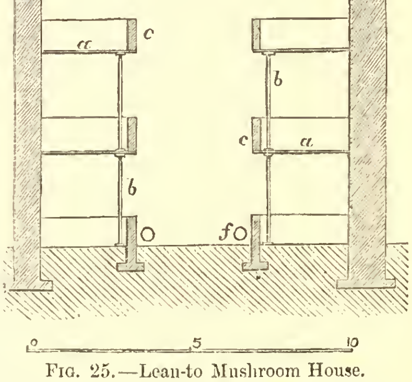

Fig. 25.—Lean-to Mushroom House.

by iron standards or brick piers, back and front, bearing up a flat bar of iron on which the slates may rest; the use of the bar will give wider intervals between the supports, which will be found convenient for filling and emptying the beds. The roof may be tiled or slated; but, to prevent the injurious influence of hot sun, there should be an inner roof or ceiling *d*, the space between which and the outer roof *e* should be packed with sawdust. A hot-water pipe *f* should run along both sides of the pathway, close to the front ledge of the lowest beds. The different shelves can be planted in succession; and the lower ones, especially those on the floor level, as being most convenient, can be utilized for forcing sea-kale and rhubarb.

Another style of house which answers remarkably well may be formed by an arch of brickwork, making a kind of tunnel, or by a semi-arch projected against a brick wall or against the side of a bank (fig. 26). In either case the arch *d* should be covered with

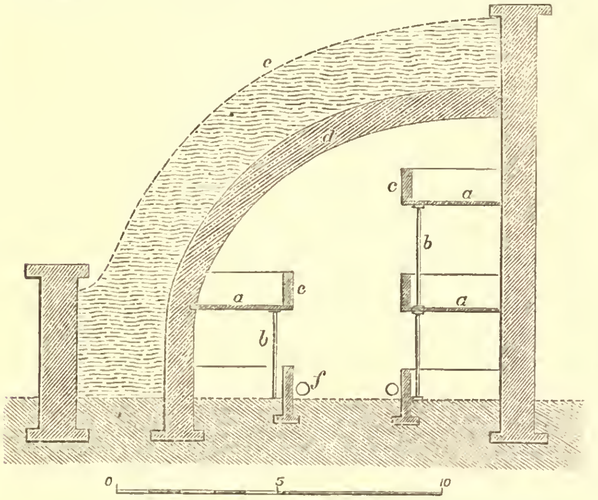

FIG. 26.—Semi-Arch Mushroom House.

a thick bank of earth *e*, and planted with spreading shrubs to keep it cool and shaded. The size of the beds and the fitting up may be exactly the same as in fig. 25 already described, except that on one side the available height will be necessarily less.

14. *Fruit Room.*—In many gardens a portion of the shed accommodation behind the ranges of glass-houses is made to do service as a fruit room, but it is sometimes difficult to secure in this way the conditions favourable for the conservation of fruit. The main requisites are coolness and a steady uniform temperature, combined with darkness and moderate but not excessive dryness. A dry cool cellar makes an excellent fruit room.

One of the most successful examples of a fruit room is that of Mr Moorman of Clapham, described by Mr Robert Thompson in the *Journal of the Horticultural Society* (vi. 110), of which figs. 27 and 28 represent a plan and section. The building in this case

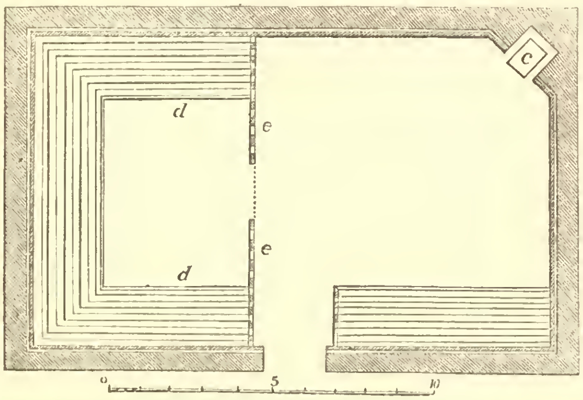

FIG. 27.—Moorman's Fruit Room (plan).

was not specially erected for a fruit room, having been originally a loft over a coach-house. The walls have an inner lining of board enclosing a cavity, which is probably one cause of the efficiency of the apartment, since the wood lining and the cavity containing air both act as slow conductors of heat. The ceiling on the north side is double, which also conduces to the same end. There is a swing window *b*, opened a little occasionally, but always covered with a roller blind so as to shut out light, and there is a small stove *c*, but seldom used, and never for the sake of warming the air, unless the temperature is below freezing; if damp is observed a little fire is lighted on a dry day, and this with ventilation soon dissi-

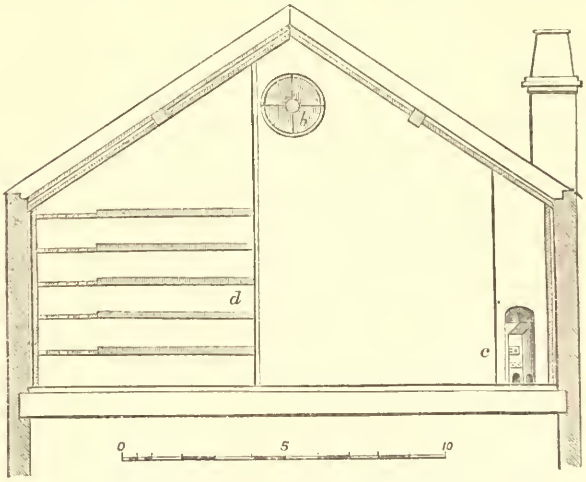

FIG. 28.—Moorman's Fruit Room (section).

pates it. The fruit shelves *d*, *d* are made with battens $1\frac{1}{2}$ inch wide and $1\frac{1}{4}$ inch apart, with a layer of clean straw placed across them, and on this the fruit is laid out singly. The shelves are enclosed by a partition of open work *e*, *e*, which is made of battens similar to the shelves themselves.

The fruit room in the Royal Horticultural Garden at Chiswick is a very good example of one on a larger scale. The floor of this is sunk about 18 inches below the ground level, and is concreted to keep out rats and mice. It is built against a north wall, and has a low sloping roof of slate. Three or four ranges of shelves are fixed all round against the walls, and there is a table occupying the centre for the display of samples of the different kinds grown. Such an apartment would form a convenient fruit room in a private garden establishment. The walls should be hollow; and a ventilator made to open and shut, and communicating obliquely with the external air, should be inserted in the ceiling near each end, the interval between ceiling and roof being packed with dry sawdust to assist in keeping up a uniform temperature. The shelves should be made of narrow battens of wood laid somewhat apart, as in Mr Moorman's house, and the central table should be fitted with shallow drawers in which to store the very choicest fruits, such as the finer dessert pears, which should be individually wrapped in tissue paper and laid in a single tier. The better kinds of fruits on the open shelves should be laid out singly. It is a wise economy not to stint space in such a structure, as many things can be accommodated for a time in a room of this sort; for example, the floor space beneath the shelves forms a good place for storing seed potatoes, especially those for the early crops. A window is necessary, as light will be occasionally required to examine and to select the fruits, but it should be tight-fitting, and on all other occasions closed by shutters so as to keep the interior dark. The door should also be closely fitted, to exclude the external air; indeed it is better if the fruit room itself can be entered from an adjoining apartment, from which light need not be excluded, and which may serve as a seed room and store room for many of the smaller garden requisites. If a hot-water pipe can be run round these apartments from some neighbouring apparatus, so much the better, but in the fruit room proper it should only be used occasionally to dispel damp, or, in the case of very severe weather, to keep out frost.

15. *Heating Apparatus.*—Plant houses are heated in a Heating.
variety of ways, but practically smoke flues and hot-water pipes are principally made use of. The cost of erection is a little more for hot-water pipes than for flues, but the former are the cheaper in the end. Steam is not now used as a heating medium, except where the waste steam of a manufactory is turned to account in some adjoining garden. The use of fermenting vegetable substances in the production of heat is rapidly disappearing from our best gardens before the application of hot water, which is far more economical and certain in its effects.

The *Smoke Flue*, that is, the continuous cavity commencing at Smoke
the back of the furnace and ending at the chimney, when used as flue.

a source of heat, should be carried along the front of the house, returning near the back; by the time it has run thus far most of the heat taken up from the fuel will be in course of transmission to the enclosed atmosphere of the house to be heated. There should be a gradual rise for some distance after leaving the furnace, which should be from 1 to 2 feet below the level of the front flue; and there should be no sharp angles or turnings. Earthenware pipes may be substituted when appearance is not a consideration. Smoke flues should be cleaned out at least once a year. When properly constructed, they answer their purpose sufficiently well; but this mode of heating is now virtually superseded in all gardens of note by the hot-water system.

Hot water. *Hot Water.*—The diffusion of heat in plant houses by causing hot water to circulate in iron pipes or vessels was brought into notice in 1827, and has gradually superseded all other modes. The apparatus is more durable than flues, occupies less space, can be placed in situations where flues cannot, is more elegant in appearance, gives out a more steady and uniform heat, and can seldom be overheated. The true cause of the circulation of the water in the pipes may be explained by fig. 29. When the water in the boiler

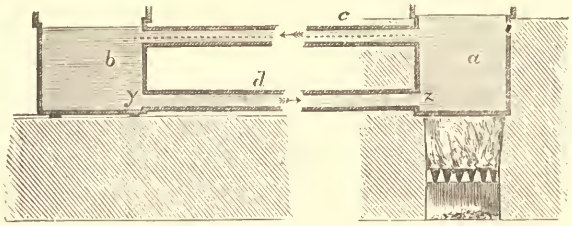

Fig. 29.—Diagram of Tank Boiler showing Circulation in Pipes.

a is heated up, it expands and so becomes lighter than that in the cistern *b*; the pressure at *z* in the horizontal pipe *d* is thus less than at *y*, so that the water flows through *d* from *b* to *a*, and *b* is kept supplied from the pipe *c*. In this arrangement, which represents the common tank boiler, with a cistern at the extremity of the pipes, the process of heating was slow, and many changes have consequently been made.

The furnace. *The Furnace.*—The most perfect furnace is that in which the combustion is most complete. On this account the fire should be surrounded by slow conductors of heat, such as Welsh lumps or other kinds of fire-brick; and the sides of the furnace should not be formed by any part of the boiler, nor should the furnace bars be tubular and connected with the boiler, though this latter plan is sometimes adopted to prevent the burning out of the bars. All the air necessary for maintaining combustion should enter from below, that is, through the ash-pit, and not through the door or sides of the furnace; but to produce this effect the furnace should be fitted with double doors and ash-pit registers, for thus only can

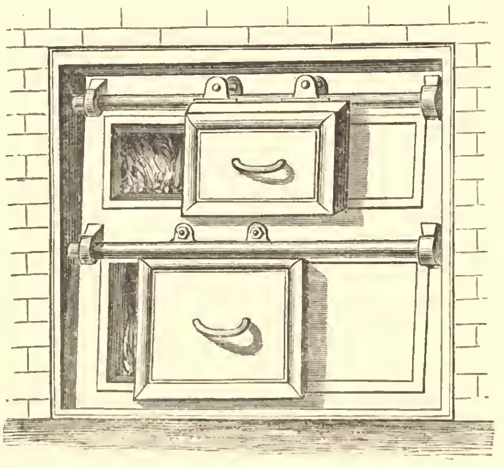

Fig. 30.—Sliding Furnace Doors.

the stoker have control over his furnace. By shutting the ash-pit and furnace door closely combustion is lessened, and the fire may be kept almost in a state of quiescence for many hours together; while, on opening either the door or ash-pit register, air is admitted and combustion goes on. Sylvester's furnace doors or doors of similar sliding form (fig. 30) are preferable to the ordinary hinged doors, because they can be opened to any extent, and are less liable to get out of order. These doors are faced with fire-brick, and run on rollers on an iron rod, or slide by means of a ledge. Mr Taplin recommended, in the *Florist and Pomologist* (1868, p. 32), that, to prevent the burning away of the furnace bars and the formation of clinkers, the ash-pit should be kept filled with water, and states that the bars will then last three times as long as with the ordinary dry ash-pit. The ash-pit may be built in cement for this purpose, or fitted with a cast-iron pan for the water.

Hot-Water Boilers.—Only a few of the principal types of the very diverse kinds of boilers can be noticed here. The simpler the form and the less complicated the whole apparatus is the better. It is essential that a large area of the boiler surface should be brought within the direct action of the fire.

Rogers's Conical Boiler (fig. 31), which has long been in use, is very suitable for heating pits and small houses, since it is econo-

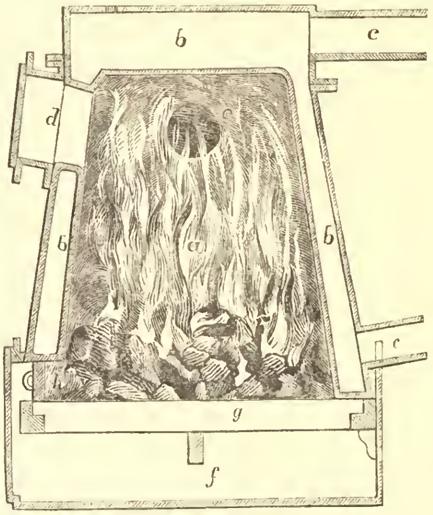

Fig. 31.—Rogers's Conical Boiler.

mical of fuel, and gives out a steady heat for a long time—15 to 20 hours. It is formed of two truncated concentric cones, with a space of 2 or 3 inches between them for the water, the furnace being in the inner cone, and the fuel supplied from the top. It was originally surrounded with brickwork, but several improvements have been introduced. In fig. 31 the boiler is placed in a cast-iron stand, with ground circular furnace, and register ash-pit doors,—*a* being the furnace, *b* the boiler, *c* flow and return pipes, *d* the furnace door, *e* smoke-pipe to the vent, *f* ash-pit, *g* grating, *h* hole for cleaning the furnace. The best kinds of fuel are coke, gas cinders, and anthracite; but common coal which does not cake very much is also suitable, as it is soon formed into coke.

Saddle Boilers.—The saddle boiler is a very efficient form, steady and sure in its working. In its improved forms it is, perhaps, the best for general purposes. It should be set over a furnace, the sides and end of which should be of fire-brick. It may be quite plain, or with the inner surface ribbed or corrugated (fig. 32), a modification adopted by Mr Gray of Chelsea. In all saddle boilers,

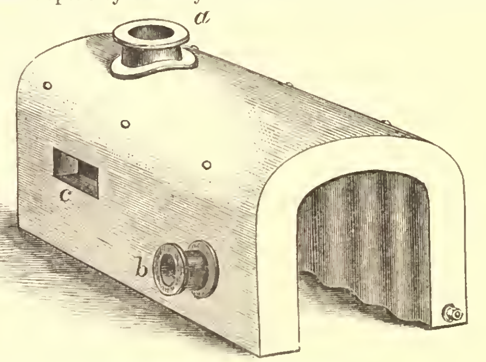

Fig. 32.—Gray's Saddle Boiler.

which should be deep from front to back, and set well back from the doors of the furnace, the full force of the fire strikes the dome of the boiler directly, and so long as the fire continues this is the part most directly influenced by its heat. The flow pipe is shown at *a*, and the return pipe at *b*, while *c* represents an opening (one on each side) for the passage of the smoke into the flues, the end being a water-way, and forming part of the boiler. The boiler is emptied by a small tap affixed to the pipe shown in the front.

There are many forms of what are called *Flued Saddle Boilers*, all of them good and thoroughly efficient if properly set. One of these, with a terminal water-way, is shown in elevation at fig. 33, and in section, showing the mode of setting, at fig. 34. The fire is made under the principal arch *a*; the flame and smoke return through the flue *b*, and then turn back over the top of the boiler

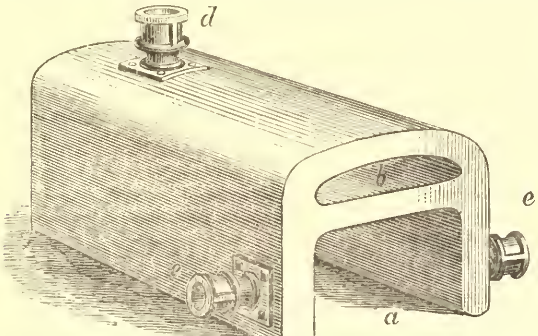

FIG. 33.—Flued Saddle Boiler.

to the outlet *c*, which can be placed at whatever point is in each case most convenient. The other parts referred to are—*d* flow pipe, *e* return pipes, *i* soot-door for cleaning flues, *g* furnace door, *h* ash-pit door.

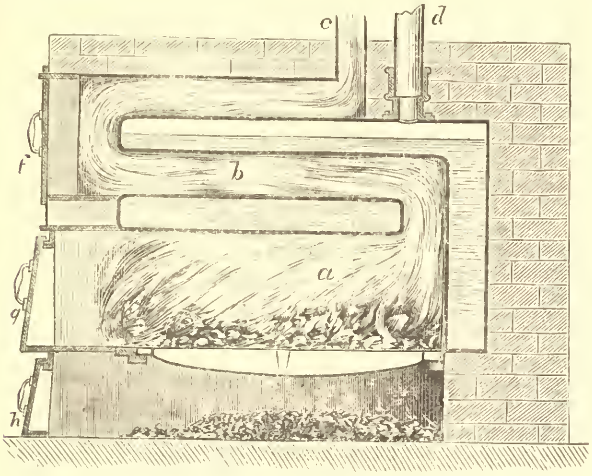

FIG. 34.—Flued Saddle Boiler (section).

The *Gold Medal Boiler* (figs. 35–38) is perhaps one of the best of these modified saddles, and like the others has a dome or arch *a*, and back water-way *b*; the heated products of combustion striking against this back are sent up the central flue *c*, and then diverted into the side flues *d*, *d*, before passing into the chimney shaft *e*. Fig. 36 shows a transverse section, and fig. 37 a longitudinal section set in brickwork, which is shown in elevation in fig. 38.

FIG. 35.—Gold Medal Boiler.

The ash-pit is shown at *f*, the furnace door at *h*, the centre and side flues at *c* and *d*, the water-way end at *b*, the soot-door at *i*, the sludge-plugs for cleaning out the interior at *g*, the flow pipe at *m*, the return at *n*, while *l* shows a hollow space around the boiler for utilizing the heat given off by its exterior surface. This boiler is named from its having won the gold medal in a boiler competition at Birmingham in 1872. The Witley Court boiler and the Glasgow boiler are both excellent forms of the flued saddle type.

Stevens's Trentham Boiler (fig. 39) is a very powerful and economical one, for large establishments especially. It is a modification of the well-known Cornish boiler, and consists of two wrought-iron cylinders substantially rivetted together, and having Trentham boiler.

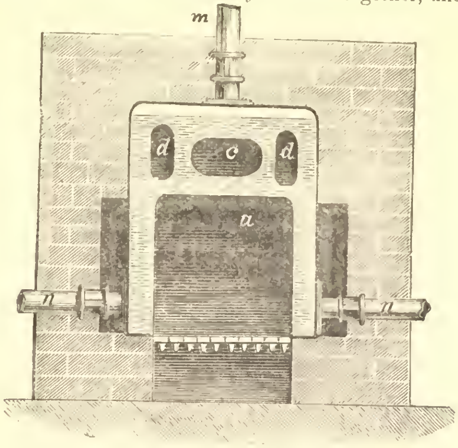

FIG. 36.—Gold Medal Boiler (transverse section).

a water space of about 2 inches between them. The frame for the furnace doors *d* is attached to the front. It is supported by two cast-iron chairs *a*, *a*, the front chair forming the frame for the lower flue doors *b*, which fasten by a simple catch, and can readily

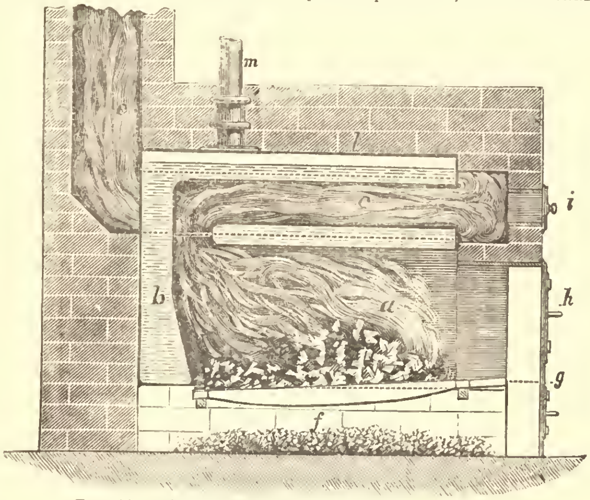

FIG. 37.—Gold Medal Boiler (longitudinal section).

be lifted off for cleaning the flues. The plug *c*, opened by unscrewing it, is for the purpose of clearing out all interior accumulations of dirt, which should be done thoroughly at short intervals. The flow pipe is at *e*, the return at *f*. In setting, the chairs are placed

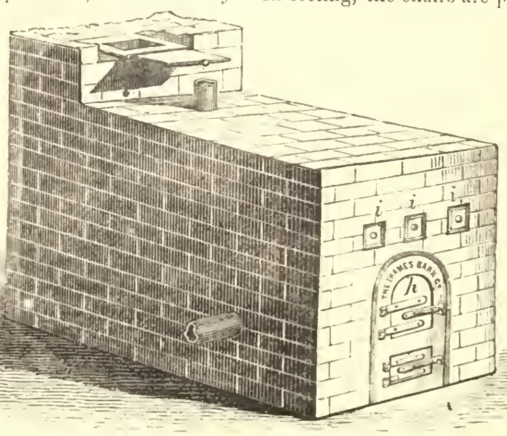

FIG. 38.—Gold Medal Boiler (brickwork setting).

level on a solid foundation, and two 9-inch walls are built up so as just to clear the boiler, and about level with the centre of the cylinder; on these a course of fire-brick lumps is laid, and brought close up to the side of the cylinder, and resting on the lumps an arch is turned leaving a space the depth of the top flue doors *b*, to serve as an upper flue, while the space below forms a lower flue. The grate bars are inside the cylinder towards the lower part, the space above them forming the furnace, and that below them the

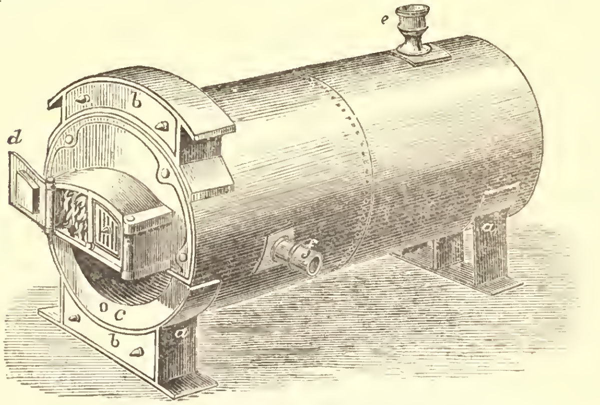

Fig. 39.—Stevens's Trentham Boiler.

ash-pit. The heat thus passes through the centre of the cylinder, then returns by the upper flue over its top, and is conducted to the chimney by the lower flue, which arrangement is found to work better than when the heated air is made to pass through the lower flue first.

Tubular boilers.

Tubular Boilers.—While the action of tubular boilers is rapid, and they are undoubtedly very powerful, they are said to be prodigal in their consumption of fuel, and liable to crack. In many cases, however, they have done good work for many years, and they are consequently employed to a considerable extent. The original tubular boilers were horizontal, but the upright form has nearly superseded this, and the *Upright Oval Tubular* of Mr Gray, and the *Duplex Upright Tubular* of Messrs Weeks & Co., both of Chelsea,—the latter marked by improvements introduced specially to meet the foregoing objections,—are the best forms at present in use. The Duplex (fig. 40) is made in two equal parts, each being capable of

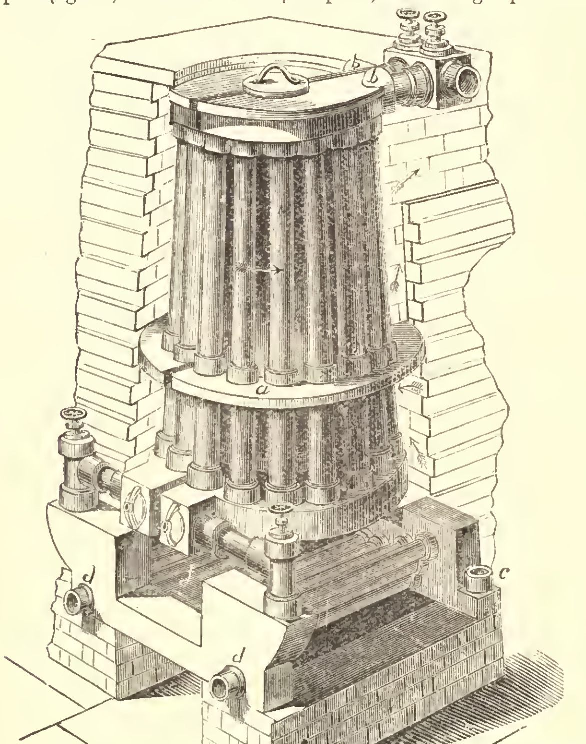

Fig. 40.—Weeks's Duplex Tubular Boiler.

being worked alone. Each section consists of a semicircle of upright tubes forming the boiler proper, fitted with the diaphragm *a*, by which more perfect combustion of the fuel is secured, a series of horizontal pipes forming the furnace *f*, a flow pipe *b* and a return pipe *c*, and an outlet *d* for removing sedimentary deposits from the interior.

Ladds's Boiler (fig. 41) is a horizontal tubular, which is found to be extremely powerful as well as economical. It is a rectangular box 6 feet long, made of 2-inch iron pipes, fixed into hollow water spaces which form the ends; these pipes act as fire bars, and form the sides of the furnace. Above the fire there are three series of horizontal pipes, each covered by a layer of tiles so placed as to convert the two intervening spaces into flues, along which the flames and smoke travel for 18 feet, the smoke escaping at the far end by an opening in the upper layer of tiles. Each tier of pipes

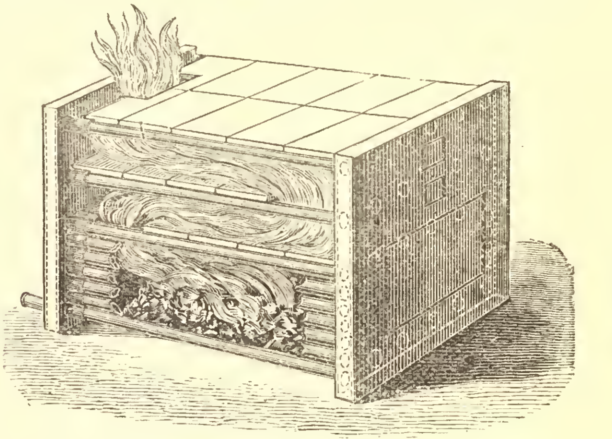

Fig. 41.—Ladds's Boiler.

in its turn therefore gets its share of heat from the burning fuel, and the consequence is that the apparatus is very quick in its action. The tubes are fitted in with Portland cement and hempen cord packing—tar ropes being found to destroy the cement. These boilers each heat 3000 feet or more of 4-inch piping. On the top of the upper layer of tiles are placed about 9 inches of ashes, then ordinary inch boards which rest on 4½-inch retaining walls, and on these 8 or 10 inches more of ashes, which very efficiently prevents any loss of heat.

Stoves, &c.—In the case of very small houses petroleum stoves or lamps are sufficient to keep out all ordinary frosts, but they are attended with a disagreeable smell. A small conical or cylindrical boiler attached to a system of piping is by far the safest and best in such cases. The furnace heating may also be effected either with petroleum, or, better still, as requiring no attendance, with gas. The furnace should be accessible from the outside only, so that none of the products of combustion may enter the house. A small conservatory might be readily heated in this way from a furnace fixed in a recess of the back wall or in the basement of the house, and placed near one of the fire-places, so that the outlet may be conducted into the chimney. A flow and return passing along under the side and front stage (avoiding doorways) might be kept heated by means of a small boiler of any form set over a circlet of gas jets. If on the level, the arrangement would be more simple still, since the boiler could be set in the house without brickwork, and the furnace constructed beneath it by piercing through the exterior wall, and fitting the opening with an ordinary furnace door.

Hot-water pipes are best made of cast-iron. Tow or rope, and a mixture of red and white lead, are generally used for packing or caulking the joints, though some prefer vulcanized india-rubber rings, which make good sound joints, and are very easily removable; for the joints near the fire iron cement must, however, be used. Flat pipes, and fluted or semi-circular pipes have sometimes been used, but the cylindrical form is much to be preferred. The number of pipes must be regulated by the extent to be heated, and the degree of temperature required; it is often well to have three or even four flow pipes and only one return pipe.

Pipes of 4-inch bore are almost universally employed, but 3-inch pipes may often be used in small houses. It is a mistake to stint the quantity of piping, since it is far more economical and better for the plants to have a larger surface heated moderately than a smaller surface heated to the highest possible degree. The pipes should, moreover, be placed near the front or lowest part of the house, and, to prevent loss of heat by conduction, should be supported clear of the ground, not less than 6 inches, upon cast-iron chairs.

Mr Cannell of Swanley has adopted the plan of fixing two or three distinct lines of small piping close under the roof glass, so as to prevent the air near the glass from getting cold. This contrivance is particularly useful in repelling damp during winter; and it may also be adopted for warming pits intended for the growth of half-hardy plants.

Hot water may be beneficially applied to garden walls, not, however, for the purpose of forcing the blossoms, but to assist in maturing late fruit and the young wood in unpropitious seasons.

To this end the walls must be built hollow, and the pipes placed near the bottom of the cavity, and supported on cast-iron chairs placed on the top of the foundation course of material. This method was first exemplified by Mr Atkinson in the gardens of the duke of Bedford at Woburn Abbey in 1828.

Heating by tanks. The *Tank System* of heating garden structures was introduced some years since by Mr W. E. Rendle. It consists in circulating hot water in broad shallow tanks instead of closed pipes. It will be obvious that as the water is to flow along these open (or only loosely covered) conduits, they must themselves be level, and the boiler must be either at the same level or below it, the connexion between the two being made in either case by hot-water pipes of suitable length. The tanks are formed of wood, brick, stone, or cast-iron. When of wood, they require to be made of good sound plank, not less than 2 inches thick, and properly jointed, and they are usually covered with slates. Stone or brick tanks require to be lined with a thick coating of Roman cement, while stone, slate, or brick pavement may be employed for covers. The cast-iron tanks have covers of the same material.

When one tank only is employed, as for example in supplying bottom heat to the front bed of a propagating pit, it should be constructed with a division along the centre, running to within about a foot of the end, which should be left open to allow of the water passing to the other side; the flow pipe from the boiler should be connected with the end of the tank on one side of the central division, and the return pipe for leading the water back to the boiler should be connected at the same end on the other side of the division, a sufficient number of pipes being also connected with the flow and return pipes to heat the atmosphere to the temperature desired. It is convenient to have valves fixed in the flow and return pipes, so as to shut off bottom or top heat as may be required. In a larger house a tank may run along the front, across the end, and along the back to the end whence it started; and this may be either divided along the centre as in the former case, the water flowing the whole distance on one side the division and returning on the other, or a broad tank may occupy the front and back, and be connected at the end by an ordinary 4-inch pipe, the flow from the boiler being united with the front tank, and the return carried from the back tank into the boiler.

The tank system of heating is perhaps one of the readiest modes of supplying bottom heat to plunging beds either for propagating or for growing plants, though the same end is practically attained by running some of the ordinary 4-inch pipes connected with the heating apparatus through a tank which can be charged with water when necessary, and emptied when heat is not required. When the plan is used for supplying both top and bottom heat, provision must be made to prevent too much of the steam or vapour from passing into the house; and, on account of the danger of having too much damp at certain seasons, it is perhaps preferable to have a separate set of pipes for the supply of atmospheric heat.

Solar heat. *Solar Heat.*—The rays of the sun reflected from walls and other surfaces become a source of artificial heat. This species of heat, however, is materially affected by the admission of the air necessary to the health of the plants. Solar heat, if properly regulated by ventilation, is of immense importance in the ripening of all the finer fruits, as well as for the abundant development of blossoms in the case of flowering plants. In the orchard house, fruits are ripened by the influence of solar heat alone. To secure as much solar heat during the day as possible, the ventilators should be opened early in the morning, and closed early in the afternoon.

Ventilation. 16. *Ventilating Apparatus.*—The object of ventilation is not so much to aid the respiration of the plants as to carry off noxious vapours and to regulate the moisture and temperature. The mechanical agitation both of the atmosphere and of the foliage caused by a free circulation, provided it be not too cold or too rudely admitted, has also a beneficial influence on the health of the plants. All ventilation, observes Mr M'Intosh (*Book of the Garden*, i. 271), "is founded upon the simple principle that cold air is heavier and has a tendency to sink downwards, while hot air is light and rises to the top. At first sight it may appear that, for the purpose of ventilating any building, it is only necessary that holes should be made at the bottom of the apartment for the air to enter, and other holes be placed in the upper part for the air to escape. Practically, however, ventilation is far from being so simple an affair," since currents of air are very difficult to direct or control, to moderate, or even to regulate with very great nicety. Too frequently air is given only during the day, and is excluded at night, often with an increase of fire-heat. Judicious horticulturists will reverse this, since plants require fresh air by night as well as by day, and in all countries cool nights succeed even the hottest days.

The mode of ventilating plant houses formerly in use was by letting down the top roof sashes; this was often supplemented by having the front or upright sashes also made movable, and more or less widely opened either outwards or laterally during the daytime. It is much more economical, however, and equally efficacious, to have the roof sashes fixed, and the top ventilation effected by means of a lantern in the case of a span-roofed house, or by horizontal ventilators near the top of the back wall in a lean-to. The front ventilation may be effected by openings in the front wall opposite the heating pipes, by which means the cold air is warmed, which is the best plan in all houses where a high temperature has to be maintained, and is especially necessary in forcing-houses, on account of the risk of injury to the foliage from cold air; or the front sashes may be made movable, which is better in temperate houses. In the case of pits, where there are no front sashes provided, the ventilators are sufficient for the purpose. The sliding down of one sash over the other, as once generally and even now frequently practised, greatly augments the shade in oblique sunshine, and is strongly objectionable on that account. The lantern mode of construction obviates this, but in a lean-to, and even with span roofs, it is better to have shorter movable sashes, hung so as to open by being elevated at the lower edge instead of sliding one over the other. A very slight elevation is sufficient for the egress of vitiated air.

A successful plan of warming the fresh air, recommended many years ago by Mr T. Moore (*Journ. Hort. Soc.*, i. 110), consists in passing the air after its admission by front ventilators through a heated chamber separate from the tank used as the heating medium, but admitting of communication with the tank chamber if necessary for the purpose of supplying moisture. The warmed fresh air is then led out in front of the tank, and carried forwards by the circulation up the slope of the roof, descending near the back wall to the floor, whence it is sucked into the heated chamber, mingling with the fresh air as it enters to repeat the circuit. A ventilator in the back wall provides the means of egress when this is required. Another plan, well adapted for forcing-houses, consists in fixing from end to end, below the hot-water pipes used for heating the structure, a zinc pipe of 6-inch or 8-inch diameter, and perforated with small holes, one end of the tube passing through an outer wall, and being fitted with a valve which can be wholly or partly closed at pleasure. Other means of accomplishing the same end may be adopted to suit particular cases.

In order to secure the circulation of the confined air during the night, and thus to prevent an injurious rise of the temperature, and also to economize fuel, it is of advantage where practicable to use shutters. These should consist of a light frame, readily movable, and fitted so as to slide readily in grooves on a skeleton roof; and they should be covered with asphalted felt, or strong brown paper coated with tar, which is much used in Germany for covering purposes, and is both durable and cheap. This should form a close outer covering, the ventilators being set open at bottom and top.

Formerly all ventilation had to be effected by the hand unaided, each sash being opened or shut separately, a matter of some urgency on the sudden outburst of sunshine. In all good ranges of glass, and in detached houses also, the work is now effected by machinery, many ingenious combinations of which are in use for this purpose.

17. *Hygrometry.*—For the healthy growth of plants, the regulation of the moisture is as necessary as the regulation of the heat. A considerable degree of moisture is Hygrometry.

necessary in the cases of most plants cultivated in a high temperature; but the amount varies of course in different cases, and this presents one of the principal difficulties in the management of what is called a mixed collection, whether of stove or greenhouse plants. In the case of fruits, where a house is mostly devoted to one subject, whether grapes, peaches, pines, or melons, the requisite conditions can be more readily secured. The instrument with which the amount of moisture present in the atmosphere is measured is the hygrometer. The two hygrometers most generally used are Daniell's and the dry and wet bulb, the former a more delicate instrument, best adapted for scientific observations, the latter a simpler instrument, better adapted for horticultural purposes, because requiring less delicate manipulation. It consists of two thermometers mounted on one frame, the readings of which when uncovered should correspond. One bulb is left uncovered, the other is covered with muslin, and a few threads of cotton, with their other ends immersed in water, keep it constantly moist. The temperature is lowered by the evaporation from the moistened bulb, and the difference in the readings of the two thermometers shows the degree of dryness. Mr Glaisher's instructions, which accompany the set of hygrometrical tables published by him, will be found of great assistance by every one making use of this instrument.

III. *Garden Materials and Appliances.*

Soils. 18. *Soils and Composts.*—The principal soils used in gardens, either alone, or mixed to form what are called composts, are—loam, sand, peat, leaf-mould, and various mixtures and combinations of these made up to suit the different subjects under cultivation.

Loam is the staple soil for the gardener; it is not only used extensively in the pure and simple state, but enters into most of the composts prepared specially for his plants. For garden purposes loam should be rather unctuous or soapy to the touch when moderately dry, not clinging nor adhesive, and should readily crumble when a compressed handful is thrown on the ground. If it clings together closely it is too heavy and requires amelioration by the admixture of gritty material; if it has little or no cohesion when squeezed tightly in the hand, it is too light, and needs to be improved by the addition of heavier or clayey material. Sound friable loam cut one sod deep from the surface of a pasture, and stacked up for twelve months in a heap or ridge, is invaluable to the gardener. When employed for making vine borders, loam of a somewhat heavier nature can be used with advantage, on account of the porous materials which should accompany it. For stone fruits a calcareous loam is best; indeed, for these subjects a rich calcareous loam used in a pure and simple state cannot be surpassed. Somewhat heavy loams are best for potting pine apples, for melons and strawberries, and may be used with the addition of manures only; but for ornamental plants a loam of a somewhat freer texture is preferable and more pleasant to work. Loam which contains much red matter (iron) should be avoided.

Sand is by itself of little value except for striking cuttings, for which purpose fine clean sharp silver sand is the best; and a somewhat coarser kind, if it is gritty, is to be preferred to the comminuted sands which contain a large proportion of earthy matter. River sand and the sharp grit washed up sometimes by the road side are excellent materials for laying around choice bulbs at planting time to prevent contact with earth which is perhaps manure-tainted. Sea sand may be advantageously used both for propagating purposes and for mixing in composts. For the growth of pot plants sand is an essential part of most composts, in order to give them the needful porosity to carry off all excess of moisture from the roots. If the finer earthy sands only are obtainable, they must be rendered sharper by washing away the earthy particles. Washed sand is best for all plants like heaths, which need a pure and lasting compost.

Peat soil is largely employed for the culture of American plants, as rhododendrons, azaleas, heaths, &c. In districts where heather and gritty soil predominate, the peat soil is poor and unprofitable, but selections from both the heathy and the richer peat soils, collected with judgment, and stored in a dry part of the compost yard, are essential ingredients in the cultivation of many choice pot plants, such as the Cape heaths and many of the Australian plants. Most monocotyledons do well in peat, even if they do not absolutely require it.

Leaf-mould is eminently suited for the growth of many free-growing plants, especially when it has been mixed with stable manure and has been subjected to fermentation for the formation of hot beds. In any state most plants feed greedily upon it, and when pure or free from decaying wood or sticks it is a very safe ingredient in composts; but it is so liable to generate fungus, and the mycelium or spawn of certain fungi is so injurious to the roots of trees, attacking them if at all sickly or weakened by drought, that many cultivators prefer not to mix leaf-mould with the soil used for permanent plants, as peaches or choice ornamental trees. For quick growing plants, however, as for example most annuals cultivated in pots, such as balsams, cockscombs, globe-amaranths, and the like, for cucumbers, and for young soft-wooded plants generally, it is exceedingly useful, both by preventing the consolidation of the soil and as a manure. The accumulations of light earth formed on the surface in woods where the leaves fall and decay annually are leaf-mould of the finest quality.

The material known as cocoa-nut fibre refuse is analogous to leaf soil, and may be employed for similar purposes. It should be mixed with gritty matter to favour the passage of water, and indeed requires to be so mixed when in an advanced stage of decay, in order to prevent its collapse into a close pasty mass. This cocoa-nut refuse is also a useful light material into which to plunge pots containing plants, as a preservative of the roots from the drying effects of the sun or the chilling effects of frost.

Composts are mixtures of the foregoing ingredients in varying proportions, and in combination with manures if necessary, so as to suit particular plants or classes of plants. Composts. The chief point to be borne in mind in making these mixtures is not to combine in the same compost any bodies that are antagonistic in their nature, as for example lime and ammonia. In making up composts for pot plants, the fibrous portion should not be removed by sifting, except for small sized pots, but the turfy portions should be broken up by hand and distributed in smaller or larger lumps throughout the mass. When sifting is had recourse to, the fibrous matter should be rubbed through the meshes of the sieve along with the earthy particles. Before being used the turfy ingredients of composts should lie together in a heap only long enough for the roots of the herbage to die, not to decompose.

19. *Manures.*—These are of two classes, organic and inorganic—the former being of animal and vegetable, the latter of mineral origin. Manures.

Farm-yard manure consists of the mixed dung of horses and cattle thrown together, and more or less soaked with liquid drainings of the stable or byre. It is no doubt the finest stimulant for the growth of plants, and that most adapted to restore the fertile elements which the plants have abstracted from exhausted soils. This manure is best fitted for garden use when in a moderately fermented state. Organic manures.

Horse dung is generally the principal ingredient in all hot bed manure; and, in its partially decomposed state, as afforded by exhausted hot beds, it is well adapted for garden use. It is most beneficial on cold stiff soils. It should not be allowed to lie too long unmoved when fresh, as it will then heat violently, and the ammonia is thus driven off. To avoid this, it should be turned over two or three times if practicable, and well moistened—preferably with farm-yard drainings.

Cow dung is less fertilizing than horse dung, but being slower in its action it is more durable; it is also cooler, and therefore better for hot dry soils. Thoroughly decayed, it is one of the best of all manures for mixing in composts for florists' flowers and other choice plants.

Pig dung is very powerful, containing more nitrogen than horse dung; it is therefore desirable that it should undergo moderate fermentation, which will be secured by mixing it with litter and a portion of earth. When weeds are thrown to the pigs, this fermentation becomes specially desirable to kill their seeds. The drainings of a pig-stye form a most valuable liquid manure for vegetable crops.

Night-soil is an excellent manure for all bulky crops, but requires to be mixed with earth or peat, or coal-ashes, so as both to deodorize it and to ensure its being equally distributed. Quick lime should not be used, as it dispels the greater part of the ammonia. When prepared by drying and mixing with various substances, night-soil is sold as poudrette, or desiccated night-soil, the value of which depends upon the materials used for admixture.

Malt-dust is an active manure frequently used as a top-dressing, especially for fruit trees in pots. It is rapid in its action, but its effects are not very permanent. *Rape dust* is somewhat similar in its character and action.

Bones are employed as a manure with decided advantage both to vegetable crops and to fruit trees, as well as to flowers. For turnips bone manure is invaluable. The effects of bones are no doubt mainly due to the phosphates they contain, and they are most effectual on dry soils. They are most quickly available when dissolved in sulphuric acid.

Guano is a valuable manure now much employed, and may be applied to almost every kind of crop with decided advantage. It should be mixed with six or eight times its weight of loam or ashes, charred peat, charcoal-dust, or some earthy matter, before it is applied to the soil, as from its causticity it is otherwise not unlikely to kill or injure the plants to which it is administered.

Pigeon dung approaches guano in its power as manure. It should be laid up in ridges of good loamy soil in alternate layers to form a compost, which becomes a valuable stimulant for any very choice subjects if cautiously used. The dung of the domestic fowl is very similar in character.

Horn, hoof-parings, woollen rags, fish, blubber, and *blood* are all good manures, and should be utilized if readily obtainable. *Sawdust* and *tan* are of less value.

Liquid manure, consisting of the drainings of dung-heaps, stables, cowsheds, &c., or of urine collected from dwelling houses or other sources, is a most valuable and powerful stimulant, and can be readily applied to the roots of growing plants. The urine should be allowed to putrefy, as in its decomposition a large amount of ammonia is formed, which should then be fixed by sulphuric acid or gypsum; or it may be applied to the growing crops after being freely diluted with water or absorbed in a compost heap. Liquid manures can be readily made from most of the solid manures when required, simply by admixture with water. When thus artificially compounded, unless for immediate use, they should be made strong for convenience of storage, and applied as required much diluted.

Inorganic manures. *Ammonia* is the most powerful of the manures of the inorganic series, and one of the most important of the constituents of manures generally, since it is the chief source whence plants derive their nitrogen. It is largely supplied in all the most fertilizing of organic manures, but when required in the inorganic state must be obtained from some of the salts of ammonia, as the sulphate, the muriate, or the phosphate, all of which, being extremely energetic, require to be used with great caution. These salts of ammonia may be used at the rate of from 2 to 3 cwt. per acre as a top-dressing in moist weather. When dissolved in water they form active liquid manures.

Potash and *soda* are also valuable inorganic manures in the form of carbonates, sulphates, silicates, and phosphates, but the most extensively employed is the nitrate of potash. The manures of this class are of course of value only in cases where the soil is naturally deficient in them. On this account the salts of soda are of less importance than those of potash. The value of wood ashes as a manure very much depends upon the carbonate and other salts of potash which they contain.

Lime in the caustic state is beneficially applied to soils which contain an excess of inert vegetable matter, and hence may be used for the improvement of old garden soils saturated with humus, or of peaty soils not thoroughly reclaimed. It does not supply the place of organic manures, but only renders that which is present available for the nourishment of the plants. It also improves the texture of clay soils.

Gypsum, or sulphate of lime, applied as a top-dressing at the rate of 2 to 3 cwt. per acre, has been found to yield good results, especially on light soils. It is also employed in the case of liquid manures to fix the ammonia.

Burnt clay has a very beneficial effect on clay land by improving its texture and rendering soluble the alkaline substances it contains. The clay should be only slightly burnt, so as to make it crumble down readily; in fact, the fire should not be allowed to break through, but should be constantly repressed by the addition of material. The burning should be effected when the soil is dry.

Vegetable refuse of all kinds, when smother-burned in a similar way, becomes a valuable mechanical improver of the soil; but the preferable course is to decompose it in a heap with quick lime and layers of earth, converting it into leaf-mould.

Soot forms a good top-dressing; it consists principally of charcoal, but contains ammonia, whence its value as a manure is derived. It should be kept dry until required for use. It may also be used beneficially in preventing the attacks of insects, such as the onion gnat and turnip fly, by dusting the plants or dressing the ground with it.

Common salt acts as a manure when used in moderate quantities, but in strong doses is injurious to vegetation. It suits many of the esculent crops, as onions, beans, cabbages, carrots, beet-root, asparagus, &c.; the quantity applied varies from 5 to 10 bushels per acre. It is used as a top-dressing sown by the hand. Hyacinths and other bulbs derive benefit from slight doses, while to asparagus as much as 20 lb to the rood has been used with beneficial effect. At the rate of from 6 to 10 bushels to the acre it may be used on garden lawns to prevent worm casts. For the destruction of weeds on gravel walks or in paved yards a strong dose of salt, applied either dry or in solution, is found very effective, especially a hot solution, but after a time much of it becomes washed down, and the residue acts as a manure; its continued application is undesirable, as gravel so treated becomes pasty.

20. *Tools, Implements, &c.*—With regard to garden tools, instruments, implements, and machinery, it is only some of the more modern inventions and improvements that can be touched on here. The two indispensable tools are the spade and the knife. The spade is commonly used for digging and trenching, but much of this work is now better done by means of Parkes's digging-fork (fig. 42), which is both handier and lighter, and breaks up the ground better than the spade. The pickfork or Canterbury hoe (fig. 43) is a very useful tool for breaking up the surface soil, the three-pronged end being used for the looser parts, and the mattock end for breaking clods, or when the surface has become much consolidated. The drag (fig. 44) is also useful—a light three-pronged tool, which may be used for loosening the soil amongst vegetable crops as well as flower garden plants, and may also be sometimes employed, if the tines are sufficiently narrow and pointed, to drag off weeds from the surface. The hand-fork (fig. 45), a short-

Tools.

Fig. 42.—Parkes's Digging-Fork.

Fig. 43.—Pickfork.

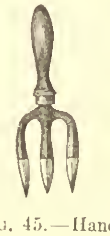

Fig. 45.—Hand-Fork.

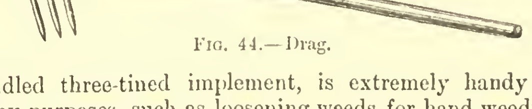

Fig. 44.—Drag.

handled three-tined implement, is extremely handy for many purposes, such as loosening weeds for hand-weeding, or for planting or transplanting small subjects; it is also very handy for plunging pots, either indoors or out, in tan-beds, ash-beds, or common soil. Hoes and rakes made with a tapered neck and socket, into which the handle is fitted, do not clog so readily as when they are driven into a ferruled handle.

For pruning purposes a variety of instruments have been invented, under the names of sécateurs, pruning-shears, pruning-scissors, &c., but nothing equals a well-tempered old-fashioned knife, varied in form, strength, and size to suit the particular object to be operated on. The averruncator is a useful instrument for cutting branches at a considerable elevation (12 to 15 feet) from the ground. Selby's flower gatherer (fig. 46), which cuts and holds the

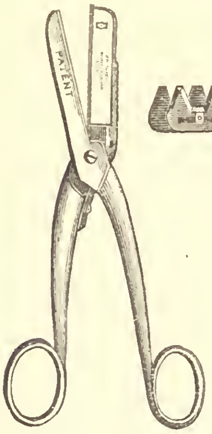

Fig. 46.—Selby's Flower Gatherer.

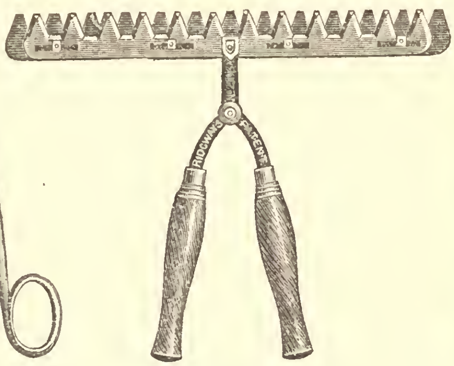

Fig. 47.—Ridgway's Hedge-Cutter.

flower at the same time, may be recommended, especially for the use of ladies. Some of the fruit gatherers also are ingenious and useful. A new instrument for clipping hedges, Ridgway's hedge-cutter (fig. 47), does its work quickly and well; and the same can be said for Adie's new lawn-edging machine.

For the destruction of insects Dean's and Appleby's and Dreschler's fumigators are all useful, but an equally efficient plan is to put a few live embers in a flower-pot, raised on two bricks so placed as not to close the hole at the bottom; on these embers moistened tobacco or tobacco paper is to be put, and over all damped moss. This will burn slowly and fill the house with smoke, care being taken that the material, as it dries, is lightly sprinkled with water, so that it does not burst into a flame.

Sulphurators are instruments for distributing flowers of sulphur, for the purpose of destroying mildew. In the case of greenhouse plants, such as heaths, simply dusting with sulphur through a muslin bag or dredger is sufficient; but in cases where vines are attacked with the *Oidium* or vine-mildew, the saving of the crop depends on the prompt diffusion of sulphur over all the affected parts, and this could not be so readily done by any other contrivance as by some one of the various forms of sulphurator (figs. 48, 49).

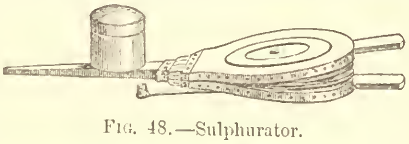

Fig. 48.—Sulphurator.

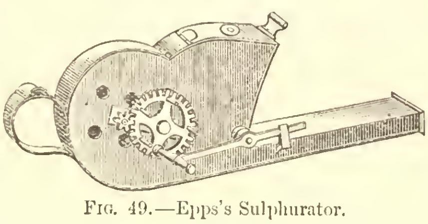

Fig. 49.—Epps's Sulphurator.

For the distribution of water in the form of spray, syringes are used, and of these there are none better than Read's patent, which acts by a piston and ball valve; while for the more powerful garden engines, those manufactured by Read (fig. 50) and Warner have the preference.

Fig. 50.—Read's Garden Engine.

Tallies. *Tallies* of wood should be slightly smeared with white paint and then written on while damp with a black-lead pencil. To preserve them from decay they should first be soaked in linseed oil. Zinc tallies are the best, on account of their durability, if written upon with a proper ink,—12 grains of bichloride of platinum dissolved in 1 oz. of distilled water. Larger labels of various materials and patterns are provided for trees and shrubs, and other permanent outdoor plants. Lead labels with stamped figures are very useful. For numbering pot plants, these may be wedge-shaped and bent over close to the pot-rim; for collections of plants they should be small and light, so that the suspending wire may not cut into the bark of the plants. Zinc labels with the names shown in relief are to be recommended when they can be obtained ready made, but are too expensive when they have to be specially prepared.

IV. *Garden Operations.*

Propagation. 21. *Propagation.*—The increase of plants, so far as the production of new individuals of particular kinds is concerned, is one of the most important and constantly recurring of gardening operations. In effecting this, various processes are adopted, which will now be described.

Seeds. (1) *By Seeds.*—This may be called the natural means of increasing the number of any particular kind of plant, but it is to be remembered that we do not by that means secure an exact reproduction of the parent. We may get a progeny very closely resembling it, yet each plant possessing a distinct individuality of its own; or we may get a progeny very unlike the parent, or a mixed progeny showing various degrees of divergence. Many seeds will grow freely if sown in a partially ripened state; but as a general rule seeds have to be kept for some weeks or months in store, and hence they should be thoroughly ripened before being gathered. They should be sown in fine rich soil, and such as will not readily get consolidated. In the case of outdoor crops, if the soil is inclined to be heavy, it is a good plan to cover all the smaller seeds with a light compost. Very small seeds should only have a sprinkling of light earth or of sand, and sometimes only a thin layer of soft moss to exclude light and preserve an equable degree of moisture. Somewhat larger seeds sown indoors may be covered to the depth of one-eighth or one-fourth of an inch, according to their size. Outdoor crops require to be sown, the smaller seeds from half an inch to an inch, and the larger ones from 2 to 4 inches under the surface, the covering of the smaller ones especially being light and open. Many seeds grow well when raked in; that is, the surface on which they are scattered is raked backwards and forwards until most of them are covered. Whatever the seeds, the ground should be made tolerably firm both beneath and above them; this may be done by treading in the case of most kitchen garden crops, which are also better sown in drills, this admitting the more readily of the ground being kept clear from weeds by hoeing. All seeds require a certain degree of heat to induce germination. For tropical plants the heat of a propagating house—75° to 80°, with a bottom heat of 80° to 90°—is desirable, and in many cases absolutely necessary; for others, such as half-hardy annuals, a mild hot bed, or a temperate pit ranging from 60° to 70°, is convenient; while of course all outdoor crops have to submit to the natural temperature of the season. It is very important that seeds should be sown when the ground is in a good working condition, and not clammy with moisture.

Offsets.

(2) *By Offsets.*—This mode of increase applies specially to bulbous plants, such as the lily and hyacinth, which produce little bulbs on the exterior round their base. Most bulbs do so naturally to a limited but variable extent; when more rapid increase is wanted the heart is destroyed, and this induces the formation of a larger number of offsets. The stem bulbs of lilies are similar in character to the offsets from the parent bulb. The same mode of increase occurs in the gladiolus and crocus, but their bulb-like permanent parts are called corms, not bulbs. After they have ripened in connexion with the parent bulb, the offsets are taken off, stored in appropriate places, and at the proper season planted out in nursery beds.

Tubers.

(3) *By Tubers.*—The tuber is a fleshy underground stem, furnished with eyes which are either visible, as in the potato and in some familiar kinds of *Tropæolum* (*T. tuberosum*) and of *Oxalis* (*O. crenata*), or latent, as in the Chinese yam (*Dioscorea Batatas*). For a fuller description see BOTANY, vol. iv. p. 98. When used for propagation, the tubers are cut up into what are called "sets," every portion having an eye attached being capable of forming an independent plant. The cut portions of bulky sets should be suffered to lie a short time before being planted, in order to dry the surface and prevent rotting; this should not, however, be done with such tropical subjects as caladiums, the tubers of which are often cut up into very small fragments for propagation, and of course require to be manipulated in a properly heated propagating pit. No eyes are visible in the Chinese yam, but slices of the long club-shaped tubers will push out young shoots and form independent plants, if planted with ordinary care.

Division.

(4) *By Division.*—Division, or partition, is usually resorted to in the case of tufted growing plants, chiefly perennial herbs; they may be evergreen, as chamomile or thrift, or when dormant may consist only of underground crowns, as larkspur or lily-of-the-valley; but in either case the old tufted plant being dug up may be divided into separate pieces, each furnished with roots, and, when replanted, generally starting on its own account without much check. Suffruticose plants and even small shrubs may be propagated in this way, by first planting them deeper than they are ordinarily grown, and then after the lapse of a year, which time they require to get rooted, taking them up again and dividing them into parts or separate plants. Box-edging and southernwood are examples. The same ends may sometimes be effected by merely working fine soil in amongst the base of the stems, and giving them time to throw out roots before parting them.

Suckers.

(5) *By Suckers.*—Root suckers are young shoots from the roots of plants, chiefly woody plants, as may often be seen in the case of the elm and the plum. The shoots when used for propagation must be transplanted with all the roots attached to them, care being taken not to injure the parent plant. If they spring from a thick root it is not to be wantonly severed, but the soil should be removed and the sucker taken off by cutting away a clean slice of the root, which will then heal and sustain no harm. Stem suckers are such as proceed from the base of the stem, as is often seen in the case of the currant and lilac. They should be removed

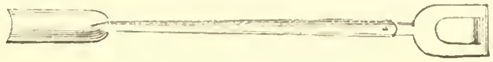

FIG. 51.—Suckering Iron.

in any case; when required for propagation they should be taken with all the roots attached to them, and they should be as thoroughly disbudded below ground as possible, or they are liable to continue the habit of suckering. In this case, too, the soil should be carefully opened and the shoots removed with a suckering iron, a sharp concave implement with long iron handle (fig. 51). When the number of roots is limited, the tops should be shortened, and some care in watering and mulching should be bestowed on the plant if it is of value.

(6) *By Runners.*—A definition of runners will be found in BOTANY, vol. iv. p. 97. The young string-like shoots produced by the strawberry are a well-known example of them. The process of rooting these runners should be facilitated by fixing them close down to the soil, which is done by small wooden hooked pegs or by stones; hair-pins, short lengths of bent wire, &c., may also be used. After the roots are formed, the strings are cut through, and the runners become independent plants.

Prolif- ousbu

(7) *By Proliferous Buds.*—Not unlike the runner, though growing in a very different way, are the bud-plants formed on the fronds of several kinds of ferns belonging to the genera *Asplenium*, *Woodwardia*, *Polystichum*, *Lastrea*, *Adiantum*, *Cystopteris*, &c. In some of these (*Adiantum caudatum*, *Polystichum lepidocaulon*) the rachis of the frond is lengthened out much like the string of the strawberry runner, and bears a plant at its apex. In others (*Polystichum angulare proliferum*), the stipes below and the rachis amongst the pinnæ develop buds, which are often numerous and crowded. In others again (*Woodwardia orientalis*, *Asplenium bulbiferum*), buds are numerously produced on the upper surface of the fronds. These will develop on the plant if allowed to remain. For propagation the bulbiferous portion is pegged down on the surface of a pot of suitable soil; if kept close in a moist atmosphere, the little buds will soon strike root and form independent plants. In the *Cystopteris* the buds are deciduous, falling off as the fronds acquire maturity, but, if collected and pressed into the surface of a pot of soil and kept close, they will grow up into young plants the following season.

Layer

(8) *By Layers.*—Layering consists in preparing the branch of a plant while still attached to the parent, bending it so that the part operated on is brought under ground, and then fixing it there by means of a forked peg. Some plants root so freely that they need only pegging down; but in most cases the arrest of the returning sap to form a callus, and ultimately young roots, must be brought about artificially, either by twisting the branch, by splitting it, by girding it closely with wire, by taking off a ring of bark, or by "tonguing." In tonguing the leaves are cut off the portion which has to be brought under ground, and a tongue or slit is then cut from below upwards close beyond a joint, of such length that, when the cut part of the layer is pegged an inch or two (or in larger woody subjects 3 or 4 inches) below the surface, the elevation of the point of the shoot to an upright position may

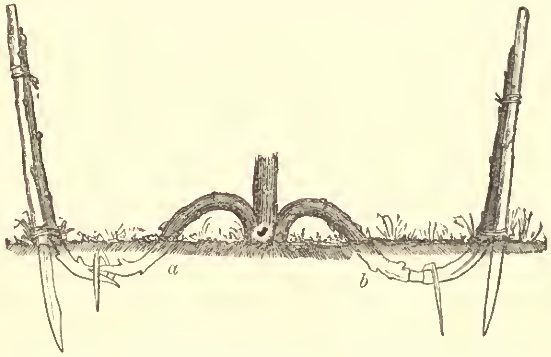

FIG. 52.—Propagation by Layers—*a*, tonguing; *b*, ringing.

open the incision, and thus set it free, so that it may be surrounded by earth to induce it to form roots. The whole branch, except a few buds at the extremity, is covered with soil. The best seasons for these operations are early spring and midsummer, that is, before the sap begins to flow, and after the first flush of growth has passed off. One whole summer, sometimes two, must elapse before the layers will be fully rooted in the case of woody plants; but such plants as carnations and picotees, which are usually propagated in this way, in favourable seasons take only a few weeks to root, as they are layered towards the end of the blooming season in July, and are taken off and planted separately early in the autumn. Fig. 52 shows a woody plant with one layer prepared by tonguing and another by ringing.

In general, each shoot makes one layer, but in plants like the *Wistaria* or *Clematis*, which make long shoots, what is called serpentine layering may be adopted; that is, the shoot is taken alternately below and above the surface, as frequently as its length permits. There must, however, be a joint at the underground part where it is to be tongued and pegged, and at least one sound bud in each exposed part, from which a shoot may be developed to form the top of the young plant.

Circu posit

(9) *By Circumposition.*—When a plant is too high or its habit does not conveniently admit of its being layered, it may often be increased by what is called circumposition, the soil being carried up to the branch operated on. The branch is to be prepared by ringing or notching or wiring as in layering, and a temporary stand made to support the vessel which is to contain the soil. The vessel may be a flower-pot sawn in two, so that the halves may be bound together when used, or it may be a flower-pot or box with a side slit which will admit the shoot; this vessel is to be

filled compactly with suitable porous earth, the opening at the slit being stopped by pieces of slate or tile. The earth must be kept moist, which is perhaps best done by a thick mulching of moss, the moss being also bound closely over the openings in the vessel, and all being kept damp by frequent syringings. Reid remarks of this method of propagation that he has effected it with clay and cow dung, well mixed, after the bark had been taken off all round, and wrapped about with a double or triple swaddling of straw or hay ropes (*Scots Gardener*, 1721).

This process is sometimes found very useful in the case of choice conservatory plants which may be getting too tall for the house, such as a fine *Dracæna* (fig. 53) or *Yucca*. Such a plant may be operated on wherever the stem has become firm and woody; the top will not fail to make a fine young specimen plant, which might be removed in the course of about twelve months, while other shoots would no doubt be obtained from the old stem, which, with its head thus reduced, might be removed to quarters where it would not be an eyesore. The head would perhaps require steadying if the stem were loaded with a pot or box of soil, as at *a* in the figure. Mr Bain records (*Paxt. Mag. Bot.*, xvi. 46) a successful experiment of this kind with a *Dracæna Draco* which was getting too tall for its position. An incision was made in the stem half an inch deep to the extent of half its circumference, lime being applied to the wound to dry up the sap. This incision was from time to time deepened (and lime-dried) until severed, the top being suspended from the roof. After some months roots were protruded from between the woody structure and its bush-like covering, and the gigantic cutting was lowered into its place, and grew away freely. In this case Mr Bain was of opinion that success was due to the slowness of the process and the precautions taken to dry and harden the stem.

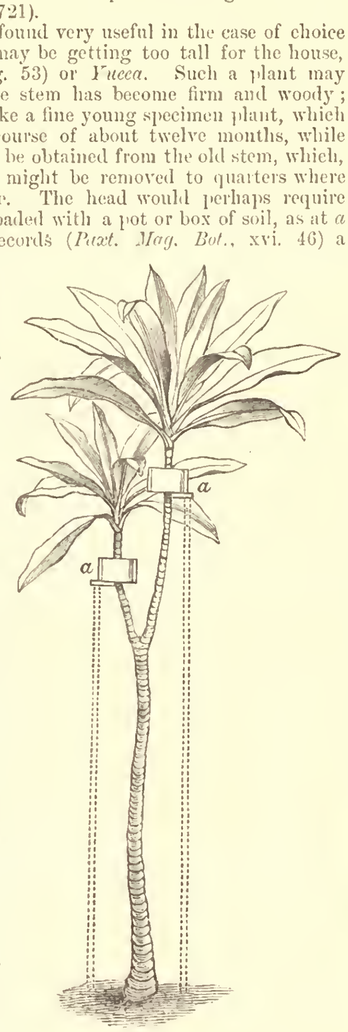

Fig. 53.

rafts. (10) *By Grafts.*—Grafting is so extensively resorted to that it is impossible here to notice all its phases. It is perhaps of most importance as the principal means of propagating our hardy kinds of fruit, especially the apple and the pear; but the process is the same with most other fruits and ornamental hardy trees and shrubs that are thus propagated. The stocks are commonly divided into two classes:—(1) free stocks, which consist of seedling plants, chiefly of the same genus or species as the trees from which the scions are taken; and (2) dwarfing stocks, which are of more diminutive growth, either varieties of the same species or species of the same or some allied genus as the scion, which have a tendency to lessen the expansion of the engrafted tree. The French Paradise is the best dwarfing stock for apples, and the quince for pears. In determining the choice of stocks, the nature of the soil in which the grafted trees are to grow should have full weight. In a soil, for example, naturally moist, it is proper to graft pears on the quince, because this plant not only thrives in such a soil, but serves to check the luxuriance thereby produced. The scions should always be portions of the wood of the preceding year, selected from healthy parents; in the case of shy-bearing kinds, it is better to obtain them from the fruitful branches. The scions should be taken off some weeks before they are wanted, and half-buried in the earth, since the stock at the time of grafting should in point of vegetation be somewhat in advance of the graft. During winter, grafts may be conveyed long distances, if carefully packed. If they have been six weeks or two months separated from the parent plant, they should be grafted low on the stock, and the earth should be ridged up round them, leaving only one bud of the scion exposed above ground. The best season for grafting apples and similar hardy subjects is the month of March; but it may be commenced as soon as the sap in the stock is fairly in motion, and may be continued during the first half of April.

Whip-grafting or *Tongue-grafting* (fig. 54) is the most usual mode of performing the operation. The stock is headed off by an oblique transverse cut as shown at *a*, a slice is then pared off the side as at *b*, and on the face of this a tongue or notch is made, the cut being in a downward direction; the scion *c* is pared off in a similar way by a single clean sharp cut, and this is notched or tongued in the opposite direction as the figure indicates; the two are then fitted together as shown at *d*, so that the inner bark of each may come in contact at least on one side, and then tied round with damp soft bast as at *e*; next some grafting clay is taken on the forefinger and

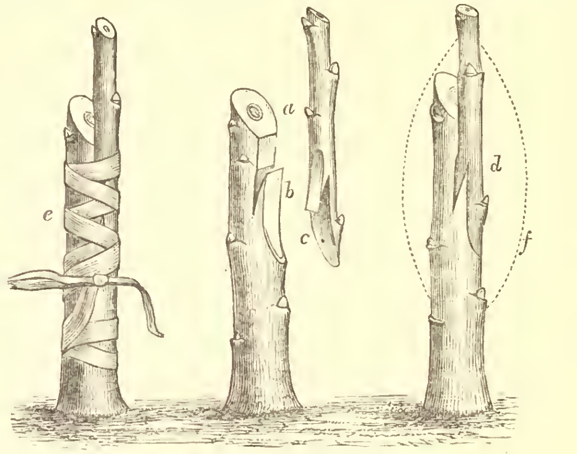

Fig. 54.—Whip-Grafting or Tongue-Grafting.

pushed down on each side so as to fill out the space between the top of the stock and the graft, and a portion is also rubbed over the ligatures on the side where the graft is placed, a handful of the clay is then taken, flattened out, and rolled closely round the whole point of junction, being finished off to a tapering form both above and below, as shown by the dotted line *f*. To do this deftly, the hands should be plunged from time to time in dry ashes, to prevent the clay from sticking to them.

Cleft-grafting (fig. 55) is another method in common use. The stock *a* is cleft down from the horizontal cut *d*, and the scion, when cut to a thin wedge form, as shown at *c* and *e*, is inserted into the cleft; the whole is then bound up and clayed as in the former case. This is not so good a plan as whip-grafting; it is improved by sloping the stock on one side to the size of the graft.

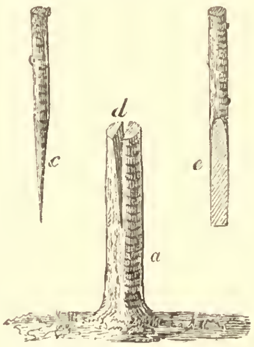

Fig. 55.—Cleft-Grafting.

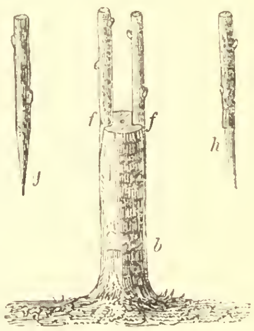

Fig. 56.—Crown-Grafting.

Crown-grafting or *Rind-grafting* (fig. 56) is preferable to cleft-grafting, inasmuch as it leaves no open spaces in the wood. The stock *b* is cut off horizontally or nearly so, and a slit is then cut in the bark *f, f*, a wedge-shaped piece of ivory being inserted to raise the bark; the scion is then cut to the same wedge-shaped form *g, h*, and inserted in the space opened for it between the albumen and the bark, after which it is tied down and clayed over in the manner already described.

Side-grafting is performed like whip-grafting, the graft being inserted on the side of a branch and not at the cut end of the stock. It may be practised for the purpose of changing a part of the tree, and is sometimes very useful for filling out vacant spaces, in trained trees especially.

Inarching is another form of side-grafting. Here the graft is fixed to the side of the stock, which is planted or potted close to the plant to be worked. The branches are applied to the stock while yet attached to the parent tree, and remain so until united. In the case of trained trees, a young shoot is sometimes inarched to its parent stem to supply a branch where one has not been developed in the ordinary way.

For the propagation by grafts of stove and greenhouse plants the process adopted is whip-grafting or a modification of it. The parts are, however, sometimes so small that the tongue of the graft is dispensed with, and the two stems simply pared smooth and bound together. In this way hardy rhododendrons of choice sorts, greenhouse azaleas, the varieties of the orange family, camellias, roses, rare conifers, and numerous other plants are increased. In small subjects soft cotton is used for tying instead of bast, and grafting-wax is substituted for grafting-clay. The best is the French cold mastic "L'Homme Lefort." All grafting of this kind is done in the propagating house, at any season when grafts are obtainable in a fit state,—the plants when operated on being placed in close frames warmed to a suitable temperature.

Root-grafting is sometimes resorted to where extensive increase is an object, or where stem-grafting or other means of propagation are n t available. In this case the scion is grafted directly on to a portion of the root of some appropriate stock, both graft and stock being usually very small; the grafted root is then potted so as to cover the point of junction with the soil, and is plunged in the bed of the propagating house, where it gets the slight stimulus of a gentle bottom heat. Dahlias (fig. 57) and pæonies may be grafted

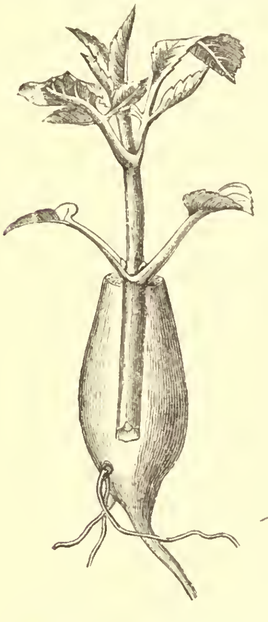

Fig. 57.—Root-Grafting of Dahlia.

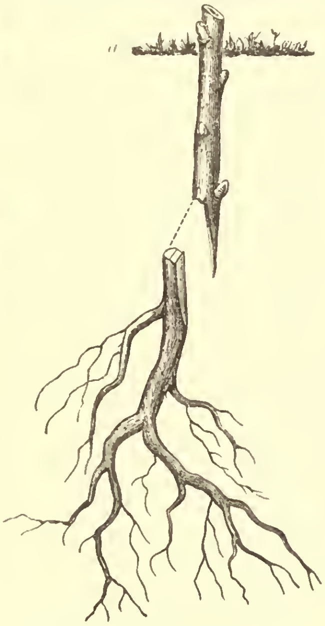

Fig. 58.—Root-Grafting of Woody Plant.

by inserting young shoots into the neck of one of the fleshy roots of each kind respectively—the best method of doing so being to cut a triangular section near the upper end of the root, just large enough to admit the young shoot when slightly pared away on two sides to give it a similar form. In the case of large woody plants thus worked (fig. 58) the grafted roots, after the operation is completed, are planted in nursery beds, so that the upper buds only are exposed to the atmosphere, as shown at *c* in the figure.

uds. (11) *By Buds.*—Budding is the inserting of a bud cut with a portion of bark of the plant to be propagated into the bark of the stock, where it is bound gently but firmly. Stone fruits, such as peaches, apricots, plums, cherries, &c., are propagated in this way, as well as roses, and many other plants. In the propagating house budding may be done at any season when the sap is in motion; but for fruit trees, roses, &c., in the open air, it is usually done in July or August, when the buds destined for the following year are completely formed in the axils of the leaves, and when the bark separates freely from the wood it covers. Those buds are to be preferred, as being best ripened, which occur on the middle portion of a young shoot.

The simplest and most generally practised form of budding is that called *Shield-budding or* T-*budding* (fig. 59). The operator should be provided with a budding-knife in which the cutting edge of the blade is rounded off at the point, and which has a thin ivory or bone handle, for raising the bark of the stock. A horizontal incision is made in the bark quite down to the wood, and from this a perpendicular slit is drawn downwards to the extent of perhaps an inch, so that the slit has a resemblance to the letter T, as at *a*. A bud is then cut by a clean incision from the tree intended to be propagated, having a portion of the wood attached to it, and so that the whole may be an inch and a half long, as at *d*. The bit of wood *e* must be gently withdrawn, care being taken that the bud adheres wholly to the bark or shield, as it is called, of which *f* is a side view. The bark on each side of the perpendicular slit being then cautiously opened, as at *b*, with the handle of the knife, the bud and shield are inserted as shown at *c*. The upper tip of the shield is cut off horizontally, and brought to fit the oark of the stock at the transverse incision. Slight ties of soft cotton wool or worsted, or even moist bast-matting, are then applied. In about a month or six weeks the ligatures may be taken away, when, if the operation has been

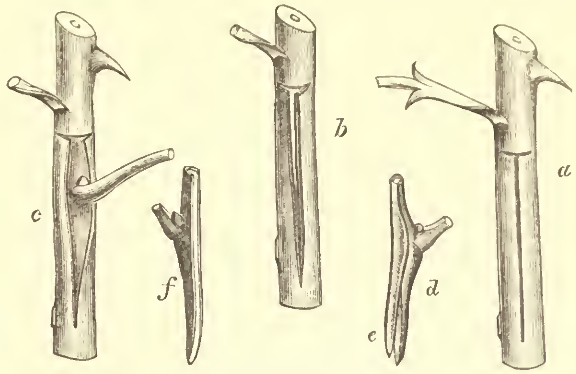

Fig. 59.—Shield-Budding.

successful, the bud will be fresh and full, and the shield firmly united to the wood. In the following spring a strong shoot will be thrown out, and to this the stock is headed down by gradations during the course of the summer.

To be successful the operation should be performed with a quick and light hand, so that no part of the delicate tissues be injured, as would happen if they were left for a time exposed, or if the bud were forced in like a wedge. The union is effected as in grafting, by means of the organizable sap or cambium, and the less this is disturbed until the inner bark of the shield is pressed and fixed against it the better. Inverted T-budding, in which the two incisions are in the form ⊥, is for some reasons preferable to the more ordinary method.

(12) *By Branch Cuttings.*—Propagation by cuttings is the mode of increase most commonly adopted, next to that by seeds. It is effected by taking a portion from a branch or shoot of the plant, and placing it in the soil. There are great differences to be observed in the selection and treatment of cuttings. Sometimes soft green shoots, as in *Verbena* (fig. 60, *a*), are used; sometimes the shoots must be half-ripened, and sometimes fully matured. So of the mode of preparation; some will root if cut off or broken off at any point and thrust into wet earth or sand in a warm place (fig. 60, *a*); others require to be cut with the utmost care just below a joint or leaf-base, and by a keen blade so as to sever the tissues without tearing or bruising; and others again after being cut across require to be split up for a short distance. It is usual and in most cases necessary to cut away the lower portion of a cutting up to just below the Branch cutting

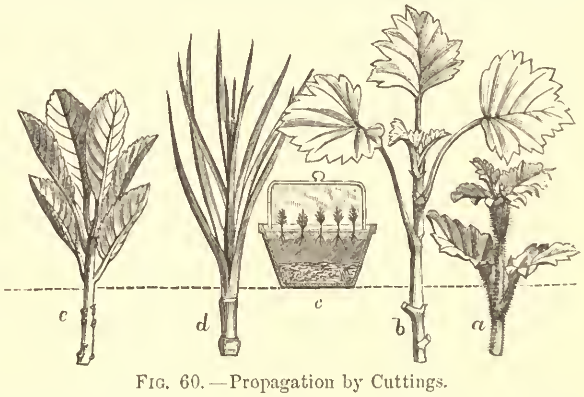

Fig. 60.—Propagation by Cuttings.

node or joint (fig. 60, *b*, *d*, *e*). The internodal parts will not often divide so as to form separate individual plants; sometimes, however, this happens; it is said that the smallest piece of *Torenia asiatica*, for instance, will grow. Then as to position, certain cuttings grow readily enough if planted outdoors in the open soil, some preferring shade, others sunshine, while less hardy subjects must be covered with a bell-glass, or must be in a close atmosphere with bottom heat, or must have the aid of pure silver sand to facilitate their rooting (fig. 60, *c*). Cuttings should in all cases be taken from healthy plants, and from shoots of a moderate degree of vigour. It is also important to select leafy growths, and not such as will at once run up to flower. Young shoots which have become moderately firm generally make the best cuttings, but sometimes the very softest shoots strike more readily. For all plants in a growing state spring is the safest time for taking cuttings.

Cuttings of deciduous plants should be taken off after the fall of the leaf, and should have all underground buds carefully removed so as to prevent as far as possible the formation of suckers. These cuttings should be about one foot in length, and should be planted at once in the ground so as to leave only the top with the two or three preserved buds exposed. If a clean stem, however, is desired, a longer portion may be left uncovered.

Cuttings of growing plants are prepared by removing with a sharp knife, and moderately close, the few leaves which would otherwise be buried in the soil; they are then cut clean across just below a joint; the fewer the leaves thus removed, however, the better, as if kept from being exhausted they help to supply the organizable matter out of which the roots are formed. Free-rooting subjects strike in any lightish sandy mixture; but difficult subjects should have thoroughly well-drained pots, a portion of the soil proper for the particular plants made very sandy, and a surfacing of clean sharp silver sand about as deep as the length of the cutting (fig. 60, *e*). Mr Ayres, writing in the *Gardeners' Chronicle* (1843, p. 116), recommends 5-inch pots for cuttings; and these he prepares by placing over the hole at the bottom of each an inverted 3-inch pot, around it potsherds broken small, over these some moss, and then the compost made up of equal quantities of peat, sand, and leaf-mould, leaving about half an inch at top for white sand, which runs into the holes as the cuttings are inserted. Mr Ayres advises that "a stock of pots thus prepared should be kept in a frame or propagating house, as nothing is so injurious to cuttings taken from plants growing in heat as to put them into cold soil. Cuttings cannot be too short if they have the necessary buds to form a plant; neither can they be inserted too shallow, if they are made firm in the pots."

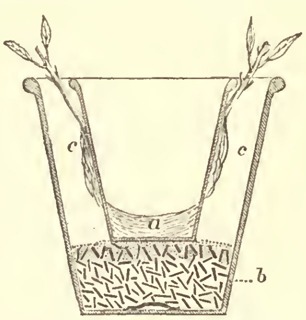

FIG. 61.—Double Cutting Pot.

All plants while striking may be kept in a temperature rather higher than that in which they grow naturally, and the soil about them should be kept moist, although they must not from want of drainage in any degree get sodden with wet. The humidity kept up about the cuttings is maintained by covering them with bell-glasses, or setting them in handlights or small glazed frames of convenient size.

A special contrivance for a cutting pot (fig. 61) was brought into notice many years ago by Mr A. Forsyth. A smaller pot was put into a larger one, the hole at the bottom being closed with clay *a*; the bottom of the outer pot is filled with crocks *b*, so that the small pot is brought up to the level of the larger one; and the space between the two pots *c* is filled with propagating soil, the cuttings being so planted that their ends rest against the sides of the inner pot, which is then filled with water, and this passing slowly through the sides of the pots, just keeps the soil moistened.

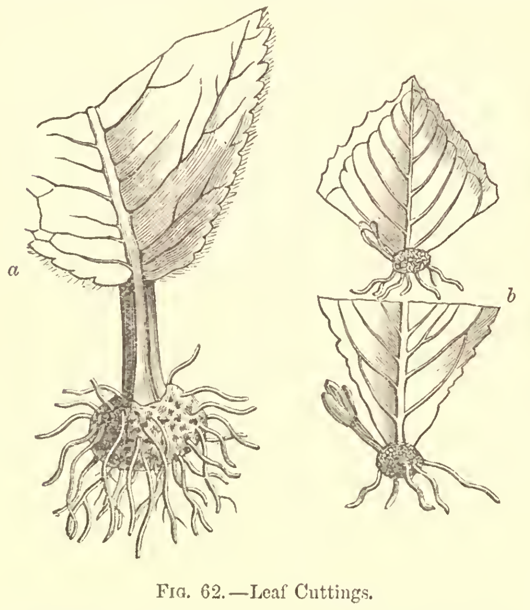

FIG. 62.—Leaf Cuttings.

Such delicate plants as heaths are reared in silver sand, a stratum of which is placed over the sandy peat soil in the cutting pot, and thus the cuttings, though rooting in the sand, find at once on the emission of roots congenial soil for them to grow in (fig. 60, *c*).

Hardy plants, such as pinks, pansies, &c., are propagated by cuttings planted during early summer in light rich soil. The cuttings of pinks are called pipings (fig. 60, *d*), and are planted about June, while pansies may be renewed in this way both in spring and in autumn.

(13) *By Leaf Cuttings.*—Many plants may be propagated by planting their leaves or portions of their leaves as cuttings, as, for example, the herbaceous *Gloxinia* (fig. 62, *a*) and *Gesnera*, the succulent *Sempervivum*, *Echeveria*, *Pachyphytum*, and their allies, and such hard-leaved plants as *Theophrasta* (fig. 62, *b*). The leaves are best taken off with the base whole, and should be planted in well-drained sandy soil; in due time they form roots, and ultimately from some latent bud a little shoot which forms the young plant. The treatment is precisely like that of branch cuttings. Gloxinias, begonias, &c., grow readily from fragments of the leaves cut clean through the thick veins and ribs, and planted edgewise like cuttings. This class of subjects may also be fixed flat on the surface of the cutting pot, by means of little pegs or hooks, the main ribs being cut across at intervals, and from these points roots, and eventually young tubers, will be produced (fig. 63). Leaf cuttings.


Fig. 63.—Leaf Propagation.

(14) *By Root Cuttings.*—Some plants which are not easily increased by other means propagate readily from root cuttings. Amongst the indoor plants which may be so treated, the *Bouvardia*, *Pelargonium*, *Aralia*, and *Wigandia* may be mentioned. The *modus operandi* is to turn the plant out of its pot, shake away the soil so as to free the roots, and then select as many pieces of the stouter roots as may be required. These are cut up into half-inch lengths (sometimes less), and inserted in light sandy soil round the margin of a cutting pot, so that the upper end of the root cutting may be level with the soil or only just covered by it. The pots should be watered so as to settle the soil, and be placed in the close atmosphere of the propagating pit or frame, where they will need scarcely any water until the buds are seen pushing through the surface. Root cuttings

There are various herbaceous plants which may be similarly treated, such as sea-kale and horseradish, and, among ornamental plants, the beautiful autumn-blooming *Anemone japonica* and *Senecio pulcher*. The sea-kale and horseradish require to be treated in the open garden, where the cut portions should be planted in lines in well-worked soil; but the roots of the *Anemone* and *Senecio* should be planted in pots and kept in a close frame with a little warmth till the young shoots have started.

Various hardy ornamental trees are also increased in this way, as the quince, elm, robinia, and mulberry, and the rose amongst shrubs. The most important use to which this mode of propagation is put is, however, the increase of roses, and of the various plums used as stocks for working the choicer stone fruits. The method in the latter case is to select roots averaging the thickness of the little finger, to cut these into lengths of about 3 or 4 inches, and to plant them in lines just beneath the surface in nursery beds. The root cuttings of rose-stocks are prepared and treated in a similar way.

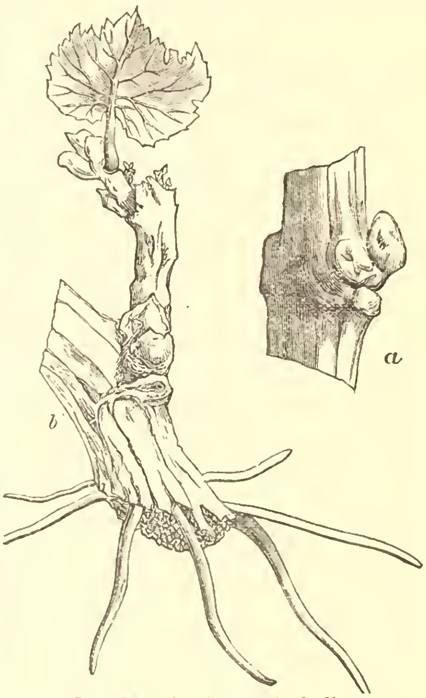

FIG. 64.—Cutting of Single Eye.

(15) *By Cuttings of Single Eyes.*—This mode of propagation is performed by cutting the branches into short lengths, each containing one well-matured bud or eye, with a short portion of the stem above and below. It is a common mode of propagating vines, the eyes Eye cuttings

being in this case cut from the ripened leafless wood. The eyes (fig. 64, *a*) are planted just below the surface in pots of light soil, which are placed in a hot bed or propagating pit, and in due time each pushes up a young shoot which forms the future stem, while from about its base the young roots are produced (fig. 64, *b*) which convert it into an independent plant. In the case of plants with persistent leaves, the stem may be cut through just above and below the bud, retaining the leaf which is left on the cutting, the old wood and eye being placed beneath the oil and the leaf left exposed. In this way the india-rubber tree (*Ficus elastica*), for example, and many other tender plants may be increased with the aid of a brisk bottom heat. Many of the free-growing soft-wooded plants may also be grown from cuttings of single joints of the young wood, where rapid increase is desired; and in the case of opposite-leaved plants two cuttings may often be made from one joint by splitting the stem longitudinally, each cutting consisting of a leaf and a perfect bud attached to half the thickness of the stem.

Trans-planting.

22. *Planting and Transplanting.*—In preparing a fruit tree for transplantation, the first thing to be done is to open a trench round it at a distance of from 3 to 4 feet, according to size. The trench should be opened to about two spades' depth, and any coarse roots which may extend thus far from the trunk may be cut clean off with a sharp knife. The soil between the trench and the stem is to be reduced as far as may seem necessary or practicable by means of a digging fork, the roots as soon as they are liberated being fixed on one side and carefully preserved. By working in this way all round the ball, the best roots will be got out and preserved, and the ball lightened of all superfluous soil. The tree will then be ready to lift if carefully prized up from beneath the ball, and if it does not lift readily, it will probably be found that a root has struck downwards, which will have to be sought out and cut through. Whenever practicable, it is best to secure a ball of earth round the roots. On the tree being lifted from its hole the roots should be examined, and all which have been severed roughly with the spade should have the ends cut smooth with the knife to facilitate the emission of fibres. The tree can then be transported to its new position. The hole for its reception should be of sufficient depth to allow the base of the ball of earth, or of the roots, to stand so that the point whence the uppermost roots spring from the stem may be 2 or 3 inches above the general surface level. Then the bottom being regulated so as to leave the soil rather highest in the centre, the plant is to be set in the hole in the position desired, and steadied there by hand. Next the roots from the lower portion of the ball are to be sought out and laid outwards in lines radiating from the stem, being distributed equally on all sides as nearly as this can be done; some fine and suitable good earth should be thrown amongst the roots as they are thus being placed, and worked in well up to the base of the ball. The soil covering the roots may be gently pressed down, but the tree should not be pulled up and down, as is sometimes done, to settle the soil. This done, another set of roots higher up the ball must be laid out in the same way, and again another, until the whole of the roots, thus carefully laid, are embedded as firmly as may be in the soil, which may now receive another gentle treading. The stem should next be supported permanently, either by one stake or by three, according to its size. The excavation will now be filled up about two-thirds perhaps; and if so the tree may have a thorough good watering, sufficient to settle the soil closely about its roots. After twenty-four hours the hole may be levelled in, with moderate treading, if the water has soaked well in, the surface being left slightly sloping upwards towards the stem of the tree. In transplanting trees of the ornamental class, less need be attempted in respect to providing new soil, although the soil should be made as congenial as practicable.

In transplanting smaller subjects, such as plants for the flower garden, much less effort is required. The plant must be lifted with as little injury to its rootlets as possible, and carefully set into the hole, the soil being filled in round it, and carefully pressed close by the hand. For moving small plants the garden trowel is a very convenient tool, but we are inclined to give the preference to the hand-fork (fig. 45). For larger masses, such as strong-growing herbaceous plants, a spade or digging-fork will be requisite.

When seedlings of vigorous plants have to be "pricked out," a dibble (fig. 64) is the best implement to be used. The ground being prepared and, if necessary, enriched, and the surface made fine and smooth, a hole is made with the dibble deep enough and large enough to receive the roots of the seedling plants without doubling them up, and the hole is filled in by working the soil close to the plant with the point of the dibble. The pricking out of seedlings in pots in the propagating pit is effected in a similar way. The plants, indeed, often require to be removed and set from half an inch to an inch apart before they have become sufficiently developed to admit of being handled with any degree of facility, and for these a pointed stick of convenient size is used as a dibble. In extreme cases it is best to lift the little seedling on the end of a flattish pointed stick, pressing this into the new soil where the plant is to be placed, and liberating it and closing the earth about it by the aid of a similar stick held in the other hand.

Large trees may be successfully transplanted by the aid of transplanting machines, of which different forms are in use. These will be found figured and described in the various horticultural and arboricultural publications. See, *e.g.*, M'Intosh's *Book of the Garden* (ii. p. 374 *sq.*). The best season for transplanting deciduous trees is during the early autumn months. As regards evergreens opinions are divided, some preferring August and September, others April or May. They can be successfully planted at either period, but for subjects which are at all difficult to remove the spring months are to be preferred.

Potting.

23. *Potting and Repotting.*—Garden pots are made with a comparatively large hole in the bottom, and those of the largest size have also holes at the side near the bottom; these openings are to prevent the soil becoming saturated or soured with superabundant water. To prepare the pot for the plant, a broadish piece of potsherd, called a "crock," is placed over the large hole, and if there be side holes they also are covered. The bottom crock is made from a piece of a broken garden pot, and is laid with the convex side upwards; then comes a layer of irregular pieces of crock of various sizes, about an inch deep in a 5-inch pot, 2 inches in an 11-inch or 12-inch pot, &c. The mode of crocking a pot is shown in fig. 65. A few of the coarser lumps from the outer edge of the heap of potting soil are spread over the crocks. The same end, that of keeping the finer particles of the soil from mixing with the drainage crocks, may be attained by shaking in a little clean moss. A handful or two of the soil is then put in, and on this the plant with its roots spread out is to be set a trifle higher than the plant should stand in the pot when finished off; more soil is to be added, and the whole pressed firmly with the fingers, the base of the stem being just below the pot-rim, and the surface being smoothed off so as to slope a little outwards. When finished off, the pots should be well watered, to settle the soil; but they should stand till the water has well drained away, since, if they are moved about while the fresh soil is very wet, there will be a risk of its becoming puddled or too much consolidated. Larger plants do not need quite such delicate treatment,

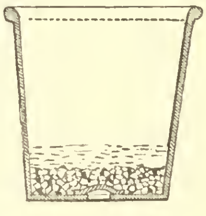

FIG. 65.—Section of Pot showing Crocks.

but care should be taken not to handle the roots roughly. The soil for these should be less comminuted, and the amount of drainage material more ample. Larger bodies of soil also require to be more thoroughly consolidated before watering; otherwise they would settle down so as to leave an unsightly void at the pot-rim.

Some plants, especially when potted temporarily, may be dealt with in a simpler way. A single crock may be used in some cases, and in others no crock at all, but a handful of half-decayed leaves or half-decayed dung thrown into the bottom of the pot. This mode of potting does well for bulbs, such as hyacinths, which are either thrown away or planted out when the bloom is over. The bedding plants generally may be potted in this way, the advantage being that at planting-out time there is less risk of disturbing the roots than if there were potsherds to remove. Plants of this character should be potted a little less firmly than specimens which are likely to stand long in the pot, and indeed the soil should be made comparatively light by the intermixture of leaf-mould or some equivalent, in order that the roots may run freely and quickly into it.

For epiphytal plants like orchids the most thorough drainage must be secured by the abundant use of potsherds, small pots being sometimes inserted inside the larger ones, or by planting in shallow pots or pans, so that there shall be no large mass of soil to get consolidated. For most of these the lightest spongy but sweet turfy peat must be used, this being packed lightly about the roots, and built up above the pot-rim, or in some cases freely mixed before use with chopped sphagnum moss and nodules of broken pots or of charcoal. The plants under these conditions often require to be supported by wooden pegs or sticks. Some of the species grow better when altogether taken out of the soil and fixed to blocks of wood, but in this case they require a little coaxing with moss about the roots until they get established. In other cases they are planted in open baskets of wood or wire, using the porous peat and sphagnum compost. Both blocks and baskets are usually suspended from the roof of the house, hanging free, so that no accumulation of water is possible. In these cases, however, the greatest caution is necessary to prevent the plants from suffering from drought.

When repotting is adopted as a temporary expedient, as in the case of bedding-out plants which it is required to push forward as much as possible, it will suffice if provision is made to prevent the drainage hole from getting blocked, and a rich light compost is provided for the encouragement of the roots. When, however, a hard-wooded plant has to be repotted, the case is different; it may stand without further potting for one year or two years or more, and therefore much more care is necessary. The old ball of earth must be freed from all or most of the old crocks without doing injury to the roots, and the sharp edge of the upper surface gently rubbed off. If there be any sour or sodden or effete soil into which the roots have not run, this should be carefully picked out with a pointed stick. The ball is to be set on the new soil just high enough that when finished the base of the stem may be about level with the pot-rim, towards which the surface should slope gently, and the space between the old ball and the sides of the pot is to be filled in gradually with the prepared compost, which is from time to time to be pressed down with a blunt-ended flat piece of wood called a potting-stick, so as to render the new soil as solid as the old. The object of this is to prevent the plant from starving by the water applied all running off by way of the new soil, and not penetrating the original ball of earth. When this amount of pressure is necessary, especially in the case of loamy composts, the soil itself should be rather inclined to dryness, and should in no case be sufficiently moist to knead together into a pasty mass. In ordinary cases the potting soil should be just so far removed from dryness that when a handful is gently pressed it may hang together, but may lose its cohesion when dropped.

When plants are required to stand in ornamental china pots or vases, it is better both for the plants and for avoiding risk of breakage to grow them in ordinary garden pots of a size that will drop into the more valuable vessels. Slate pots or tubs, usually square, are sometimes adopted, and are durable and otherwise unobjectionable, only, their sides being less porous, the earth does not dry so rapidly, and some modification of treatment as to watering is necessary. For large conservatory specimens wooden tubs, round or square, are frequently used; these should be coated with pitch inside to render them more durable.

Various other contrivances take the place of garden pots for special purposes. Thus shallow square or oblong wooden boxes, made of light inexpensive wood, are very useful for seed-sowing, for pricking out seedlings, or for planting cuttings. When the disturbance of the roots incidental to all transplanting is sought to be avoided, the seed or plant is started in some cases in squares of turf (used grassy-side downwards), which can when ready be transferred to the place the plant is to occupy. Cucumber and melon plants and vines reared from eyes are sometimes started in this way, both for the reason above mentioned, and because it prevents the curling of the roots apt to take place in plants raised in pots. Strips of turf are sometimes used for the rearing of early peas, which are sown in a warmish house or frame, and gradually hardened so as to bear exposure before removal to the open air.

24. *Watering.*—The guiding principle in watering plants is to do it thoroughly when it is required, and to abstain from giving a second supply till the first has been taken up. Watering.

When watering becomes necessary for kitchen-garden crops, the hose should be laid on and the lines of esculents allowed to drink their fill, if fresh succulent vegetables are desired. So also, if well-swelled and luscious fruits, such as strawberries, are required, there must be no parching at the roots. This applies even more strongly to conservatory borders and to forcing-houses than to the outside fruit-tree borders, because from these the natural rain supply is in most cases more distinctly cut off. In the case of forcing-houses, the water should be heated before being applied to the borders containing the roots of the trees.

In the watering of pot plants the utmost care is requisite if the plant be a shy-growing or valuable one, and yet it is almost impossible to give any intelligible instruction for performing the operation. The roots should never be suffered either to get thoroughly dry or to get sodden with excess of water. An adept will know by the ring of the pot on striking it with his knuckles whether water is wanted or not, according as it rings loud and clear or dull and heavy. With very choice subjects watering may be necessary two or three times a day in drying summer weather. It is a wrong though common practice to press the surface of the soil in the pot in order to feel if it is moist enough, as this soon consolidates it, and prevents it from getting the full benefit of aeration.

In all heated houses the water used should be warmed at least up to the temperature of the atmosphere, so as to avoid chilling the roots. This is also necessary in the case of water used for syringing the plants, which should be done two or three times a day in all stoves and forcing-houses, especially during the period when the young growth is being developed. The damping of all absorbent surfaces, such as the floors or bare walls, &c., is frequently necessary several times a day in the growing season, so as to keep up a humid atmosphere; hence the advantage of laying the floors a little rounded, as then the water draws off to the sides against the kerbstone, while the centre remains dry for promenaders.

In cooler structures it becomes necessary in the dull season of the year to prevent the slopping of water over the plants or on the floor, as this tends to cause "damping off,"—the stems assuming a state of mildewy decay, which not unfrequently, if it once attacks a plant, will destroy it piece by piece. For the same reason cleanliness and free ventilation are of great importance.

ning. 25. *Pruning.*—Pruning is a very important operation in the fruit garden, its object being twofold,—(1) to give form to the tree, and (2) to induce the free production of flower buds as the precursors of a plentiful crop of fruit. To form a standard tree, either the stock is allowed to grow up with a straight stem, by cutting away all side branches up to the height required, say about 6 feet, the scion or bud being worked at that point, and the head developed therefrom; or the stock is worked close to the ground, and the young shoot obtained therefrom is allowed to grow up in the same way, being pruned in its progress to keep it single and straight, and the top being cut off when the desired height is reached, so as to cause the growth of lateral shoots. If these are three or four in number, and fairly balanced as to strength and position, little pruning will be required. The tips of unripened wood should be cut back about one-third their length at an outwardly placed bud, and the chief pruning thereafter required will be to cut away inwardly directed shoots which cross or crowd each other and tend to confuse the centre of the tree. Bushy heads should be thinned out, and those that are too large cut back so as to remodel them. If the shoots produced are not sufficient in number, or are badly placed, or very unequal in vigour, the head should be cut back moderately close, leaving a few inches only of the young shoots, which should be pruned back to buds so placed as to furnish shoots in the positions desired. When worked at the top of a stem formed of the stock, the growth from the graft or bud must be pruned in a similar way. Three or four leading shoots should be selected to pass ere long into boughs and form a well-balanced skeleton for the tree; these boughs, however, will soon grow beyond any artificial system the pruner may adopt.

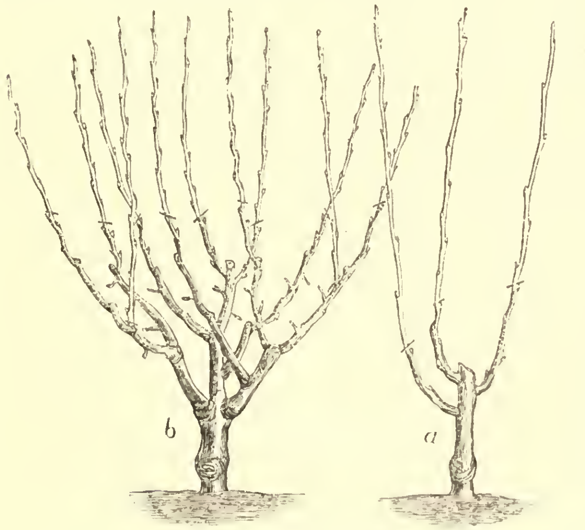

Fig. 66.—Dwarf-Tree Pruning.

To form a dwarf or bush fruit tree the stock must be worked near the ground, and the young shoot produced from the scion or bud must be cut back to whatever height it is desired the dwarf stem should be, say $1\frac{1}{2}$ to 2 feet. The young shoots produced from the portion of the new wood retained are to form the skeleton of the bush tree, and must be dealt with as in the case of standard trees. The growth of inwardly-directed shoots is to be prevented, and the centre kept open, the tree assuming a cup-shaped outline. Fig. 66, reduced from M. Hardy's excellent work, *Traité de la Taille des Arbres Fruitiers*, will give a good idea how these dwarf trees are to be manipulated, *a* showing the first year's development from the maiden tree after being headed back, and *b* the form assumed a year or two later.

In forming a pyramidal tree, the lateral growths, instead of being removed, as in the standard tree, are encouraged to the utmost; and in order to strengthen them the upper part of the leading shoot is removed annually, the side branches being also shortened somewhat as the tree advances in size. In fig. 67, reduced from M. Hardy's work,

Fig. 67.—Pyramid Pruning.

a shows a young tree with its second year's growth, the upright shoot of the maiden tree having been moderately headed back, being left longer if the buds near the base promise to break freely, or cut shorter if they are weak and wanting in vigour. The winter pruning, carried out with the view to shape the tree into a well-grown pyramid, would be effected at the places marked by a cross line. The lowest branch would have four buds retained, the end one being on the lower side of the branch. The two next would be cut to three buds, which here also are fortunately so situated that the upper one is on the lower side of the branches. The fourth is not cut at all, its terminal bud being allowed to grow to draw strength into it. The fifth is an example where the bud to which the shoot should be cut back is wrongly placed; a shoot resulting from such a cut is apt instead of growing outwards to grow erect, and lead to confusion in the form of the tree, to avoid which it is tied down in its proper place during the summer by a small twig. The upper shoots are cut closer in. Near the base of the stem are two prominent buds, which would produce two vigorous shoots, but these would be too near the ground, and the buds should therefore be suppressed; but, to strengthen the lower part, the weaker buds just above and below the lowest branch should be forced into growth, by making a transverse incision close above each. Fig. 67, *b* shows what a similar tree would be at the end of the third year's growth.

In order to bring a young tree into the cordon shape, all its side branches are shortened back, either to form permanent spurs, as in the case of pears, or to yield annual young shoots, as in peaches and nectarines. The single-stemmed cordon may be trained horizontally, obliquely at any required angle, or vertically if required, the first two arrangements being preferable. If a double cordon is required, the original young stem must be headed back, and the two best shoots produced must be selected, trained right and left, and treated as for the single cordon.

The forms chiefly adopted for trees trained to walls and espalier rails are the fan-shaped, the half-fan, and the horizontal, with their various modifications.

Of late years the close pruning of the young trees has been objected to, and the "extension system" has, in many cases, been adopted. The maiden tree is headed down, and two shoots led away right and left. Two laterals should be allowed to grow from the upper side of them, one from near the base, the other from near the middle, all others being pinched out beyond the second or third leaf during summer, but cut away to the last bud in winter. The tree will thus consist of six shoots, probably 3 feet to 4 feet long, which are not to be pruned unless they are unequal in strength, a defect which is rather to be remedied by summer pinching than by winter pruning. The second year three young shoots are to be left on each of the six, one close to the base, one about the middle, and one at the point, the rest being rubbed off. These three shoots will produce laterals, of which one or two may be selected and laid in; and thus a number of moderately strong fertile shoots will be obtained, and at the end of the season a comparatively large tree will be the result.

Fig. 68.—Pruning for Fan-Shaped Tree.

Fig. 69.—The same—third year.

The method of pruning formerly adopted for the formation of a fan-shaped tree was to head down the maiden plant to about two eyes, so placed as to yield a young shoot on each side (fig. 68), the supernumerary shoots being rubbed off while quite young, and the reserved shoots trained against the wall during the summer so as to get them well matured. The next year they were cut back again, often nearly to the base, in order that the lower pair of these shoots might each produce two well-placed young shoots, and the upper pair three young shoots. The tree would thus consist of ten shoots, to be laid out at regular distances, and then if closely cut the skeleton of the tree would be as in fig. 69. These main shoots were not again to be shortened back, but from each of them three young shoots were to be selected and trained in two, on the upper side, one near the base, and the other halfway up, and one on the lower side placed about midway between these two; these with the leading shoot, which was also to be nailed in, made four branches of the current year from each of the ten main branches, and the form of the tree would therefore be that of fig. 70. The other young shoots produced were pinched off while quite young, to throw all the strength of the tree into those which were to form its basis, and to secure abundant light and air. In after years the leading shoot was not to be cut back, but all

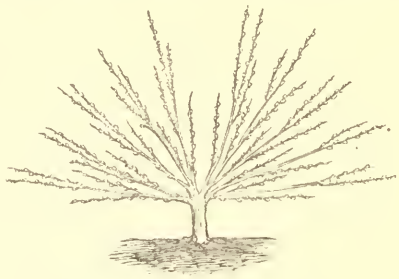

Fig. 70.—The same—fourth year.

the lateral shoots were to be shortened, and from these year by year other shoots were to be selected to fill up the area occupied by the tree.

In pruning for a horizontal tree the young maiden tree has to be headed back nearly to its base, and from the young shoots three are to be selected, the two best placed lower ones to form an opposite or nearly opposite pair of main branches, and the best placed upper one to continue the erect stem (fig. 71). This upper shoot is at the next winter pruning to be cut down to within about a foot of the

Fig. 71.—Pruning for Horizontally-Trained Tree.

Fig. 72.—The same—third year.

point whence it sprung, and its buds rubbed off except the upper one for a leader, and one on each side just below it to furnish another pair of side shoots; these being trained in position, the tree would appear as in fig. 72. The same course is to be followed annually till the space is filled. Sometimes in very favourable soils and with vigorous trees two pairs of branches may be obtained in one season by summer-stopping the erect shoots and selecting others from the young growths thus induced, but more commonly the trees have to be built up by forming one pair of branches

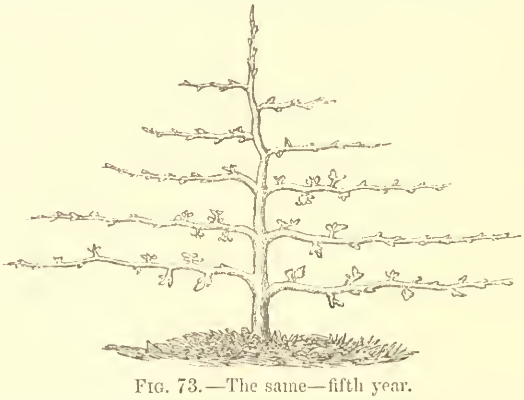

Fig. 73.—The same—fifth year.

annually. The shoots are not at first lowered to the horizontal line, but are brought down gradually; and while the tree is being formed weak shoots may be allowed to grow in a more erect position than it is ultimately intended they should occupy. Thus in four or five years the tree will have acquired something the character of fig. 73, and will go on thus increasing until the space is filled.

The half-fan is a combination of the two forms, but as regards pruning does not materially differ from the horizontal, as two opposite side branches are produced in succession upwards till the space is filled, only they are not taken out so abruptly, but are allowed to rise at an acute angle and then to curve into the horizontal line.

In all the various forms of cordons, in horizontal training, and in fan and half-fan training, the pruning of the main branches when the form of the tree is worked out will vary in accordance with the kind of fruit under treatment. Thus in the peach, nectarine, apricot, plum, and cherry, which are commonly trained fan-fashion, the first two will have to be pruned so as to keep a succession of young annual shoots, these being their fruit-bearing wood. The others are generally pruned so as to combine a moderate supply of young wood with a greater or less number of fruit spurs. In the pear and apple the fruit is borne principally on spurs, and hence what is known as spur-pruning has to be adopted, the young shoots being all cut back nearly to their base, so as to cause fruit buds to evolve from the remaining eyes or buds. Cordons of apples and pears have to be similarly treated, but cordons of peaches and nectarines are pruned so as to provide the necessary annual succession of young bearing wood.

The nature of the cut itself in pruning is of more consequence, especially in the case of fruit trees, than at first sight may appear. The branches should be separated by a clean cut at an angle of about 45°, just at the back of a bud, the cut entering on a level with the base of the bud and passing out on a level with its top (fig. 74, *a*), for when

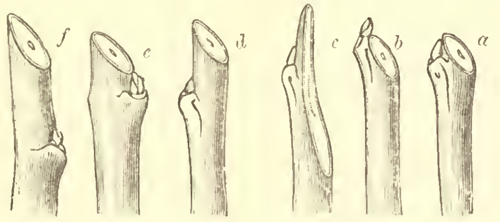

Fig. 74.—Cuts—Good and Bad.

cut in this way the wound becomes rapidly covered with new wood, as soon as growth recommences, whereas if the cut is too close the bud is starved, or if less close an ugly and awkward snag is left. Fig. 74, *b* and *c*, are examples of the former, and *d, e, f* of the latter. Dr Lindley has designated the cut shown at fig. 74, *b* the cut to the quick (*Gardeners' Chronicle*, 1847, p. 19):—

"In order to avoid the risk of the 'cut to the quick,' some gardeners make use of the 'snag cut' (*d, e, f*), in which the wound is made on the same side of the branch as that occupied by the bud, slanting downwards towards it. That plan is objectionable; for it involves the necessity of leaving behind a dead portion of the branch, to be removed at a later pruning, so the work must be done twice over; moreover, it is an admission of a want of the skill required to make the 'clean cut' skilfully. Lastly, there is the 'slivering cut' (*c*), in which a long ragged unequal shave is taken off the branch, much too low in the beginning, and much too high at the end. It is the cut made by garden labourers. It is clumsy, ugly, awkward, and dangerous, for it is apt to injure the branch on which it is made. In all cases, the amputation should be made by one firm-drawn cut. The clean cut can be performed by a dexterous operator to within a shaving of the right line; and the mastery of this art is no mean acquisition."

In the case of fruit trees, and indeed of deciduous plants generally, pruning requires to be done during the winter or resting period, and the earlier in that period the better, as then the buds become plump and full of sap, and produce strong shoots when the time for growth arrives. If, on the contrary, it is done while the plant is in full growth, the whole system of the tree sustains a check, the circulation is deranged, the quality of the sap becomes deteriorated, and a dead stump or unhealthy shoot is the frequent result. This, however, does not apply to the pruning of the herbaceous or succulent growths of the current season, nor to soft-wooded plants generally, for this kind of pruning, called summer pruning, is essential to the formation of handsome specimens of the latter, and is a very important help in the formation of the fruit or blossom buds of fruit trees.

Summer Pruning should be performed while the shoots are yet young and succulent, so that they may in most cases be nipped off with the thumb-nail. It is very necessary in the case of trees trained to a flat surface, as a wall or espalier rail, to prevent undue crowding. In some cases, as, for example, with peaches, the superfluous shoots are wholly removed, and certain selected shoots reserved to supply bearing wood for next year. In others, as pears, the tops of the young shoots are removed, leaving three or four leaves and their buds at the base, to be developed into fruit buds by the additional nourishment thus thrown into them (fig. 75, *a*). One or two may

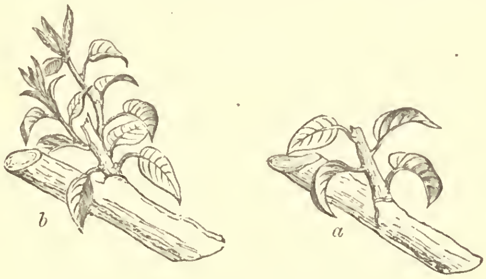

Fig. 75.—Summer Pruning for Spurs.

push out a late summer growth, *b*; this will serve as a vent for the vigour of the tree, and if the lowermost only go to the formation of a fruit spur, the object will have been gained. They are cut to the last dormant bud in winter.

But summer pruning has been much extended since the introduction of restricted growth and the use of dwarfing stocks. Orchard-house trees, and also pyramidal and bush trees of apples, pears, and plums, are mainly fashioned by summer pruning; in fact, the less the knife is used upon them, except in the necessary cutting of the roots in potted trees, the better. In the case of orchard-house plants no shoots are suffered to lengthen out, except as occasionally wanted to fill up a gap in the outline of the tree. On the contrary, the tops of all young shoots are pinched off when some three or four leaves are formed, and this is done again and again throughout the season. When this pruning is just brought to a balance with the vigour of the roots, the consequence is that fruit buds are formed all over the tree, instead of a thicket of sterile and useless wood. Pyramidal and bush trees out of doors are, of course, suffered to become somewhat larger, and sufficient wood must be allowed to grow to give them the form desired; but after the first year or two, when the framework is laid out, they are permitted to extend very slowly, and never to any great extent, while the young growths are continually nipped off, so as to clothe the branches with fruit buds as closely placed as will permit of their healthy development.[1]

The *Pruning of Flowering Plants* is generally a much lighter matter than the pruning of fruit trees. If a young seedling or cutting of any soft-wooded plant is to be bushy, it must have its top nipped out by the thumb-nail or pruning-scissors at a very early stage, and this stopping must be repeated frequently. If what is called a well-furnished plant is required, an average of from 2 to 3 inches is all the extension that must be per-

[1] On the general subject of pruning fruit trees the reader may usefully consult Thompson's *Gardener's Assistant*, Bréhaut's *Modern Peach Pruner*, Forney's *Jardinier Fruitier*, Hardy's *Traité de la Taille des Arbres Fruitiers*, and Dubreuil's *Culture des Arbres et Arbrisseaux à Fruits de Table*.

mitted—sometimes scarcely so much—before the top is nipped out; and this must be continued until the desired size is attained, whether that be large or small. Then generally the plant is allowed to grow away till bloom or blooming shoots are developed. To form a pyramidal plant, which is a very elegant and useful shape to give to a decorative pot plant, the main stem should be encouraged to grow upright, for a length perhaps of 6 or 8 inches before it is topped; this induces the formation of laterals, and favours their development. The best-placed upper young shoot is selected and trained upright to a slender stake, and this also is topped when it has advanced 6 or 8 inches further, in order to induce the laterals on the second portion to push freely. This process is continued till the required size is gained. With all the difficult and slow-growing plants of the hard-wooded section, all the pruning must be done in this gradual way in the young wood as the plant progresses.

Some plants, like pelargoniums, can only be kept handsomely formed and well furnished by cutting them down severely every season, after the blooming is over. The plants should be prepared for this by keeping them rather dry at the root, and after cutting they must stand with little or no water till the stems heal over, and produce young shoots, or "break," as it is technically termed. The appearance of a specimen pelargonium properly pruned is shown in fig. 76, in which *a* shows a young plant, the

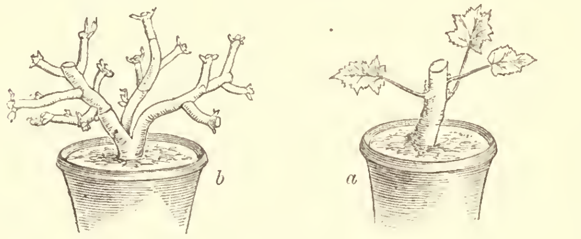

Fig. 76.

head of which has been taken off to form a cutting, and whose buds are ready to break into young shoots. Three shoots will be produced, and these, after growing from 4 to 6 inches in length, should be stopped by pinching out the point, this giving rise to lateral shoots. These will blossom in due course, and, after being ripened thoroughly by full exposure to the sun, should be cut back as shown at *b*. This is the proper foundation for a good specimen, and illustrates how all such subjects should be pruned to keep them stocky and presentable in form.

Root Pruning is most commonly practised in fruit tree cultivation. It is often resorted to as a means of restoring fertility in plants which have become over rank and sterile in growth. The effect of it, or of transplanting, is to reduce the supply of crude sap to the branches, and consequently to cause a check in their development. In root-pruning all roots that have struck downwards into a cold uncongenial subsoil must be pruned off if they cannot be turned in a lateral direction, and all the lateral ones that have become coarse and fibreless must also be shortened back by means of a clean cut with a sharp knife, while some hard rubbly material may if necessary be put under the tree before it is again planted, all its roots being laid out laterally, radiating as equally as possible from the centre. The operation is best performed early in autumn, and may be safely resorted to in the case of fruit trees of moderate age, and even of old trees if due care be exercised. In transplanting trees all the roots which may have become bruised or broken in the process of lifting should be cut clean away behind the broken part, as they then more readily strike out new roots from the cut parts. In all these cases the cut should be a clean sloping one, and made in an upward and outward direction.

The root-pruning of pot-plants is necessary in the case of many soft-wooded subjects which are grown on year after year—pelargoniums and fuchsias, for example. After the close pruning of the branches to which they are annually subjected, and when the young shoots have shot forth an inch or two in length, they are turned out of their pots and have the old soil shaken away from their roots, the longest of which, to the extent of about half the existing quantity, are then cut clean away, and the plants repotted into small pots. This permits the growing plant to be fed with rich fresh soil, without having been necessarily transferred to pots of unwieldy size by the time the flowering stage is reached.

Ringing.—One of the expedients for inducing a state of fruitfulness in trees, is the ringing of the branches or stem, that is, removing a narrow annular portion of the bark, by which means, it is said, the trees are not only rendered productive, but the quality of the fruit is at the same time improved. The advantage depends on the obstruction given to the descent of the sap. The ring should be cut out in spring, and be of such a width that the bark may remain separated for the season. A tight ligature of twine or wire answers the same end. The advantages of the operation may perhaps be gained by judicious root pruning, and it is not at all adapted for the various stone fruits. Ringi

26. *Training.*—What is called training is the guiding of the branches of a tree or plant in certain positions which they would not naturally assume, the object being partly to secure their full exposure to light, and partly to regulate the flow and distribution of the sap. To secure the former object, the branches must be so fixed as to shade each other as little as possible; and to realize the second, the branches must have given to them an upward or downward direction, as they may require to be encouraged or repressed. Something of the same vegetative vigour which is given to a plant or tree by hard pruning is afforded by training in an upward direction so as to promote the flow of the sap; while the repression effected by summer pruning is supplemented by downward training, which acts as a check. One main object is the pre- Traini

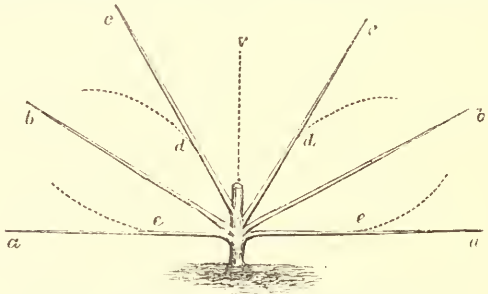

Fig. 77.—Diagram illustrating Branch Distribution.

servation of equilibrium in the growth of the several parts of the tree; and for this various minor details deserve attention. Thus a shoot will grow more vigorously whilst waving in the air than when nailed close to the wall; consequently a weak shoot should be left free, whilst its stronger antagonist should be restrained; and a luxuriant shoot may be retarded for some time by having its tender extremity pinched off to allow a weaker shoot to overtake it.

Mr Robert Thompson, who is to be regarded as an authority, says (*Gardener's Assistant*, 340):—

"A fair exposure to light is one of the principal objects to be borne in mind in training; but the branches may be well regulated as regards exposure to light, without being equally so with respect to the flow of sap. For instance, they may be disposed like the radii of a circle touching the circumference at equal distances (fig. 77, *aa*, *bb* *cc*, *v*). We shall, however, suppose that the central vertical shoot *v* has been cut back nearly to its base in order to furnish from buds there situated the rudiments of other branches. The sap flows with much greater force into the upright or nearly upright branches than it does into those having a horizontal position; therefore branches radiating at equal distances, like those in the figure, would soon become very unequal in point of vigour; *cc* would of course be strong, *aa* comparatively weak, whilst *bb* would maintain a somewhat intermediate condition. If, instead of training the shoots *cc* in a straight direction, we depress them at *dd* and bend them in the growing season as indicated by the curved line towards *bb*, we shall greatly check their over-luxuriance. On the other hand, by elevating the horizontal shoots at *cc*, and training them in the direction of the dotted line towards *bb*, those shoots will be thereby greatly invigorated. In short, by curving the upper branches downwards and the lower ones upwards, the flow of sap is checked in the former and promoted in the latter; and the consequence is that *aa* and *cc* are equal to the medium *bb* and to each other."

By these and other expedients, and by the prudent use of the knife, fruit trees may be readily trained into the forms indicated below, which are amongst the best out of the many which have been devised.

Fig. 78.—Pyramidal Training.

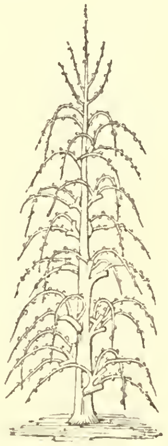

Fig. 79.—Training *en quenouille*.

The training of standard and bush trees in the open ground has been already referred to under the section *Pruning*. When the growth of pyramids is completed, the outline is something like that of fig. 78, and very pretty trees are thus formed. It is better, however, especially if the tendency to bear fruit is rather slack, to adopt what the French call *en quenouille* training (fig 79), which consists in tying or weighting the tips of the branches so as to give them all a downward curve. Pear trees worked on the quince stock, and trained *en quenouille*, are generally very fertile.

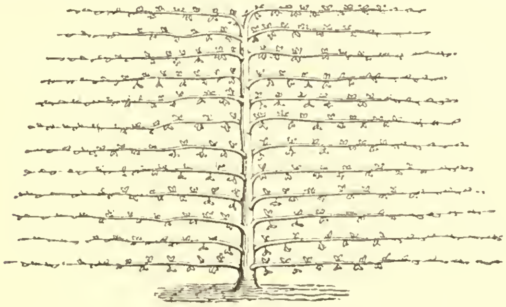

Fig. 80.—Horizontal Training.

Wall trees, it must be evident, are placed in a very unnatural and constrained position, and would in fact soon be reduced to a state of utter confusion, if allowed to grow unrestricted; hence the following modes of training have been adopted.

Horizontal Training (fig. 80) has long been a favourite form in England. There is one principal ascending stem from which the branches depart at right angles, at intervals of about a foot. Horizontal training is best adapted to the apple and the pear; and for the more twiggy growing slender varieties, the forms shown in fig. 81 have been recommended. In these the horizontal branches are placed wider, 18 to 20 inches apart, and the smaller shoots are trained between them, either on both sides, as at *a*, or deflexed from the lower side, as at *b*. The latter is an

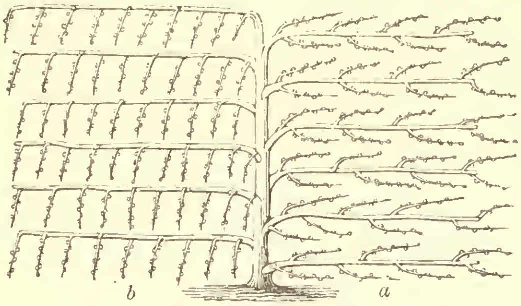

Fig. 81.—Forms of Horizontal Training.

excellent method of reclaiming neglected trees. Every alternate branch should be taken away, and the spurs cut off, after which the young shoots are trained in, and soon produce good fruit.

In *Fan Training* (fig. 82) there is no leading stem, but the branches spring from the base and are arranged somewhat like the spokes of a fan. This mode of training is com-

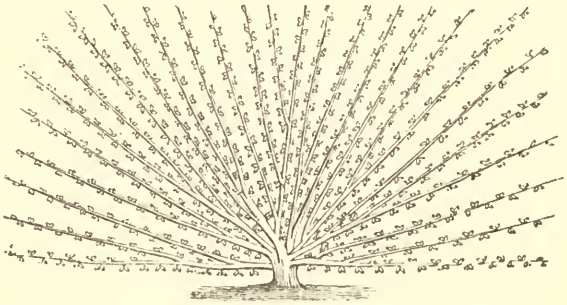

Fig. 82.—Fan Training.

monly adopted for the peach, nectarine, apricot, and Morello cherry, to which it is best adapted. Though sometimes adopted, it is not so well suited as the horizontal form for apples and pears, because, when the branches reach the top of the wall, where they must be cut short, a *tête de saule*, or hedge of young shoots, is inevitable. A modification of the fan shape (fig. 83) is sometimes adopted for

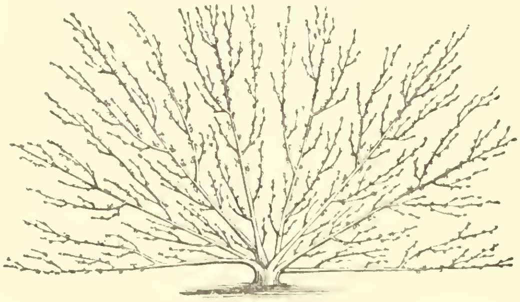

Fig. 83.—Modified Fan Training.

stone fruits, such as the apricot. In this the object is to establish a number of mother branches, and on these to form a series of subordinate members, chiefly composed of bearing wood. The mother branches or limbs should not be numerous, but well-marked, equal in strength, and regularly disposed. The side branches should be pretty abundant, short, and not so vigorous as to rival the leading members.

The *Half-fan* mode of training, which is intermediate between horizontal and fan training, is most nearly allied to the former, but the branches leave the stem at an acute angle, a disposition supposed to favour the more equal distribution of the sap. Sometimes, as in fig. 84, two vertical stems are adopted, but there is no particular advantage in this, and a single-stemmed tree is more manageable. The half-fan form is well adapted for such fruits as the plum and the cherry; and, indeed, for fruits of vigorous habit, it seems to combine the advantages of both the foregoing.

Trees must be fixed to the walls and buildings against which they are trained by means of nails and shreds, or in cases where it is desired to preserve the wall surface intact, by permanent nails or studs driven in in regular order. Sometimes the walls are furnished with galvanized wires, but this has been objected to as causing cankering of the shoots, for which, however, painting is recommended as a remedy, and which is also avoided, it is said, by crossing the tying material between the wire and the wood, and so preventing them from coming in contact. If they are adopted, the wires should be close to the wall to prevent a cold draught between it and the tree. Care should be taken that the ties or fastenings do not eventually cut

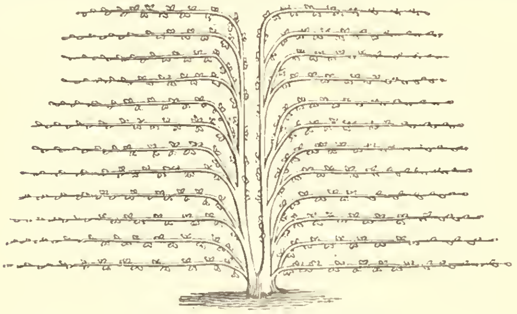

FIG. 84.—Half-Fan Training.

into the bark as the branches swell with increased age. When shreds and nails are used, cast wall nails and "medicated shreds" are the best; the nails should be of small size for the young shoots.

For tying plants to trellises and stakes nothing is better than soft tarred string. Osier ties are sometimes used for espaliers. The training in of summer shoots on wall-trees is often done by means of slender twigs; indeed the prunings of the trees themselves, stripped of their leaves, often serve the purpose very well; the ends are tucked under the adjacent fixed shoots, the young shoots to be fastened in being thus held close to the wall. Crooked shoots should be straightened at the principal or winter training; this is done by pulling the convex side towards the straight line desired by means of the tie or shred, the next above and below being set so as to pull in the opposite direction.

In training greenhouse plants the young branches should be drawn outwards by means of ties fastened to a string or wire under the pot-rim; the centre then fills up, and slender stakes are used as required; but the fewer these are in number the better. Climbers are trained from the bottom around or across trellises, of which the cylindrical or the balloon-shaped, or sometimes the flat oval or circular, are the best forms. The size should be adapted to the habit of the plant, which should cover the whole by the time flowers are produced. Bast fibre and raphia fibre are to be preferred for light subjects of this character, as they can be split to any degree of fineness; but the latter is not durable enough or strong enough for coarse-growing border flowers. Very durable trellises for greenhouse climbers are made of slender round iron rods for standards, having a series of hooks on the inner edge, into which rings of similar metal are dropped; the rings may be graduated so as to form a broad open top, or may be all of the same size, when the trellis will assume the cylindrical form. Fig. 85 shows a pot specimen of clematis trained over a balloon-shaped trellis.

FIG. 85.—Clematis trained on Balloon-shaped Trellis.

The training of bedding plants over the surface of the soil is done by small pegs of birch wood or bracken, by loops of wire, or sometimes by loops of bast having the ends fixed in the soil by the aid of the dibble. The object is to fill up the blank space as quickly and as evenly as possible.

27. *Forcing* is the accelerating, by special treatment, Forc
of the growth of certain plants, which are required to be had in leaf, in flower, or in fruit before their natural season,—as, for instance, the leaves of mint at Eastertide or the leafstalks of sea-kale and rhubarb at Christmas, the flowers of summer in the depth of winter, or some of the choicest fruits perfected so much before their normal period as to complete, with the retarded crops of winter, the circle of the seasons.

In the management of artificial heat for this purpose, a considerable degree of caution is required. The first stages of forcing should, of course, be very gentle, so that the whole growth of the plants may advance in harmony. A very hot atmosphere would unduly force the tops, while the roots remained partially or wholly inactive; and a strong bottom heat, if it did not cause injury by its excess, would probably result in abortive growth.

Any sudden decrease of warmth would be very prejudicial to the progress of vegetation through the successive stages of foliation, inflorescence, and fructification. But it is not necessary that one unvarying range of temperature should be kept up at whatever pains or risk. Indeed, in very severe weather it is found better to drop a little from the maximum temperature by fire heat, and the loss so occasioned may be made good by a little extra heat applied when the weather is more genial. Night temperatures also should always be allowed to drop somewhat, the heat being increased again in the morning. In other words, the artificial temperature should increase by day and decrease by night, should rise in summer and fall in winter, should, in short, imitate as nearly as possible the varying influence of the sun.

For the growth of flowers generally, and for that of all fruits, every ray of light to be obtained in the dull winter season is required, and therefore every possible care should be taken to keep the glass clean. A moist genial atmosphere too is essential, a point requiring unremitting attention on account of the necessity of keeping up strong fires. With moisture as with heat, the cultivator must hold his hand somewhat in very severe or very dull weather; but while heat must not drop so as to chill the progressing vegetation, so neither must the lack of moisture parch the plants so as to check their growth.

There are some few subjects which when forced do not require a light house. Thus amongst flowers the white blossoms of the lilac, so much prized during winter, are produced by forcing the plant in darkness. Rhubarb and sea-kale among esculents both need to be forced in darkness to keep them crisp and tender, and mushrooms also are always grown in dark structures. In fact, a roomy mushroom house is one of the most convenient of all places for forcing the vegetables just referred to. The lilac would be better placed in a dark shed heated to about 60°, in which some dung and leaves could be allowed to lie and ferment, giving off both a genial heat and moisture.

One of the most important preliminaries to successful forcing is the securing to the plants a previous state of rest. The thorough ripening of the preceding season's wood in fruit trees and flowering plants, and of the crown in perennial herbs like strawberries, and the cessation of all active growth before the time they are to start into new growth, are of paramount importance. The ripening process must be brought about by free exposure to light, and by the application of a little extra heat with dryness, if the season should be unfavourable; and both roots and tops must submit to a limitation of their water supply. When the ripening is perfected, the resting process must be aided by keeping the temperature in which they await the forcing process as low as each particular subject can bear.

V. *Flowers.*

wer den. 28. *Flower Garden and Pleasure Grounds.*—Wherever there is a flower garden of considerable magnitude, and in a separate situation, it should be constructed on principles of its own. The great object must be to exhibit to advantage the graceful forms and glorious hues of flowering plants and shrubs. Two varieties of flower gardens have chiefly prevailed in Britain. In one the ground is turf, out of which flower-beds, of varied patterns, are cut; in the other the flower-beds are separated by gravel walks, without the introduction of grass. When the flower garden is to be seen from the windows, or any other elevated point of view, the former is to be preferred; but where the surface is irregular, and the situation more remote, and especially where the beauty of flowers is mainly looked to, the choice should probably fall on the latter.

The situation of the flower garden must be influenced by the nature of the lawns, and of the site of the mansion to which it is attached. Generally speaking, it should not be at any great distance from the house; and in places where there is no distant view of importance, it may be constructed under the windows. On the other hand, when the park is spacious, and the prospects extensive and picturesque, it is perhaps better that the flower garden should be at a little distance from and out of sight of the house, but easy of access in any sort of weather. In most cases, even when it is in the vicinity of the mansion, the flower garden should for security against ground game and other intruders be encircled with some sort of fence. In detached localities the fences may be made sufficiently strong to prevent the intrusion of every species of vagrant; it is not difficult to mask them with shrubs and trees. The style of the mansion should determine that of the flower garden, and also its position. The flower garden attached to an elaborate mansion, should, for the most part, occupy the lawn on the south, the east, or the west front; and the carriage-entrance, where possible, should be on the north front, the park extending nearly or quite up to the front door. This arrangement must, however, sometimes be departed from in consequence of the difficulties of providing a proper approach to the entrance-door, and must also be regulated by the position of the principal rooms, which should if possible command a view of the flower garden.

When the garden is upon a large scale, and especially where a natural inclination in the ground exists, or can be formed artificially, terraces and parapet walls should be introduced, with flights of steps, and embellishments in connexion with them, such as fountains, statuary, sculpture, &c. Grass terraces alone have a mean appearance in such a position. The parapet walls afford excellent accommodation for half-hardy and beautiful flowering plants.

With regard to flower-plots, when the figures are separated by turf, it is necessary that the little lawns or glades should have a certain degree of breadth, as nothing has a worse effect than overcrowding. A multitude of little figures should also be avoided, as they produce the disagreeable effect well named by Gilpin "spottiness." In this sort of flower garden it is desirable that a gravel walk should skirt at least one side of the principal figures, for in the humid climate of Britain the grass would otherwise render them inaccessible with comfort during a great part of the year. In those gardens where turf is wholly or partly excluded, the compartments should be of a larger and more massive character. Narrow borders, bounded by parallel straight lines and concentric curves, should be avoided. The centres of the figures should be filled with tall-growing shrubs, and even with an occasional low evergreen tree, such as a yew or a holly. The walks, arranged in long concave curves, may communicate here and there with one another. A dial, a few seats and arbours, with an urn or two or a vase, may be introduced with good effect.

The flower garden may include several different compartments. Thus, for example, there is the "Rock Garden," which should consist of variously grouped masses of large stones, those which are remarkable for being figured by water-wearing, or containing petrifactions or impressions, or showing something of natural stratification, being generally preferred. In the cavities between the stones, filled with earth, alpine or trailing plants are inserted, and also some of the choicest flowers. In proper situations, a small pool of water may be introduced for the culture of aquatic plants. In a suitable position one of the walks is sometimes arched over with wire-work, and covered with ornamental climbing shrubs, forming a delightful promenade in the glowing days of summer. A separate compartment laid out on some regular plan is often set apart for roses, under the name of the "Rosery." A moist or rather a shady border, or a section of the pleasure ground supplied with bog earth, may be devoted to what is called the "American Garden," which, as it includes the gorgeous rhododendrons and azaleas, forms one of the grandest features of the establishment during the early summer, while if properly selected the plants are effective as a garden of evergreens at all seasons. The number of variegated and various-coloured hardy shrubs is now so great that a most pleasant plot for a "Winter Garden" may be arrayed with plants of this class, with which may be associated hardy subjects which flower during that season or very early spring, as the Christmas rose, and amongst bulbs the crocus and snowdrop. Later on, the spring garden department is a scene of great attraction; and some of the gardens of this character, as those of Cliveden and Belvoir, are among the most fascinating examples of horticultural art.

Lawns. 29. *Lawns.*—In the formation of lawns the ground must be regularly broken up so that it may settle down evenly, any deep excavations that may have to be filled in being very carefully rammed down to prevent subsequent settlement. The ground must also be thoroughly cleared of the roots of all coarse perennial weeds, and be worked to a fine tilth ready for turfing or sowing. The more expeditious method is of course to lay down turf, which should be free from weeds, and is cut usually in strips of 1 foot wide, 3 feet long, and about an inch in thickness. This must be laid very evenly and compactly, and should then be beaten down firmly with the implement called a turf-beater (fig. 86). When there is a large space to cover, it is much the cheaper plan to sow the lawn with grass-seeds, and equally effective, though the sward takes longer to thicken. It is of the utmost importance that a good selection of grasses be made, and that pure seeds should be obtained. The following sorts can be recommended, the quantities given being those for sowing an acre of ground:—

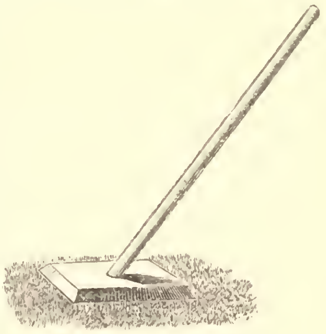

Fig. 86.—Turf-Beater.

Cynosurus cristatus—Crested Dog's-tail	6 lb
Festuca duriuscula—Hard Fescue	3 lb
Festuca ovina—Sheep's Fescue	3 lb
Lolium perenne tenue	18 lb
Poa nemoralis sempervirens—Evergreen Meadow-grass	3 lb
Poa trivialis—Trivial Meadow-grass	3 lb
Trisetum flavescens—Yellow Oat-grass	2 lb
Trifolium repens—Dutch Clover	6 lb

The seeds should be thoroughly mixed, and very evenly sown, after which the surface should be raked over to bury them, and then rolled down while dry so as to finish it off smooth and level. When thus sown, lawns require to be promptly weeded. During the growing season established lawns should be mown at least once a week. They should be occasionally rolled, and towards autumn they require frequent sweepings to remove worm-casts.

Hardy annuals. 30. Hardy Annuals.—Annual plants are those which grow up from seed, flower, ripen seed, and die in the course of one season—one year. They are useful in the mixed garden, for though in some cases they are of short duration, many of them are possessed of much beauty of hue and elegance of form. Annuals may be divided into three classes:—the *hardy*, which are sown at once in the ground they are to occupy; the *half-hardy*, which succeed best when aided at first by a slight hot bed, and then transplanted into the open air; and the *tender*, which are kept in pots, and treated as greenhouse or stove plants, to which departments they properly belong. Some of the more popular annuals, hardy and half-hardy, have been very much varied as regards habit and the colour of the flowers, and purchases may be made in the seed shops of such things as China asters, stocks, Chinese and Indian pinks, larkspurs, phloxes, and others, amongst which some of the most beautiful of the summer flowers may be found.

The hardy annuals may be sown in the open ground during the latter part of March or beginning of April, as the season may determine, for the weather should be dry and open, and the soil in a free-working condition before sowing is attempted. In favourable situations and seasons some of the very hardiest, as Silene pendula, Saponaria, Nemophila, Gilia, &c., may be sown in September or October, and transplanted to the beds or borders for very early spring flowering. Those sown in spring begin to flower about June. The patches, if left to flower where they are sown, should be thinned out while young, to give them space for proper development. It is from having ample room that pricked out transplanted seedlings often make the finest plants. The soil should be rich and light.

The half-hardy series are best sown in pots or pans under glass in mild heat, in order to accelerate germination. Those of them which are in danger of becoming leggy should be speedily removed to a cooler frame and placed near the glass, the young plants being pricked off into fresh soil, in other pots or pans or boxes, as may seem best in each case. All the plants must be hardened off gradually during the month of April, and may generally be planted out some time in May, earlier or later according to the season.

The class of tender annuals, being chiefly grown for greenhouse decoration, should be treated much the same as soft-wooded plants, being sown in spring, and grown on rapidly in brisk heat, near the glass, and finally hardened off to stand in the greenhouse when in flower.

We add a select list of some of the more distinct annuals desirable for general cultivation as decorative plants, and shall then mention a few of the most popular kinds separately:—

Acroclinium roseum: half-hardy, 1 ft., rose-pink or white; everlasting.
Agrostis pulchella: hardy, 6 in.; a most graceful grass for bouquets.
Amberboa moschata atropurpurea (Sweet Sultan): hardy, 1½ ft., purple; musk-scented.
Bartonia aurea: hardy, 2 ft., golden yellow; showy and free.
Brachycome iberidifolia: half-hardy, 1 ft., blue or white with dark disk.
Calendula officinalis Meteor: hardy, 1 ft., orange striped with yellow.
Calliopsis bicolor (tinctoria): hardy, 2 to 3 ft., yellow and chestnut-brown.
Calliopsis Drummondii: hardy, 1 to 2 ft., golden yellow with red disk.
Campanula Loreyi: hardy, 1½ ft., purplish-lilac or white.
Centaurea Cyanus: hardy, 3 ft., blue, purple, pink, or white; showy.
Clarkia pulchella: hardy, 1½ ft., rosy-purple; some varieties very handsome.
Collinsia bicolor: hardy, 1½ ft., white and purple; pretty.
Collinsia verna: hardy, 1 ft., white and azure; sow as soon as ripe.
Convolvulus tricolor atroviolacea: hardy, 1 ft., white, blue, and yellow. This is the Convolvulus minor of gardens.
Erysimum Perofskianum: hardy, 2 ft., deep orange; in erect racemes.
Eschscholtzia californica: hardy, 1½ ft., yellow with saffron eye.
Eschscholtzia crocea flore-pleno: hardy, 1½ ft., orange yellow; double.
Eutoca viscida: hardy, 2 ft., bright blue with white hairy centre.
Gaillardia Drummondii (picta): half-hardy, 1½ ft., crimson, yellow margin.
Gilia achilleæfolia: hardy, 2 ft., deep blue; in large globose heads.
Godetia Lindleyana: hardy, 2 to 3 ft., rose-purple, with crimson spots.
Godetia Whitneyi: hardy, 1 ft., rosy-red, with crimson spots. The variety Lady Albemarle is wholly crimson, and very handsome.
Gypsophila elegans: hardy, 1½ ft., pale rose; branched, very graceful.
Helianthus cucumerifolius: hardy, 3 to 4 ft., golden yellow, black disk; branching, free, and bold without coarseness.
Helichrysum bracteatum: half-hardy, 2 ft.; the incurved crimson, rose, and other forms very handsome.
Hibiscus Trionum (africanus): hardy, 1½ ft., cream colour, black centre.
Iberis umbellata (Candytuft): hardy, 1 ft., white, rose, purple, crimson. Some new dwarf white and flesh-coloured varieties are very handsome.
Kaulfussia amelloides: hardy, 1 ft., blue or rose; the var. kermesina is deep crimson.
Koniga maritima (Sweet Alyssum): hardy, 1 ft., white; fragrant, compact.
Lavatera trimestris: hardy, 3 ft., pale rose showy malvaceous flowers.
Leptosiphon densiflorus: hardy in light soil, 1 ft., purplish or rosy-lilac.
Leptosiphon roseus: hardy in light soil, 6 in., delicate rose; fine in masses.
Linaria bipartita splendida: hardy, 1 ft., deep purple.
Linum grandiflorum: hardy, 1 ft., splendid crimson; var. roseum is pink.
Lupinus luteus: hardy 2 ft., bright yellow, fragrant.
Lupinus mutabilis Cruckshanksii: hardy, 4 ft., blue and yellow; changeable.
Lupinus nanus: hardy, 1 ft., bluish-purple; abundant flowering.
Malcolmia maritima (Virginian Stock): hardy, 6 in., lilac, rose, or white.
Malope trifida: hardy, 3 ft., rich glossy purplish-crimson; showy.
Matthiola græca (Wallflower-lvd. Stock): hardy, 1 ft., various as in Stock.
Mesembryanthemum tricolor: half-hardy, 3 in., pink and crimson, with dark centre.
Mimulus cupreus: half-hardy, 6 in., coppery red, varying considerably.
Mimulus luteus tigrinus: half-hardy, 1 ft., yellow spotted with red; var. duplex has hose-in-hose flowers.
Mirabilis Jalapa: half-hardy, 3 ft., various colours; flowers evening-scented.
Nemesia floribunda: hardy, 1 ft., white and yellow; pretty and compact.
Nemophila insignis: hardy, 6 in., azure blue with white centre.
Nemophila maculata: hardy, 6 in., white with violet spots at the edge
Nigella hispanica: hardy, 1½ ft., pale blue, white, or dark purple.
Œnothera odorata: hardy, 2 to 3 ft., yellow; fragrant.
Omphalodes linifolia (Venus's Navelwort): hardy, 1 ft., white.
Papaver Rhœas flore-pleno: hardy, 2 ft., scarlet and other colours; showy.
Papaver somniferum flore-pleno: hardy, 3 ft., white, lilac, rose, &c.; petals sometimes fringed.
Petunia violacea hybrida: half-hardy, 1½ ft., various colours; sow in heat.
Pharbitis hispida: hardy, 6 ft., various; the many-coloured twining Convolvulus major.
Platystemon californicus: hardy, 1 ft., sulphur yellow; neat and distinct.
Portulaca splendens: half-hardy, 6 in., crimson, rose, yellow, white, &c. single and double; splendid prostrate plants for sunny rockwork.
Pyrethrum Parthenium aureum: half-hardy, 1 ft.; grown for its golden foliage, and much used for bedding.
Reseda odorata (Mignonette): hardy, 1 ft., greenish, but exquisitely fragrant; there are some choice new sorts.
Rhodanthe maculata: half-hardy, 1½ ft., rosy-pink or white; larger flower-heads than the next.
Rhodanthe Manglesii: half-hardy, 1 ft., rosy-pink; a drooping everlasting.
Salpiglossis sinuata: half-hardy, 2 to 3 ft., yellow, purple, crimson, &c.; much varied and beautifully veined.
Sanvitalia procumbens flore-pleno: half-hardy, 6 in., golden yellow; procumbent.
Saponaria calabrica: hardy, 6 to 8 in., bright rose pink or white; continuous blooming, compact-growing.
Schizanthus pinnatus: hardy, 1 to 2 ft., purple-lilac, prettily blotched; curiously lobed flowers.
Schizopetalon Walkeri: hardy, 1 ft., white, sweet-scented at night; curiously fringed petals.
Senecio elegans: half-hardy, 1½ ft., white, rose, or purple; the various double forms are showy.
Silene pendula: hardy, 1 ft., bright rose pink; very showy in masses; var. compacta forms close dense tufts.
Silene Pseudo-Atocion: hardy, 1 ft., rose pink; free-flowering.
Specularia Speculum: hardy, 6 in., reddish-violet; free-flowering.

Sphenogyne speciosa: half-hardy, 1 ft., orange-yellow, with black ring around the disk.

Tagetes signata: half-hardy, 1½ ft., golden yellow; continuous blooming, with elegant foliage. The French and African marigolds, favourites of some, are allied to this.

Tropæolum aduncum (Canary Creeper): half hardy, 10 ft., yellow, fringed; an elegant climber.

Viscaria cœli rosa: hardy, 1½ ft., rosy-purple with pale centre; pretty.

Viscaria oculata cardinalis: hardy, 1½ ft., rosy-crimson; very brilliant.

Waitzia aurea: half-hardy, 1½ ft., golden yellow; a showy everlasting.

Xeranthemum annuum flore-pleno: hardy, 2 ft., lilac-purple; floriferous.

The following annuals are entitled to separate notice:—

China Aster. 31. The China *Aster* (Callistephus chinensis). The groups of asters are very numerous; but some of the best for ornamental gardening are the chrysanthemum-flowered, the pæony-flowered, the crown or cockade, and the globe-quilled, of each of which there are from six to a dozen distinct colours. What are called crown asters have a white centre and dark crimson or purple circumference, and are very beautiful. The colours range from white and blush through pink and rose to crimson, and from lilac through blue to purple, in various shades. These should be sown early in April in pans, in a gentle heat, the young plants being quickly transferred to a cool pit, and there pricked out in rich soil as soon as large enough, and eventually planted out in the garden in May or June, in soil which has been well worked and copiously manured, where they grow from 8 to 18 inches high, and flower in great beauty towards the end of summer. They also make very handsome pot plants for the conservatory.

Stock. 32. The *Stock* (Matthiola annua). These also are much varied both in respect to habit and colour, and of some of the forms as many as two dozen colours are cultivated, some of which are very beautiful. The Ten-week and the large-flowered German are both favourite strains. The fragrance of these flowers renders them universal favourites. They should be treated much the same as asters for autumn-blooming plants, but for early blooming require to be sown about August, and wintered in pots in a cold frame, for which purpose the Intermediate Stock is the best adapted (see *Biennials*, par. 41). They grow from 1 to 2 feet high, according to the variety.

Antirrhinum. 33. The *Snapdragon* (Antirrhinum majus), which grows about 2 feet high, should be sown in February in a warm pit; prick off in pots, and subsequently into boxes, drawing off into a cool frame when established, and planting out in May or June. They are not true annuals, but may be treated as such.

Chinese Pink. 34. The *Chinese* or *Indian Pink* (Dianthus chinensis, and its varieties Heddewigii and laciniatus) and several allied forms, which grow from 6 inches to a foot high, are very richly coloured, and highly varied in marking. Sow in pits in gentle heat, in March, transferring them quickly after germination to a cool pit, that they may not get drawn or leggy; they may be planted out in May. They will also flower later on in favourable seasons, if sown outdoors early in April.

Larkspur. 35. The *Larkspur* affords two distinct types, the Rocket Larkspur (Delphinium Ajacis), which varies from a foot to a foot and a half, and the branching Larkspur (D. Consolida), growing 3 feet high, of each of which there are various colours, double and single. The candelabrum form of the latter is very handsome. Sow in March in the open border where they are to flower.

Phlox Drummondii. 36. The *Phlox Drummondii*, a spreading plant about a foot high, of which there are now many varieties of colour, is one of the most beautiful of all annuals, and very prolific of blossom. Sow in the places where it is to flower, in April, in good firm soil.

Sweet Pea. 37. The *Sweet Pea* (Lathyrus odoratus) is indispensable in every garden, especially Painted Lady (white and rose) and the improved forms called Invincible Scarlet and Invincible Black. Sow in rows or patches in February, and again in March, in good rich soil. The plants grow 3 to 4 feet high, and require stakes to support the stems.

Nasturtium. 38. The *Nasturtium* (Tropæolum majus), in its dwarf form known as Tom Thumb (T. m. nanum), is an excellent bedding or border flower, growing about a foot high, each plant forming a dense patch full of flowers, and blooming on for a considerable period if kept growing. The scarlet, the yellow, and the rose-coloured are very attractive. Sow in April in the beds or borders; and again in May for a succession.

Zinnia. 39. The *Zinnia elegans*, of which both single and double forms are cultivated, grows about 2 feet high, and produces flowers of various colours, the double ones being about the size of asters, and very handsome. The colours include white, yellow, orange, scarlet, crimson, and purple. It is half-hardy, and should be sown and treated much the same as the aster.

Hardy biennials. 40. HARDY BIENNIALS.—Biennials live as undeveloped plants through one winter period. They require to be sown in the summer months, about June or July, in order to get established before winter; they should be pricked out as soon as large enough, and should have ample space so as to become hardy and stocky. They should be planted in good soil, but not of too stimulating a character. Those that are perfectly hardy are best planted where they are to flower in good time during autumn. This transplanting acts as a kind of check, which is rather beneficial than otherwise. Of those that are liable to suffer injury in winter, as the Brompton and Queen Stocks, a portion should be potted and wintered in cold frames ventilated as freely as the weather will permit.

The number of biennials is not large, but a few very desirable garden plants, such as the following, occur amongst them:—

Agrostemma coronaria (Rose Campion): hardy, 1½ ft., bright rose-purple or rose and white.

Beta Cicla variegata: hardy, 2 ft., beautifully coloured leaves and midribs, crimson, golden, &c.

Campanula Medium (Canterbury Bell): hardy, 2 ft., blue, white, rose, &c. The double-flowered varieties of various colours are very handsome.

Campanula Medium calycanthema: hardy, 2 ft., blue or white; hose-in-hose flowered.

Catananche cœrulea: hardy, 2 to 3 ft., blue or white.

Celsia cretica: hardy, 4 to 5 ft., yellow, with two dark spots near centre; in spikes.

Dianthus barbatus (Sweet William): hardy, 1 to 1½ ft., crimson, purple, white, or parti-coloured.

Dianthus chinensis (Indian Pink): half hardy, 1 ft., various; these flower earlier if treated as biennials.

Digitalis purpurea (Foxglove): hardy, 3 to 5 ft., rosy-purple or white; beautifully spotted in the variety called gloxiniæflora.

Echium pomponium: hardy, 4 ft., rosy-pink.

Hedysarum coronarium (French Honeysuckle): hardy, 2 to 3 ft., scarlet or white; fragrant.

Hesperis tristis (Night-scented Rocket): hardy, 3 ft., dull purplish; fragrant at night.

Lunaria biennis (Honesty): hardy, 2 to 3 ft., purple; the silvery dissepiment attractive among everlastings.

Œnothera Lamarckiana (Evening Primrose): hardy, 5 ft., bright yellow; large.

Scabiosa atropurpurea (Sweet Scabious): hardy, 3 ft., dark purple, showy; the variety nana flore-pleno is dwarfer and has double flowers.

Silene compacta: half-hardy, 2 to 3 ft., bright pink; clustered as in S. Armeria.

Verbascum Blattaria: hardy, 3 to 4 ft., yellowish, with purple hairs on the filaments; in tall spikes.

41. The most important of the biennials are the different kinds of *Stocks*. The *Intermediate Stock* (Matthiola annua intermedia) is one of the so-called scarlet stocks, and is very useful, when preserved through the winter in frames, for its dwarfness and early-flowering habit. It is used very extensively for furnishing jardinières, window boxes, flower beds, &c., during the London season, for which purpose it is sown in July and August, while if sown in spring it blooms in autumn, and furnishes a useful successional crop of flowers. Of the East Lothian stock, which is a somewhat larger grower, there are some half dozen colours, those called New Crimson and Mauve Beauty being specially admired; these are sown in July and August for summer blooming, and early in spring for flowering in autumn. Stocks.

42. The *Brompton Stock* (Matthiola incana simplicicaulis) is a robust plant, growing 3 feet high, with a long central flower stem bearing very large flowers, which are crimson, purple, or white. They require rich soil, and should be sown in June or July, being pricked out into nursery beds, and planted in September in the borders where they are to bloom. Two or three plants should be put in one patch, as then any surplusage of single-flowered individuals may be pulled away.

43. The *Queen* or *Twickenham Stock* (Matthiola incana semperflorens) is less vigorous in habit than the Brompton, and is of more spreading habit, the plants growing about 2 feet high, with the lateral branches very much developed. There are the three usual colours, purple, scarlet, and white, the first-named being a special favourite. They require to be sown in June or July, and planted out in September, so as to get well established before winter, and if they have the advantage of good soil they will flower freely in the early part of the ensuing summer. Sometimes the plants acquire almost a woody habit, and live over the second year, but the flowers are not equal to those produced the first blooming season.

44. HARDY PERENNIALS.—This term includes, not only those fibrous-rooted plants of herbaceous habit which spring up from the root year after year, but also those old-fashioned subjects known as florists' flowers, and the hardy bulbs. Some of the most beautiful of hardy flowering plants belong to this class, and their great variety, as well as the long period through which they, one or other of them, yield their flowers, are beginning again to secure them some of the consideration which has long been given mainly to bedding plants. Hardy perennials.

When the length of the flowering season is considered, it will be obvious that it is impossible to keep up the show of a single border or plot for six months together, since plants, as they are commonly arranged, come dropping into flower one after another; and even where a certain number are in bloom at the same time, they necessarily stand apart, and so the effects of contrast, which can be perceived only among adjacent objects, are lost. To obviate this defect, it has been recommended that ornamental plants should be formed into four or five separate suites of flowering, to be distributed over the garden. Not to mention the more vernal flowers, the first might contain the flora of May; the second that of June; the third that of July; and the fourth that of August and the following months. These compartments should be so intermingled that no particular class may be entirely absent from any one quarter of the garden.

Before commencing to plant, it would be well to construct tables or lists of the plants, specifying their respective times of flowering, colours, and altitudes. To diversify properly and mingle well together the reds, whites, purples, yellows, and blues, with all their intervening shades, requires considerable taste and powers of combination; and ascertained failures may be rectified at the proper time the next season. The one great object aimed at should be to present an agreeable contrast; and, as at particular seasons a monotony of tint prevails, it is useful at such times to be in possession of some strong glaring colours. White, for instance, should be much employed in July, to break the duller blues and purples which then preponderate. Orange, too, is very effective at this season. On the other hand, yellows are superabundant in autumn, and therefore reds and blues should then be sought for. The flower-gardener should have a small nursery, or reserve garden, for the propagation of the finer plants, to be transferred into the borders as often as is required.

As a rule, all the fibrous-rooted herbaceous plants flourish in good soil which has been fairly enriched with manure, that of a loamy character being the most suitable. Many of them also grow satisfactorily in a peaty soil if well worked, especially if they have a cool moist subsoil. Pentstemons and phloxes, amongst others, succeed well in soil of this character, but the surface must be well drained; the former are rather apt to perish in winter in loamy soil, if at all close and heavy. The herbaceous border should be a distinct compartment, and not less than 10 feet in width, backed up by evergreens. Such a border will take in about four lines of plants, the tallest being placed at the back and the others graduated in height down to the front. In the front row patches of the white arabis, the yellow alyssum, and the purple aubrietia, recurring at intervals of 5 or 6 yards on a border of considerable length, carry the eye forwards and give a balanced kind of finish to the whole. The same might be done with dianthuses or the larger narcissi in the second row, with pæonies, columbines, and phloxes in the third, and with delphiniums, aconitums, and some of the taller yellow composites as helianthus and rudbeckia at the back. Spring and autumn flowers, as well as those blooming in summer, should be regularly distributed throughout the border, which will then at no season be devoid of interest in any part. Many of the little alpines may be brought into the front line planted between suitable pieces of stone, or they may be relegated to a particular spot, and placed on an artificial rockery. Most of the hardy bulbs will do well enough in the border, care being taken not to disturb them while leafless and dormant.

Some deep-rooting perennials do not spread much at the surface, and only require refreshing from time to time by top-dressings. Others, as the asters, spread rapidly; those possessing this habit should be taken up every second or third year, and, a nice patch being selected for replanting from the outer portions, the rest may be either thrown aside, or reserved for increase; the portion selected for replanting should be returned to its place, the ground having meanwhile been well broken up. Some plants are apt to decay at the base, frequently from exposure caused by the lifting process going on during their growth; these should be taken up annually in early autumn, the soil refreshed, and the plants returned to their places, care being taken to plant them sufficiently deep.

General list of hardy perennials.

Only a selection of some of the best of the decorative hardy perennials can be noted, before we pass on to those popular subjects of this class which have been directly influenced by the hybridizer and improver. Many more might be added to the subjoined list:—

Acæna.—Neat trailing plants adapted for rockwork, thriving in sandy soil. A. microphylla and A. myriophylla have pretty spiny heads of flowers.

Acantholimon.—Pretty dwarf tufted plants, with needle-shaped leaves, adapted for rockwork. A. glumaceum and A. venustum bear bright pink flowers in July and August. Light sandy loam.

Acanthus.—Bold handsome plants, with stately spikes, 2 to 3 feet high, of flowers with spiny bracts. A. mollis, A. latifolius, and A. longifolius are broad-leaved sorts; A. spinosus and A. spinosissimus have narrower spiny toothed leaves.

Achillea.—Handsome composite plants, the stronger ones of easy culture in common soil. A. Eupatorium and filipendula, 3 to 4 feet, have showy yellow corymbose flowers; A. rosea, 2 feet, rosy-crimson; and A. Ptarmica flore-pleno, 2 feet, double white flowers. Others suitable for front lines or rockwork are A. tomentosa, 9 inches, bright yellow; A. ægyptiaca, 1 foot, silvery leaves and yellow flowers; A. umbellata, 8 inches, silvery leaves and white flowers; and A. Clavennæ, 6 inches, with silvery leaves and pure white flowers.

Aconitum.—Handsome border plants, the tall stems crowned by racemes of showy hooded flowers. A. Camarum, 3 to 4 feet, has deep purple flowers in August; A. sinense, 1½ to 2 feet, has large dark purple flowers in September; A. variegatum, 3 feet, has the flowers white edged with blue; A. autumnale, 3 feet, has pale blue flowers, and A. japonicum, 2½ feet, deep blue flowers, both produced in September and October.

Adenophora.—Bell-shaped flowers. A. stylosa, 2 feet, pale blue, elegant; A. denticulata, 1½ feet, dark blue; and in A. liliifolia, 1½ feet, pale blue, sweet-scented—all blooming during summer. Light soil.

Adonis.—A. vernalis, 1 foot, has large bright yellow stellate flowers in April. Deep light soil.

Ajuga.—Free-growing, dwarf, and showy. A. reptans, 8 inches, has creeping runners, which A. genevensis has not; both bear handsome spikes of blue labiate flowers. Ordinary soil.

Allium.—Hardy bulbs of the garlic family, some species of which are ornamental; the inflorescence is umbellate. In A. azureum, 1 to 2 feet, the flowers are deep-blue; in A. Moly, 1 foot, golden yellow; in A. neapolitanum, 1½ feet, white, very handsome; in A. triquetrum, 8 inches, white with green central stripes; in A. pedemontanum, 9 inches, reddish-violet, very beautiful, the umbels nodding.

Alströmeria.—Beautiful plants with fleshy tuberous roots, which are the better if not often disturbed. A. aurantiaca, 2 to 3 feet, orange streaked with red, in July and August; A. chilensis, 2 to 3 feet, blood-red, streaked with yellow, affording many varieties. Deep sandy loam or peat. Should be planted at least 6 or 8 inches deep.

Alyssum.—Showy rockwork or front row border plants of easy culture in any light soil; the plants should be frequently renewed from cuttings. A. saxatile, with greyish leaves, and deep yellow flowers, produced in April and May, and the dwarfer A. montanum are useful.

Amaryllis.—Noble half-hardy bulbs, for planting near the front wall of a hot-house or greenhouse; the soil must be deep, rich, and well-drained. A. Belladonna, the Belladonna Lily, 3 feet, has large funnel-shaped flowers in September, of a delicate rose colour. The variety A. blanda has paler flowers, almost white.

Anchusa.—Pretty boraginaceous herbs, easily grown. A. italica, 3 to 4 feet, has blue star-like flowers. A. sempervirens, 1½ feet, rich blue, is well suited for rough borders.

Androsace.—Pretty dwarf rock plants, requiring rather careful management and a gritty soil. A. Vitaliana, yellow; A. Wulfeniana, purplish-crimson; A. villosa, white or pale rose; A. lactea, white with yellow eye; A. lanuginosa, delicate rose; and A. Chamæjasme, delicate rose, are some of the best.

Antennaria.—Composite plants, with everlasting flowers. A. margaritacea, 1½ to 2 feet, has white woolly stems and leaves, and white flower-heads.

Anthericum.—Charming border flowers. A. Liliastrum, St Bruno's Lily, 1½ feet, bears pretty white sweet-scented flowers in May; A. Hookeri (Chrysobactron), 2 feet, with long racemes of bright golden yellow flowers, requires cool peaty soil.

Aquilegia.—The Columbine family, consisting of beautiful border flowers in great variety, ranging from 1 to 2 or 3 feet in height. Besides the common purple A. vulgaris with its numerous varieties, double and single, there are of choice sorts A. alpina and A. pyrenaica, blue; A. glandulosa, A. jucunda, and A. cærulea, blue and white; A. leptoceras, blue and yellow; A. canadensis, A. Skinneri, and A. truncata (californica), scarlet and yellow; A. chrysantha, yellow; and A. fragrans, white or flesh-colour, very fragrant. Light rich garden soil.

Arabis.—Dwarf close-growing evergreen cruciferous plants, adapted for rockwork and the front part of the flower border, and of the easiest culture. A. albida forms a conspicuous mass of greyish leaves and white blossoms; A. lucida, which is also white-flowered, bears its bright green leaves in rosettes, and has a variety with prettily gold-margined leaves.

Arenaria.—Evergreen rock plants of easy culture. A. graminifolia and A. laricifolia are tufted, with grassy foliage and white flowers, while A. balearica, a creeping plant, has broad leaves and solitary white flowers.

Armeria.—The Thrift or Sea-Pink, of which the common form A. maritima is sometimes planted as an edging for garden walks; there are three varieties, the common pale pink, the deep rose, and the white, the last two being the most desirable. A. cephalotes, 1½ feet, is a larger plant, with tufts of linear lance-shaped leaves, and abundant globular heads of deep rose flowers, in June and July.

Arum.—Remarkable plants, with tuberous roots, and erect hood-like spathes, enclosing the spike of flowers (spadix). A. crinitum, 1½ feet, has pedate leaves, and fetid dark chocolate hairy spathes; A. Dracunculus, 3 feet, has spotted stems, pedate leaves, and dull purple spathes; A. italicum, with greenish spathes, has the cordate hastate leaves conspicuously veined with white.

Asclepias.—A. tuberosa is a handsome fleshy-rooted plant, very impatient of being disturbed, and preferring good peat soil; it grows 1 to 1½ feet high, and bears corymbs of deep yellow and orange flowers in September. A. incarnata, 2 to 4 feet, produces deep rose sweet-scented flowers towards the end of summer.

Asphodelus.—Handsome liliaceous plants, with fleshy roots, erect stems, and showy flowers, thriving in any good garden soil. A. albus, 4 feet, A. æstivus, 4 feet, and A. ramosus, 4 feet, have all long tapering keeled leaves, and simple or branched spikes of white flowers; A. luteus, 2 feet, has awl-shaped leaves and dense spikes of fragrant yellow flowers; A. capillaris is similar to A. luteus, but more slender and elegant.

Aster.—A very large family of autumn-blooming composites, including some ornamental species, all of the easiest culture. Of these, A. alpinus, 1 foot, and A. Amellus, 1½ feet, with its var. bessarabicus, have broadish blunt leaves, and large starry bluish flowers; A. longifolius formosus, 2 feet, bright rosy lilac; A. elegans, 3 to 5 feet, small pale purple or whitish; A. laxus, 2 feet, purplish-blue; A. pendulus, 2½ feet, white, changing to rose; A. pyrenæus, 2 to 3 feet, lilac-blue; A. turbinellus, 2 to 3 feet, mauve-coloured, are showy border plants; and A. Novæ Angliæ, 5 to 6 feet, rosy-violet; A. cyaneus, 5 feet, blue-lilac; and A. grandiflorus, 3 feet, violet, are especially useful from their late-flowering habit.

Astilbe.—A. japonica, 1 to 1½ feet, better known as Hoteia japonica or Spiræa japonica, thrives in peaty or sandy soil; its glossy tripinnate leaves, and feathery panicles of white flowers early in summer, are very attractive. It proves to be a fine decorative pot-plant, and invaluable for forcing during the spring.

Astragalus.—Showy pea-flowered plants, the smaller species adapted for rockwork; sandy soil. A. dasyglottis, 6 inches, has bluish-purple flowers in August and September; and A. monspessulanus, 8 inches, crimson-purple in July; while A. hypoglottis, 6 inches, produces in summer compact heads of pretty flowers, which are either purple or white. There are many very ornamental kinds.

Aubrietia.—Beautiful dwarf spring-blooming rock plants, forming carpety tufts of flowers of simple cruciferous form. A. deltoidea is of a deep lilac-blue; A. Campbelliæ is more compact and rather darker, approaching to purple; A. grandiflora and græca are rather larger, but of a lighter hue. Light sandy soil.

Bambusa.—The Bamboo family, some of which are hardy, at least in sheltered positions, are elegant arborescent grasses. B. japonica or Metake, 4 to 7 feet, has broadish leaves; B. nigra is about the same height, but more slender; B. aurea, 6 to 10 feet, is slender and graceful; and B. (Arundinaria) falcata sometimes reaches 20 feet in height.

Baptisia.—Stoutish erect-growing, 2 to 3 feet, with smooth foliage and spikes of leguminous flowers. B. australis is purplish-blue, B. alba, white, B. exaltata, deep blue; all flowering in the summer months.

Bellis.—B. perennis flore-pleno, the Double Daisy, consists of dwarf showy 3 to 4 inch plants, flowering freely in spring if grown in rich light soil, and frequently divided and transplanted. The white and pink forms, with the white and red quilled, and the variegated-leaved aucubæfolia, are some of the best.

Bocconia.—Stately poppyworts, 6 to 8 feet. B. cordata has heart-shaped lobed leaves, and large panicles of small flesh-coloured flowers. Sometimes called Macleaya. Deep sandy loam.

Brodiæa.—Pretty bulbous plants. B. grandiflora, 1 foot, has large bluish-purple flowers; B. coccinea, 2 to 3 feet, has tubular campanulate nodding flowers of a rich crimson with green tips. Sandy loam.

Bulbocodium.—Pretty spring-flowering crocus-like bulbs. B. vernum, 4 to 6 inches high, purplish-lilac, blooms in March. Good garden soil.

Buphthalmum.—Robust composite herbs with striking foliage, for the back of herbaceous or shrubbery borders. B. cordifolium, 4 feet, has large cordate leaves, and heads of rich orange flowers in cymose panicles in July. Also called Telekia speciosa.

Calandrinia.—Showy dwarf plants for sunny rockwork, in light sandy soil. C. umbellata, 3 to 4 inches, much branched, with narrow hairy leaves, and corymbs of magenta-crimson flowers in the summer months.

Caltha.—Showy marsh plants, adapted for the margins of lakes, streamlets, or artificial bogs. C. palustris flore-pleno, 1 foot, has double brilliant yellow flowers in May.

Calystegia.—Twining plants with running perennial roots. C. pubescens flore-pleno, 8 to 10 feet, has showy double-pink convolvuloid flowers in July; C. dahurica is a handsome single-flowered summer-blooming kind, with rosy-coloured flowers.

Campanula.—Beautiful, as well as varied in habit and character. They are called bell-flowers. C. pulla, 6 inches, purplish, nodding, on slender erect stalks; C. turbinata, 9 inches, purple, broad-belled; C. carpatica, 1 foot, blue, broad-belled; C. nobilis, 1½ feet, long-belled, whitish or tinted with chocolate; C. persicifolia, 2 feet, a fine border plant, single or double, white or purple, blooming in July; and C. pyramidalis, 6 feet, blue or white, in tall branching spikes, are good and diverse. There are many other fine sorts.

Centaurea.—Bold-habited composites of showy character; common soil. C. babylonica, 5 to 7 feet, has winged stems, silvery leaves, and yellow flower-heads from June to September; C. montana, 3 feet, deep bright blue or white.

Centranthus.—Showy free-flowering plants, for rockwork, banks, or stony soil. C. ruber, 2 feet, branches and blooms freely all summer, and varies with rosy, or crimson, or white flowers. It clothes the chalk cuttings on some English railways with a sheet of colour in the blooming season.

Cheiranthus.—Pretty rock plants, for light stony soils. C. alpinus, 6 inches, grows in dense tufts, and bears sulphur-yellow flowers in May. C. ochroleucus is similar in character.

Chionodoxa.—Charming dwarf hardy bulbous plants of the liliaceous order, blooming in the early spring in company with Scilla sibirica, and of equally easy cultivation. C. Luciliæ, 6 inches, has star-shaped flowers of a brilliant blue with a white centre, and is the finest of the few known species. It blooms about April.

Colchicum.—Showy autumn-blooming bulbs (corms), with crocus-like flowers, all rosy-purple or white. C. speciosum, C. autumnale, single and double, C. byzantinum, and C. variegatum are all worth growing.

Convallaria.—C. majalis, the Lily of the Valley, a well-known sweet-scented favourite spring flower, growing freely in rich garden soil; its spikes, 6 inches high, of pretty white fragrant bells, are produced in May and June; the variety with gold-striped leaves is very ornamental.

Coreopsis.—Effective composite plants, thriving in good garden soil. C. auriculata, 2 to 3 feet, has yellow and brown flowers in July and August; C. grandiflora, 3 to 4 feet, bright yellow, in August; C. tenuifolia, 2 feet, rich golden yellow, in July.

Corydalis.—Interesting and elegant plants, mostly tuberous, growing in good garden soil. C. bracteata, 9 inches, has sulphur-coloured flowers in April, and C. nobilis, 1 foot, rich yellow, in May; C. solida, with purplish, and C. tuberosa, with white flowers, are pretty spring-flowering plants, 4 to 6 inches high.

Cyclamen.—Charming tuberous-rooted plants of dwarf habit, suitable for sheltered rockeries, and growing in light gritty soil. C. europæum, reddish-purple, flowers in summer, and C. hederifolium in autumn.

Cypripedium.—Beautiful terrestrial orchids, requiring to be planted in peat soil, in a cool and rather shady situation. C. spectabile, 1½ to 2 feet, white and rose colour, in June, is a lovely species, as is C. Calceolus, 1 foot, yellow and brown, in May; all are full of interest and beauty.

Delphinium.—The Larkspur family, tall showy plants, with spikes of blue flowers in July. The popular garden varieties are noted under par. 53. Other distinct sorts are D. grandiflorum and D. grandiflorum flore-pleno, 2 to 3 feet, of the richest dazzling blue, flowering on till September; D. chinense, 2 feet, blue, and its double-flowered variety, are good, as is D. Barlowi, 3 feet, a brilliant double blue purple. D. nudicaule, 2 feet, orange-scarlet, very showy, is best treated as a biennial, its brilliant flowers being produced freely in the second year from the seed.

Dianthus.—Chiefly rock plants with handsome and fragrant flowers, the smaller sorts growing in light sandy soil, and the larger border plants in rich garden earth. Of the dwarfer sorts for rock gardens, D. alpinus, D. cæsius, D. deltoides, D. dentosus, D. neglectus, D. petræus, and D. glacialis are good examples; while for borders or larger rockwork D. plumarius, D. superbus, D. Fischeri, D. cruentus, and the clove section of D. Caryophyllus are most desirable.

Dictamnus.—D. Fraxinella is a very characteristic and attractive plant, 2 to 3 feet, with bold pinnate leaves, and tall racemes of irregular-shaped purple or white flowers. It is everywhere glandular, and strongly scented.

Dielytra.—Very elegant plants, of easy growth in good soil. D. spectabilis, 2 to 3 feet, has pæony-like foliage, and gracefully drooping spikes of heart-shaped pink flowers, about May, but it should have a sheltered place, as it suffers from spring frosts and winds; D. formosa and D. eximia, 1 foot, are also pretty rosy-flowered species.

Digitalis.—Stately erect-growing plants, with long racemes of pouch-shaped drooping flowers. The native D. purpurea, or Foxglove, 3 to 5 feet, with its dense racemes of purple flowers, spotted inside, is very showy, but is surpassed by the garden variety called gloxinioides. The yellow-flowered D. lutea and D. grandiflora are less showy. Good garden soil, and frequent renewal from seeds.

Doronicum.—Showy composites of free growth in ordinary soil. D. caucasicum and D. austriacum, 1 to 1½ feet, both yellow-flowered, bloom in spring and early summer.

Draba.—Good rockwork cruciferous plants. D. alpina, D. aizoides, D. ciliaris, D. Aizoon, and D. cuspidata bear yellow flowers in early spring; D. cinerea and D. ciliata have white flowers. Gritty well-drained soil.

Dracocephalum.—Handsome labiate plants, requiring a warm and well-drained soil. D. argunense, 1½ feet, D. austriacum, 1 foot, D. grandiflorum, 1 foot, and D. Ruyschiana, 1½ feet, with its var. japonicum, all produce showy blue flowers during the summer months.

Echinacea.—Stout growing showy composites for late summer and autumn flowering, requiring rich deep soil, and not to be often disturbed. E. angustifolia, 3 to 4 feet, light purplish-rose, and E. intermedia, 3 to 4 feet, reddish-purple, are desirable kinds.

Epimedium.—Pretty plants, growing about a foot high, with elegant foliage, and curious flowers. E. macranthum, white flowers, and E. rubrum, red, are distinctly spurred; E. pinnatum and E. Perralderianum, yellow, less so. They bloom in spring, and prefer a shady situation and a peaty soil.

Erigeron.—Composite plants, variable in character. E. purpureus, 1½ feet, with pink flower-heads, having narrow twisted ray-florets; E. Roylei, 1 foot, dark blue; and E. pulchellus, 1 foot, rich orange, flowering during the summer, are among the best kinds. Good ordinary garden soil.

Erinus.—E. alpinus is a beautiful little alpine for rockwork, 3 to 6 inches, of tufted habit, with small-toothed leaves, and heads of pinkish-purple or, in a variety, white flowers, early in summer. Sandy well-drained soil.

Erodium.—Handsome dwarf tufted plants. E. Manescavi, 1 to 1½ feet, has large purplish-red flowers in summer; E. Reichardi, a minute stemless plant, has small heart-shaped leaves in rosette-like tufts, and white flowers striped with pink, produced successively. Light soil.

Eryngium.—Very remarkable plants of the umbelliferous order, mostly of an attractive character. E. amethystinum, 2 feet, has the upper part of the stem, the bracts, and heads of flowers all of an amethystine blue. Some of more recent introduction have the aspect of the pine-apple, such as E. bromeliæfolium, E. pandanifolium, and E. eburneum. Deep light soil.

Erythronium.—E. dens canis, the Dog's-Tooth Violet, is a pretty dwarf bulbous plant with spotted leaves, and rosy or white flowers produced in spring, and having reflexed petals. Mixed peaty and loamy soil, deep and cool.

Euphorbia.—Plants whose beauty resides in the bracts or floral leaves which surround the inconspicuous flowers. E. aleppica, 2 feet, and E. Characias, 2 to 3 feet, with green bracts, are fine plants for rockwork or sheltered corners.

Ferula.—Gigantic umbelliferous plants, with magnificent foliage, adapted for shrubbery borders or open spots on lawns. They have thick fleshy roots, deeply penetrating, and therefore requiring deep soil, which should be of a light or sandy character. F. communis, F. glauca, and F. tingitana, the last with glossy lozenge-shaped leaflets, grow 8 to 10 feet high; F. Ferulago, with more finely cut leaves, grows 5 to 6 feet high. They flower in early spring, and all have a fine appearance when in bloom, on account of their large showy umbels of yellow flowers.

Funkia.—Pretty liliaceous plants, with simple conspicuously longitudinal-ribbed leaves, the racemose flowers funnel-shaped and deflexed. F. Sieboldiana, 1 foot, has lilac flowers; F. grandiflora, 18 inches, is white and fragrant; F. cœrulea, 18 inches, is violet-blue; F. albo-marginata, 15 inches, has the leaves edged with white, and the flowers lilac. Rich garden soil.

Gaillardia.—Showy composite plants, thriving in good garden soil. G. aristata, 2 feet, has large yellow flower-heads, 2 or 3 inches across, in summer; G. Bæselari and G. Loiselii have the lower part of the ray-florets red, the upper part yellow.

Galanthus.—The Snowdrop. Early spring-flowering amaryllidaceous bulbs, with pretty drooping flowers, snow-white, having the tips of the enclosed petals green. The common sort is G. nivalis, which blossoms on the first break of the winter frosts; G. Imperati and G. plicatus have larger flowers.

Gaura.—G. Lindheimeri, 3 to 5 feet, is much branched, with elegant white and red flowers of the onagraceous type, in long slender ramose spikes during the late summer and autumn months. Light garden soil; not long-lived.

Gentiana.—Beautiful tufted erect-stemmed plants preferring a strong rich loamy soil. G. acaulis, known as the Gentianella, forms a close carpet of shining leaves, and in summer bears large erect tubular deep blue flowers. G. Andrewsii, 1 foot, has, during summer, large deep blue flowers in clusters, the corollas closed at the mouth; G. asclepiadea, 18 inches, purplish-blue, flowers in July.

Geranium.—Showy border flowers, mostly growing to a height of 1½ or 2 feet, having deeply cut leaves, and abundant saucer-shaped blossoms of considerable size. G. ibericum, platypetalum, and Backhousianum are desirable purple-flowered sorts; G. sanguineum, a tufted grower, has the flowers a deep rose colour; and the double-flowered white and blue forms of G. pratense and G. sylvaticum make pretty summer flowers. Good garden soil.

Geum.—Pretty rosaceous plants. The single and double flowered forms of G. chiloense, 2 feet, with brilliant scarlet flowers, and G. montana, 9 inches, yellow, are amongst the best sorts. Good garden soil.

Gynerium.—The Pampas-Grass, a noble species, introduced from Buenos Ayres; it forms huge tussocks, 4 or 5 feet high, above which towards autumn rise the bold dense silvery plumes of the inflorescence. It does best in sheltered nooks.

Gypsophila.—Interesting caryophyllaceous plants, thriving in dryish situations. G. paniculata, 2 feet, from Siberia, forms a dense semi-globular mass of small white flowers from July onwards till autumn, and is very useful for cutting.

Helenium.—Showy composites of free growth in lightish soil. H. autumnale, 4 feet, bears a profusion of yellow-rayed flower-heads in August and September.

Helianthemum.—Dwarf subshrubby plants well suited for rockwork, and called Sun-Roses from their blossoms resembling small wild roses, and their thriving best in sunny spots. Some of the handsomest are H. roseum, mutabile, cupreum, and rhodanthum, with red flowers; H. vulgare flore-pleno, grandiflorum, and stramineum, with yellow flowers; and H. macranthum and papyraceum, with the flowers white.

Helianthus.—The Sunflower genus, of which there are several ornamental kinds. H. multiflorus, 4 feet, and its double-flowered varieties, bear showy golden yellow flower-heads in profusion, and are well adapted for shrubbery borders; H. orgyalis, 8 feet, has drooping willow-like leaves.

Helichrysum.—Composite plants, with the flower-heads of the scarious character known as Everlastings. H. arenarium, 6 to 8 inches, is a pretty species, of dwarf spreading habit, with woolly leaves and corymbs of golden yellow flowers, about July.

Helleborus.—Charming very early blooming dwarf ranunculaceous herbs. H. niger or Christmas Rose, the finest variety of which is called maximus, has white showy saucer-shaped flowers; H. orientalis, 1 foot, rose-coloured; H. atrorubens, 1 foot, purplish-red; and H. colchicus, 1 foot, deep purple. Deep rich loam.

Hepatica.—Charming little tufted plants requiring good loamy soil, and sometimes included with Anemone. H. triloba, 4 inches, has three-lobed leaves, and a profusion of small white, blue, or pink single or double flowers, from February onwards; H. angulosa, from Transylvania, 6 to 8 inches, is a larger plant, with sky-blue flowers.

Hesperis.—H. matronalis, 1 to 2 feet, is the old garden Rocket, of which some double forms with white and purplish blossoms are amongst the choicest of border flowers. They require a rich loamy soil, not too dry, and should be divided and transplanted into fresh soil annually or every second year, in the early autumn season.

Hibiscus.—Showy malvaceous plants. H. Moscheutos, rose coloured, and H. palustris, purple, both North American herbs, 3 to 5 feet high, are suitable for moist borders or for boggy places near the margin of lakes.

Iberis.—The Candytuft, of which several dwarf spreading subshrubby species are amongst the best of rock plants, clothing the surface with tufts of green shoots, and flowering in masses during May and June. The best are I. saxatilis, 6 to 10 inches; I. sempervirens, 12 to 15 inches; and I. Pruitii (variously called coriacea, carnosa, correæfolia), 12 inches.

Lathyrus.—Handsome climbing herbs, increased by seeds or division. L. grandiflorus, 3 feet, has large rose-coloured flowers with purplish-crimson wings, in June; L. latifolius, the Everlasting Pea, 6 feet, has bright rosy flowers in the late summer and autumn; the vars. albus, white, and superbus, deep rose, are distinct. Ordinary garden soil.

Lavatera.—L. thuringiacea, 4 feet, is a fine erect-growing malvaceous plant, producing rosy-pink blossoms freely, about August and September. Good garden soil.

Leucojum.—Snowflake. Pretty early-blooming bulbs, quite hardy. L. vernum, 6 inches, blooms shortly after the snowdrop, and should have a light rich soil and sheltered position; L. pulchellum, 1½ feet, blooms in April and May; and L. æstivum, 2 feet, in May. All have white pendent flowers, tipped with green.

Liatris.—Pretty composites with the flower-heads collected into spikes. L. pumila, 1 foot, L. squarrosa, 2 to 3 feet, L. spicata, 3 to 4 feet, L. pycnostachya, 3 to 4 feet, all have rosy-purplish flowers. Deep, cool, and moist soil.

Linaria.—Toadflax. Pretty scrophulariads, of which L. alpina, 3 to 6 inches, with bluish-violet flowers having a brilliant orange spot, is suitable for rockwork; L. dalmatica, 4 feet, and L. genistæfolia, 3 feet, both yellow flowered, are good border plants.

Linum.—Flax. L. alpinum, 6 inches, large, dark blue; L. narbonense, 1½ feet, large, blue; L. perenne, 1½ feet, cobalt blue; and L. arboreum (flavum), 1 foot, yellow, are all pretty. The last is liable to suffer from damp during winter, and some spare plants should be wintered in a frame.

Lithospermum.—L. prostratum, 3 inches, is a trailing evergreen herb, with narrow hairy leaves, and paniculate brilliant blue flowers in May and June. Well adapted for rockwork or banks of sandy soil.

Lupinus.—Showy erect-growing plants with papilionaceous flowers, thriving in good deep garden soil. L. polyphyllus, 3 feet, forms noble tufts of palmate leaves, and long spikes of bluish-purple or white flowers in June and July; L. arboreus is subshrubby, and has yellow flowers.

Lychnis.—Brilliant erect-growing caryophyllaceous plants, thriving best in beds of peat earth, or of deep sandy loam. L. chalcedonica, 3 feet, has dense heads of bright scarlet flowers, both single and double, in June and July; L. fulgens, 1 foot, vermilion; L. Haageana, 1½ feet, scarlet; and L. grandiflora, 1 foot, coppery-orange, are all large-flowered and showy, but require a little protection in winter.

Malva.—M. moschata, 2 feet, with a profusion of pale pink or white flowers, and musky deeply-cut leaves, though a British plant, is worth introducing to the flower borders when the soil is light and free.

Mertensia.—M. virginica, 1 to 1½ feet, azure-blue, shows flowers in drooping panicles in May and June. It does best in shady peat borders.

Mimulus.—Monkey-flower. Free-blooming, showy scrophulariaceous plants, thriving best in moist situations. M. cardinalis, 2 to 3 feet, has scarlet flowers, with the limb segments reflexed; M. luteus and its many garden forms, 1 to 1½ feet, are variously coloured and often richly spotted; and M. cupreus, 8 to 10 inches, is bright coppery-red. M. moschatus is the Musk-plant, of which the variety Harrisoni is a greatly improved form, with much larger yellow flowers.

Monarda.—Handsome labiate plants, flowering towards autumn, and preferring a cool soil and partially shaded situation. M. didyma, 2 feet, scarlet or white; M. fistulosa, 3 feet, purple; and M. purpurea, 2 feet, deep purple, are good border flowers.

Muscari.—Pretty dwarf spring-flowering bulbs. M. botryoides (Grape Hyacinth), 6 inches, blue or white, is the handsomest; M. moschatum (Musk Hyacinth), 10 inches, has peculiar livid greenish-yellow flowers and a strong musky odour; M. monstrosum (Feather Hyacinth), bears sterile flowers broken up into a feather-like mass. Good garden soil.

Myosotis.—Forget-me-not. Lovely boraginaceous plants. M. dissitiflora, 6 to 8 inches, with large handsome and abundant sky-blue flowers, is the best and earliest, flowering from February onwards; it does well in light cool soils, preferring peaty ones, and should be renewed annually from seeds or cuttings. M. rupicola, 2 to 3 inches, intense blue, is a fine rock plant, preferring shady situations and gritty soil; M. sylvatica, 1 foot, blue, pink, or white, used for spring bedding, should be sown annually in August.

Nardosmia.—N. fragrans, the Winter Heliotrope, though of weedy habit, with ample cordate coltsfoot-like leaves, yields in January and February its abundant spikes, about a foot high, of greyish flowers scented like heliotrope; it should have a corner to itself.

Nepeta.—N. Mussinii, 1 foot, is a compactly spreading greyish-leaved labiate, with lavender-blue flowers, and is sometimes used for bedding or for marginal lines in large compound beds.

Nierembergia.—N. rivularis, 4 inches, from La Plata, has slender creeping rooting stems, bearing stalked ovate leaves, and large funnel-shaped white flowers, with a remarkably long slender tube; especially adapted for rockwork, requiring moist sandy loam.

Œnothera.—The genus of the Evening Primrose, consisting of showy onagrads, all of which grow and blossom freely in rich deep soils. Œ. missouriensis (macrocarpa), 6 to 12 inches, has stout trailing branches, lance-shaped leaves, and large yellow blossoms; Œ. taraxacifolia, 6 to 12 inches, has a stout crown from which the trailing branches spring out, and these bear very large white flowers changing to delicate rose; this perishes in cold soils, and should therefore be raised from seed annually. Of erect habit are Œ. speciosa, 1 to 2 feet, with large white flowers; Œ. fruticosa, 2 to 3 feet, with abundant yellow flowers; and Œ. serotina, 2 feet, also bright yellow.

Omphalodes.—Elegant dwarf borageworts. O. verna, 4 to 6 inches, a creeping shade-loving plant, has bright blue flowers in the very early spring; O. Luciliæ, 6 inches, has much larger lilac-blue flowers, and is an exquisite rock plant for warm sheltered spots. Light sandy soil.

Onosma.—O. taurica, 6 to 8 inches, is a charming boraginaceous plant, from the Caucasus, producing hispid leaves, and cymose heads of drooping tubular yellow flowers. It is of evergreen habit, and requires a warm position on the rockwork, and well-drained sandy soil; or a duplicate should be sheltered during winter in a cold dry frame.

Ourisia.—Handsome scrophulariaceous plants, from Chili, thriving in moist well-drained peaty soil, and in moderate shade. O. coccinea, 1 foot, has erect racemes of pendent crimson flowers.

Papaver.—The Poppy. Very showy plants, often of strong growth, and of easy culture in ordinary garden soil. P. orientale, 3 feet, has crimson-scarlet flowers, 6 inches across, and the variety bracteatum closely resembles it, but has leafy bracts just beneath the blossom. P. alpinum, 6 inches, white with yellow centre; P. nudicaule, 1 foot, yellow, scented, and P. pilosum, 1 to 2 feet, deep orange, are ornamental smaller kinds.

Pentstemon.—The popular garden varieties are noticed under par. 63. Other distinct kinds are P. campanulatus, 1½ feet, pale rose, of bushy habit; P. humilis, 9 inches, bright blue; P. speciosus, cyananthus, and Jaffrayanus, 2 to 3 feet, all bright blue; P. barbatus, 3 to 4 feet, scarlet, in long terminal panicles; P. Murrayanus, 6 feet, with scarlet flowers and connate leaves; and P. Palmeri, 3 to 4 feet, with large wide-tubed rose-coloured flowers.

Phlomis.—Bold and showy labiates, growing in ordinary soil. P. Russelliana (lunariæfolia), 4 feet, yellow, and P. tuberosa, 3 feet, purplish-rose, both with downy hoary leaves, come in well in broad flower borders.

Physostegia.—Tall autumn-blooming labiates, of easy growth in ordinary garden soils. P. imbricata, 5 to 6 feet, has pale purple flowers in closely imbricated spikes.

Polemonium.—Pretty border flowers. P. cœruleum (Jacob's Ladder), 2 feet, has elegant pinnate leaves, and long panicles of blue rotate flowers. The variety called variegatum has very elegantly marked leaves, and is sometimes used as a margin or otherwise in bedding arrangements. Good garden soil.

Polygonatum.—Elegant liliaceous plants, with rhizomatous stems. P. multiflorum (Solomon's Seal), 2 to 3 feet, with arching stems, and drooping white flowers from the leaf axils, is a handsome border plant, doing especially well in partial shade amongst shrubs, and also well adapted for pot culture for early forcing. Good garden soil.

Polygonum.—A large family, varying much in character, often weedy, but of easy culture in ordinary soil. P. vacciniifolium, 6 to 10 inches, is a pretty prostrate subshrubby species, with handsome rose-pink flowers, suitable for rockwork, and prefers boggy soil; P. affine (Brunonis), 1 foot, deep rose, is a showy border plant, flowering in the late summer; P. cuspidatum, 8 to 10 feet, is a grand object for planting where a screen is desired, as it suckers abundantly, and its tall spotted stems and handsome cordate leaves have quite a noble appearance.

Primula.—Beautiful and popular spring flowers, of which many forms are highly esteemed in most gardens. P. vulgaris, 6 inches, affords numerous handsome single and double-flowered varieties, with various-coloured flowers for the spring flower beds and borders (par. 68). Besides this, P. Sieboldii (cortusoides amœna), 1 foot, originally deep rose with white eye, but now including many varieties of colour, such as white, pink, lilac, and purple; P. japonica, 1 to 2 feet, crimson-rose; P. denticulata, 1 foot, bright bluish-lilac, with its allies P. erosa and P. purpurea, all best grown in a cold frame; P. viscosa, 6 inches, purple, and its white variety nivalis, with P. pedemontana and P. spectabilis, 6 inches, both purple; and the charming little Indian P. rosea, 3 to 6 inches, bright cherry rose colour, are but a few of the many beautiful kinds in cultivation.

Pulmonaria.—Handsome dwarf borageworts, requiring good deep garden soil. P. officinalis, 1 foot, has prettily mottled leaves and blue flowers; P. sibirica is similar in character, but has broader leaves more distinctly mottled with white.

Pyrethrum.—Composite plants of various character, but of easy culture P. Parthenium eximium, 2 feet, is a handsome double white form of ornamental character for the mixed border; P. uliginosum, 5 to 6 feet, has fine large white radiate flowers, in October; P. Tchihatchewii, a close-growing dense evergreen creeping species, with long-stalked white flower-heads, is adapted for covering slopes in lieu of turf, and for rockwork.

Ramondia.—R. pyrenaica, 3 to 6 inches, is a pretty dwarf plant, requiring a warm position on the rockwork, and a moist peaty soil more or less gritty; it has rosettes of ovate spreading root-leaves, and large purple yellow-centred rotate flowers, solitary or two to three together, on naked stalks.

Ranunculus.—The florists' ranunculus is noticed in par. 70. R. amplexicaulis, 1 foot, white; R. aconitifolius, 1 to 2 feet, white, with its double variety R. aconitifolius flore-pleno (Fair Maids of France); and R. acris flore-pleno (Bachelor's Buttons), 2 feet, golden yellow, are pretty. Of dwarfer interesting plants there are R. alpestris, 4 inches, white; R. gramineus, 6 to 10 inches, yellow; R. parnassifolius, 6 inches, white; and R. rutæfolius 4 to 6 inches, white with orange centre.

Rudbeckia.—Bold-habited composite plants, well suited for shrubbery borders, and thriving in light loamy soil. The flower-heads have a dark-coloured elevated disk. R. Drummondii, 2 to 3 feet, with the ray-florets reflexed, yellow at the tip and purplish-brown towards the base; R. fulgida, 2 feet, golden yellow with dark chocolate disk, the flower-heads 2 to 3 inches across; and R. speciosa, 2 to 3 feet, orange-yellow with blackish-purple disk, the flower-heads 3 to 4 inches across, are showy plants.

Salvia.—The Sage, a large genus of labiates, often very handsome, but sometimes too tender for English winters. S. Sclarea, 5 to 6 feet, is a very striking plant little more than a biennial, with branched panicles of bluish flowers issuing from rosy-coloured bracts; S. patens, 2 feet, which is intense azure, has tuberous roots, and may be taken up, stored away, and replanted in spring like a dahlia. S. pratensis, 2 feet, blue, a showy native species, is quite hardy; the variety lupinoides has the centre of the lower lip white.

Saxifraga.—A very large genus, comprising plants of varied aspect, many of them handsome though simple in character, and most of them adapted for rockwork, requiring only ordinary good soil. Some of the larger growing species, now often called Megasea, are grand early-flowering border plants with broad leaves and large cymose clusters of rosy-pink flowers, *e.g.*, S. purpurascens, S. cordifolia, and S. crassifolia, with their varieties. Of another group with silvery leaves there are representatives in S. longifolia, S. cæsia, S. Cotyledon, S. pectinata, and S. Rocheliana; of the green mossy group in S. hypnoides, S. ceratophylla, S. muscoides, &c.; and of the London Pride section in S. umbrosa, S. Andrewsii, S. Geum, and S. Bucklandii. S. oppositifolia, 2 to 3 inches, purple or white, is a brilliant plant for rockwork, forming a carpet over the surface of the stones.

Scilla.—Beautiful dwarf bulbous plants, thriving in well-worked sandy loam, or sandy peat. S. bifolia, 3 inches, and S. sibirica, 4 inches, both intense blue, are among the most charming of early spring flowers; S. patula, 6 to 8 inches, and S. campanulata, 1 foot, with star-shaped greyish-blue flowers, freely produced, are fine border plants, as is the later blooming S. peruviana, 6 to 8 inches, dark blue or white.

Sedum.—Pretty succulent plants of easy growth, and mostly suitable for rockwork. They are numerous, varied in the colour of both leaves and foliage, and mostly of compact tufted growth. S. spectabile, 1 to 1½ feet, pink, in great cymose heads, is a fine plant for the borders, and worthy also of pot-culture for greenhouse decoration. Mention may also be made of the common S. acre (Stonecrop), 3 inches, yellow, and its variety with yellow-tipped leaves.

Sempervivum.—House-Leek. Neat-growing succulent plants, forming rosettes of fleshy leaves close to the ground, and rapidly increasing by runner-like offsets; they are well adapted for rockwork, and do best in sandy soil. The flowers are stellate, cymose, on stems rising from the heart of the leafy rosettes. S. arachnoideum, purplish, S. arenarium, yellow, S. globiferum, and S. Laggeri, rose, grow when in flower 3 to 6 inches high; S. calcareum, rose colour, and S. Boutignianum, pale rose, both have glaucous leaves tipped with purple; S. Heuffelii, yellow, with deep chocolate leaves, and S. Wulfeni, sulphur-yellow, are from 8 to 12 inches high.

Silene.—Pretty caryophyllaceous plants, preferring sandy loam, and well adapted for rockwork. S. alpestris, 6 inches, white, and S. quadridentata, 4 inches, white, are beautiful tufted plants for rockwork or the front parts of borders; S. maritima flore-pleno, 6 inches, white, S. Elizabethæ, 4 inches, bright rose, and S. Schafta, 6 inches, purplish-rose, are also good kinds.

Sisyrinchium.—Pretty dwarf iridaceous plants, thriving in peaty soil. S. grandiflorum, 10 inches, deep purple or white, blooms about April, and is a fine plant for pot-culture in cold frames.

Spiræa.—Vigorous growing plants of great beauty, preferring good deep rather moist soil; the flowers small but very abundant, in large corymbose or spicate panicles. S. Aruncus 4 feet, white; S. astilboides, 2 feet, white;

S. Filipendula flore-pleno, 1½ feet, and S. Ulmaria flore-pleno, 3 feet, both white; S. palmata, 2 feet, rosy-crimson; and S. venusta, 3 feet, carmine rose, are some of the best.

Statice.—Pretty plants with broad radical leaves, and a much-branched inflorescence of numerous small flowers. S. latifolia, 2 feet, greyish-blue; S. tatarica, 1 foot, lavender-pink; S. speciosa, 1½ feet, rose colour; and S. eximia, 1½ feet, rosy-lilac—are good border plants. S. bellidifolia, 9 inches, lavender; S. emarginata, 6 inches, purple; S. globulariæfolia, 9 inches, white; and S. nana, 4 inches—are good sorts for the rockery.

Stenactis.—S. speciosa, 1 to 2 feet, is a showy composite, of easy culture in good garden soil; it produces large corymbs of flower-heads, with numerous narrow blue ray-florets surrounding the yellow disk.

Stipa.—S. pennata (Feather Grass), 1½ feet, is a very graceful-habited grass, with stiff slender erect leaves, and long feathery awns to the flowers.

Stokesia.—S. cyanea, 2 feet, is a grand autumn-flowering composite plant, with blue flower-heads, 4 inches across. Sandy loam and warm situation.

Symphytum.—Rather coarse-growing but showy boraginaceous plants, succeeding in ordinary soil. S. caucasicum, 2 feet, with blue flowers changing to red, is one of the finer kinds for early summer blooming.

Thalictrum.—Free-growing but rather weedy ranunculaceous plants, in many cases having elegantly cut foliage. T. aquilegifolium, 2 feet, purplish from the conspicuous stamens, the leaves glaucous, is a good border plant; and T. minus has foliage somewhat resembling that of the Maidenhair fern. Ordinary garden soil.

Triteleia.—Charming spring-flowering bulbs, thriving in any good sandy soil. T. Murrayana, 8 inches, lavender-blue, and T. uniflora, 6 inches, white, are both pretty plants of the easiest culture, either for borders or rockeries.

Tritoma.—Splendid stoutish-growing plants of noble aspect, familiarly known as the Poker plant, from their erect rigid spikes of flame-coloured flowers; sometimes called Kniphofia. T. Uvaria, 3 to 4 feet, bright orange-red, passing to yellow in the lower flowers, is a fine autumnal decorative plant. They should be protected from frosts by a covering of ashes over the crown during winter.

Trollius.—Showy ranunculaceous plants, of free growth, flowering about May and June. T. europaeus, 18 inches, lemon, globular; T. asiaticus, 2 feet, deep yellow; and T. napellifolius, 2 to 2½ feet, golden yellow, are all fine showy kinds. Rich and rather moist soil.

Tulipa.—Splendid dwarfish bulbs, thriving in deep sandy well-enriched garden soil, and increased by offsets. They bloom during the spring and early summer months. T. Gesneriana, the parent of the florists' tulip (par. 71), 12 to 18 inches, crimson and other colours; T. Eichleri, 1 foot, crimson with dark spot; T. Greigi, 1 foot, orange with dark spot edged with yellow, and having dark spotted leaves; T. oculus solis, 1 foot, scarlet with black centre; and T. sylvestris, 12 to 18 inches, bright yellow, are showy kinds.

Verbascum.—Showy border flowers of erect spire-like habit, of the easiest culture. V. Chaixii, 4 to 5 feet, yellow, in large pyramidal panicles; V. phœniceum, 3 feet, rich purple or white; and V. formosum, 6 feet, golden yellow in dense panicles, are desirable species.

Veronica.—The Speedwell family, containing many ornamental members; all the hardy species are of the easiest cultivation in ordinary garden soil. The rotate flowers are in close erect spikes, sometimes branched. V. crassifolia, 2 feet, dark blue; V. incarnata, 1½ feet, flesh-colour; V. corymbosa, 1½ feet, pale blue in corymbosely-arranged racemes; V. gentianoides, 2 feet, grey with blue streaks; and V. virginica, 5 feet, white, are distinct.

Vinca.—Periwinkle. Pretty rock plants, growing freely in ordinary soil. V. herbacea, of creeping habit, with purplish-blue flowers; V. minor, of trailing habit, blue; and V. major, 1 to 2 feet high, also trailing, are suitable for the rock garden. The last two are evergreen, and afford varieties which differ in the colour of their flowers, while some are single and others double.

Viola.—Violet. Charming dwarf plants, mostly evergreen and of tufted habit, requiring well-worked rich sandy soil. V. calcarata, 6 inches, light blue; V. cornuta, 6 to 8 inches, blue; V. lutea, 4 inches, yellow; V. altaica, 6 inches, yellow or violet with yellow eye; V. palmaensis, 6 to 8 inches, lavender-blue; V. pedata, 6 inches, pale blue; and V. odorata, the Sweet Violet, in its many single and double flowered varieties, are all desirable.

Yucca.—Noble subarborescent liliaceous plants, which should be grown in every garden. They do well in light well-drained soils, and have a close family resemblance, the inflorescence being a panicle of white drooping tulip-shaped flowers, and the foliage rosulate, sword-shaped, and spear-pointed. Of the more shrubby-habited sorts Y. gloriosa, recurvifolia, and Treculeana, are good and distinct; and of the dwarfer and more herbaceous sorts Y. filamentosa, flaccida, and angustifolia are distinct and interesting kinds, the first two flowering annually.

The taste for cultivation of the class of plants of which the foregoing list embraces the more prominent members is on the increase, and our gardens will benefit by its extension; but we may hope that the folly of limiting the interest of the flower garden to this class of subjects alone, to the exclusion of the brilliant bedding flowers which have been evolved out of less showy materials by the gardener's skill, as some writers would seem to desire, may never be realized.

We now proceed to notice at greater length the more important plants of this class,—those to which horticulturists have devoted the greatest attention, with the result, in many cases, of largely increasing the varieties of these "florists' flowers."

45. The *Anemone* (Anemone coronaria), often called the Poppy Anemone, is a tuberous-rooted plant, with parsley-like divided leaves, and large showy poppy-like blossoms on stalks of from 6 to 9 inches high; the flowers are of various colours, but the principal are scarlet, crimson, blue, purple, and white. There are also double-flowered varieties, in which the stamens in the centre are replaced by a tuft of narrow petals. It is an old garden favourite, and of the double forms there are named varieties. They grow best in a loamy soil, enriched with well-rotted manure, which should be dug in below the tubers. These may be planted in October, and for succession in January, the autumn planted ones being protected by a covering of leaves or short stable litter. They will flower in May and June, and when the leaves have ripened should be taken up into a dry room till planting time. Anemones are easily raised from the seed, and a bed of the single varieties is a valuable addition to a flower-garden, as it affords, in a warm situation, an abundance of handsome and often brilliant spring flowers, almost as early as the snowdrop or crocus. The genus contains many other lively spring blooming plants, of which A. hortensis and A. fulgens have less divided leaves and splendid rosy-purple or scarlet flowers; they require similar treatment. Another set is represented by A. Pulsatilla, the Pasque-flower, whose violet blossoms have the outer surface hairy; these prefer a calcareous soil. The splendid A. japonica, and its white variety called Honorine Jobert, the latter especially, are amongst the finest of autumn blooming hardy perennials; they grow well in light soil, and reach 2½ to 3 feet in height, blooming continually for several weeks. A group of dwarf species, represented by the native British A. nemorosa and A. apennina, are amongst the most beautiful of spring flowers for planting in woods and shady places.

Antirrhinum.

46. The *Antirrhinum* (Antirrhinum majus) is very easily managed. Sown in heat, and forwarded until the general time for planting out, it becomes a summer annual, and may be so treated (par. 33); but under a slower and more hardy regime it may be sown in boxes in August, and pricked off into other boxes and wintered in a frame, for, though not often destroyed, it sometimes suffers greatly in a severe season. So treated, and planted out in well-prepared beds of good friable garden soil, it will become very showy and effective, and if a good strain of seed has been obtained many very beautiful kinds may generally be selected from the progeny. The named sorts are propagated by cuttings, and wintered in a frame. Some of the double-flowered sorts are interesting. There are forms with white, yellow, rose, crimson, magenta, and variously mottled and striped flowers, some of them of great beauty, but the named sorts are too fugitive to make it desirable to record a list of them.

Auricula.

47. The *Auricula* (Primula Auricula), a native of the Alps, has been an inmate of British gardens for about three hundred years, and is still prized by florists as one of their choicest flowers. The auricula loves a cool soil and shady situation. The florists' varieties are grown in rich composts, for the preparation of which numberless receipts have been given; but many of the old nostrums are now exploded, and a more rational treatment has taken their place. Thus Mr Douglas, the most recent authority, writes (*Hardy Florists' Flowers*):—

> "There is no mystery, as some suppose, about the potting, any more than there is about the potting material. The compost should consist of turfy loam four parts, leaf-mould one part, sharp river or silver sand one part, and a few bits of broken charcoal mixed with it. The pots to be used should be from 3 to 4½ inches in diameter, inside measure; about 1 inch of potsherds should be placed in the bottom of each pot, and over this some fibrous turf, from which the fine particles of earth have been removed. The old soil should be shaken from the roots of the plants to be potted; and before potting cut off, if necessary, a portion of the main root. In potting press the soil rather firmly around the roots."

Auriculas are best grown in a cold frame mounted on legs about 2 feet from the ground, and provided with hinged sashes. A graduated stage formed of wood battens 6 inches broad, with a rise of 2 inches, should be fixed so as to take each one row of pots, with the plants standing at about 15 inches from the glass; the spaces between the shelves should be closed, while the top board of the back and the front should be hinged so as to be let down when desired for ventilation, the sashes, too, being movable for the same purpose, and also to afford facilities for examining and attending to the plants. This frame should face the north, and stand under shelter of a wall or hedge. No protection will be needed except in very severe frosts, when two or three thicknesses of garden mats may be thrown over the glass, and allowed to remain on until the soil is thawed, should it become frozen.

Auriculas may be propagated from seed, which is to be sown as soon as ripe, in July or August, in boxes, kept under cover, and exposed only to the rays of the morning sun. When seed has been saved from the finer sorts, the operation is one of considerable nicety, as it not unfrequently happens that the best seedlings are at first exceedingly weak. They generally flower in the second or third year, a few good sorts being all that can be expected from a large sowing. The established varieties are increased by taking off the offshoots, an operation which is performed at the time of potting in July or the beginning of August.

The original of the auricula is a hardy perennial herb, of dwarf habit, bearing dull yellowish blossoms. This and the commoner forms raised from seed, as well as one or two double forms, are interesting hardy border flowers. The choice florists' varieties are divided into five classes:—the *green-edged*, with the margins of the flowers green; the *grey-edged*, with the green margins powdered with meal so as to appear to be coloured grey; the *white-edged*, with the mealy powder so dense as to cover the green; the *selfs*, which have none of the green variegation of margin seen in the foregoing, but are of some distinct colour, as purple, maroon, &c., but have, like the preceding, a white paste surrounding the eye; and the *alpines*, which resemble the selfs in not having any green marginal variegation, but differ in having a yellow centre more or less dense. The individual flowers of the first three groups of florists' auriculas show four distinct circles:—first the eye or tube, which should have the stamens lying in it, but sometimes has the pin-headed stigma instead, which is a defect; second, the paste or circle of pure white surrounding the eye; third, the body colour, a circle of some dark tint, as maroon or violet, which feathers out more or less towards the edge, but is the more perfect the less it is so feathered, and is quite faulty if it breaks through to the outer circle; fourth, the margin, which is green or grey or white. These circles should be about equal in width and clearly defined, and the nearer they are to this standard the more perfect is the flower. In the group of selfs the conditions are the same, except that there is no margin, and consequently the body colour, which should be uniform in tone, extends to the edge. In the alpines there should be no paste or white surrounding the eye, but this space should be either golden-yellow or creamy-yellow, which makes two subdivisions in this group; and the body colour is more or less distinctly shaded, the edges being of a paler hue. There is besides a group of laced alpines, in which a distinct and regular border of colour surrounds each of the marginal lobes.

The following is a selection of good sorts now obtainable in the respective groups:—

Green-edged.—Leigh's Col. Taylor, Booth's Freedom, Litton's Imperator, Ashton's Prince of Wales, Trail's Prince of Greens, Page's Champion.

Grey-edged.—Headly's George Lightbody, Lancashire's Lancashire Hero, Sykes's Complete, Kay's Alexander Meiklejohn, Walker's George Levick, Headly's C. E. Brown.

White-edged.—Heap's Smiling Beauty, Hepworth's True Briton, Ashworth's Regular, Taylor's Glory, Summerscale's Catherina, Lee's Bright Venus.

Selfs.—Netherwood's Othello, Campbell's Pizarro, Spalding's Blackbird, Pohlman's Garibaldi, Turner's C. J. Perry, Lightbody's Meteor Flag.

Alpines.—Turner's John Leech, Turner's Bessie Ray, Gorton's Diadem, Turner's A. F. Barron, Turner's Jessie, Turner's Susie Matthams.

Carna-ion.

48. The *Carnation* (Dianthus Caryophyllus), a native, as some suppose, of Italy, but occasionally found in an apparently wild state in England, has long been held in high estimation as a garden flower, not only for the beauty but for the delightful fragrance of its blossoms. The varieties are numerous, and are ranged under three groups, called *bizarres, flakes*, and *picotees*. The last, from their distinctness of character, are now generally looked upon as if they were a different plant, whereas they are, in truth, but a seminal development from the carnation itself, their number and variety being entirely owing to the assiduous endeavours of the modern florist to vary and to improve them.

The true carnations, as distinguished from picotees, are those which have the colours arranged in longitudinal stripes or bars of variable width on each petal, the ground colour being white. The *bizarres* are those in which stripes of two distinct colours occur on the white ground, and it is on the purity of the white ground and the clearness and evenness of the striping that the technical merit of each variety rests. There are scarlet bizarres marked with scarlet and maroon, crimson bizarres marked with crimson and purple, and pink and purple bizarres marked with those two colours. The *flakes* are those which have stripes of only one colour on the white ground, and here we have purple flakes striped with purple, scarlet flakes striped with scarlet, and rose flakes striped with rose colour. There are still the *selfs*, or those showing one colour only, as white, yellow, crimson, purple, &c., and these are commonly called *cloves*.

The *picotee* differs from the carnation in having the petals laced instead of striped with a distinct colour; the subgroups bear the designations red-edged, purple-edged, rose-edged, and scarlet-edged, all having white grounds; each group divides into two sections, the heavy-edged and the light-edged respectively. In the heavy-edged sorts the colour appears to be laid on in little touches, passing from the edge inwards, but so closely that they coalesce into one line of colour from $\frac{1}{12}$ to $\frac{1}{16}$ of an inch broad, and more or less feathered on the inner edge, the less feathered the better; while the light-edged sorts display only a fine edge, commonly called a wire edge, of colour on the white ground. To these have to be added yellow picotees, a group of great beauty, but deficient in correctness of marking.

Even the choice varieties of the carnation or picotee may be very successfully grown in most unfavourable localities; but the commoner sorts, such as may be raised freely from seed, on account of their robust constitution, are perhaps to be preferred for the ordinary flower garden; while the single-flowered sorts are by no means to be despised, especially those having decided colours. It is by selecting the best seedlings that new varieties of merit are produced. The established varieties are propagated by layers or by pipings, the former plan being adopted with strong healthy plants in an ordinarily congenial season. The latter is sometimes had recourse to when the plants do not produce young shoots of sufficient length to admit of their being layered; and the cuttings, planted under close glasses in a bed where there is a very slight bottom heat, will generally root. Layering is, however, a more expeditious mode. It is performed at the time the plants are in flower, or as soon after as possible. The rooted layers may be removed and potted or planted out towards the end of September, or early in October, the choice sorts being potted in rather small pots and kept in a cold frame during winter, at which season the great enemy to be guarded against is damp.

The soil for carnations and picotees should be a good turfy loam, free from wireworm, and as fibry as it can be obtained; to four parts of this add one part of rotten manure and one of leaf-mould, with sufficent sharp sand to keep it loose. A moderate addition of old lime rubbish, if attainable, will also be an advantage. This should be laid up in a dry place, and frequently turned over with the fork or spade, so as to be in a free friable condition for use towards the end of February or early in March. As to the size of the blooming pots, Mr Douglas observes:—

"I do not care to use them larger than 10 inches in diameter, inside measure, and three plants may be put into a pot that size; a 9-inch pot may be used for a pair of a strong-growing sort, while weaker growers may be potted two in an 8-inch or even a 7-inch pot. If it is intended to propagate all the layers produced, that must be taken into account, as the plants will not have so good a chance in a small as in a large pot. After potting they should be kept in a well-ventilated frame until established, and set in the open air in an open sunny spot when the weather becomes genial, the flowering stems being tied up carefully as they grow up. At the flowering season they should be put in a thoroughly ventilated glass house, where they can be shaded from bright sunshine, or under the protection of a canvas screen to keep off rain and sun. Where there is any tendency in the flowers to burst the calyx on one side, the other divisions should be slit down a little, and the calyx should have a ligature, not too tight, of thread or matting; this, if done early, will prevent the petals falling aside and destroying the symmetry of the flower."

The groups are so numerous that to name a selection of the best sorts would occupy too much space. Ample information on this head may be obtained from Mr Douglas's book already referred to (*Hardy Florists' Flowers*); and critically descriptive lists of all the varieties then grown, by the highest authority, Mr E. S. Dodwell, will be found in the volumes of the *Florist and Pomologist* for 1876 and 1877.

49. The *Chrysanthemum* (Chrysanthemum sinense) is one of the most popular of autumn flowers. It is a native of China, whence it has long been introduced. The small-flowered pompons, and the grotesque-flowered Japanese sorts are of more recent date, the former having originated from the Chusan daisy, a variety introduced by Mr Fortune in 1846, and the latter having also been introduced by the same traveller about 1862. The plants may be increased by division, in March or April, the divided portions being planted in beds of rich soil, under the shelter of a wall or fence, as a safeguard against cold and stormy weather. The shoots should be thinned out to about four or six from each root, and these should be staked as they grow up. They look extremely well in such a border, if arranged in two or three rows according to their heights, and with a judicious intermixture of colours, the advantage of growing them in this way being that a canvas screen can be put over them, by which means they not only flower in greater perfection, but last for a longer period. They are of the easiest culture, and may be grown readily enough even in town gardens. Chrysan-themum

The chrysanthemum is, however, of very great importance as a greenhouse plant for autumn and winter flowering, and for this purpose, as well as for exhibition culture, it is generally raised from cuttings, or suckers, which are taken off by some growers about October, and planted singly in 3-inch pots, the plants being wintered in cold frames, and shifted into larger-sized pots about March; they are topped when about 6 inches high, and the young shoots thus induced are again topped when 3 or 4 inches long. Others take short cuttings in March, and strike them quickly in a mild hotbed, airing freely as soon as rooted, and shifting and stopping as in the other case. As soon as fine weather sets in in June, the plants, having received one or two previous shifts according to the size which they are required to reach, should be plunged outdoors in a tolerably open spot, and there carefully watered and syringed. About the middle of July they should be shifted into their blooming pots, the pompons requiring less room than the large-flowered and Japanese sorts, and after the end of July it is not advisable to continue the topping—technically "stopping"—of the young shoots, as it may interfere with the blooming. As soon as the flower-buds become visible, the plants are benefited by a watering of weak liquid manure two or three times a week. The pots should still be plunged in a bed of coal ashes or cocoa-nut refuse, till about the end of September, when they should be put under glass as a precaution against injury from autumn frosts, having, however, full ventilation by day. Abundant root watering is necessary until the flowers are developed, when the supply may be slightly diminished, and the atmosphere should be kept dryish by abundant ventilation. The compost used for potting in all the stages after the cuttings, for which any light earth will suffice, should consist of four parts loam to one of rotten dung and one of leaf-mould, giving rather more leaf-mould and less manure for the first potting, and rather more manure for the last; a little coarsely-pounded gritty matter may be added advantageously. For the large-flowered sorts 11-inch pots are large enough to produce very handsome specimens, and 8-inch pots suffice for the pompons, but very useful plants may be had in smaller pots than these. For fine specimen flowers only a single shoot is allowed to grow up, and this goes on unstopped, and finally develops two or three very large flowers; these latter require disbudding, as some sorts give the best flowers from the terminal buds, others from the side buds. The aphis or green fly is a great enemy to the plants, and must be kept under; dusting the hearts of the shoots with tobacco powder is a safe and efficient remedy; but, whatever be the method employed, it should be applied before the blossoms open.

The following are a few of the best varieties in each section:—

Large-flowered.—Abbé Passaglia, Alfred Salter, Beethoven, Beverley, Dr Brock, Emily Dale, Empress of India, George Glenny, Golden Beverley.

Jardin des Plantes, Lady Hardinge, Mrs George Rundle, Mrs Heale, Prince Alfred, Prince of Wales, Princess of Wales, Venus, White Globe. These are all incurved flowers. To them might be added, for their merit as conservatory specimen plants, Chevalier Domage, Crimson Velvet, Julie Lagravère, and Mrs Forsyth.

Japanese.—Elaine, Fair Maid of Guernsey, James Salter, and Wizard, early sorts; Dr Masters, Fulton, Grandiflora, Hero of Magdala, Meg Merrilees, Purpureum album, Red Dragon, and The Daimio, later sorts.

Anemone-flowered.—Acquisition, Empress, Fleur de Marie, Gluck, King of Anemones, Lady Margaret, Louis Bonamy, Miss Margaret, Miss Pethers, Prince of Anemones, Princess Louise, Sunflower.

Pompons.—Adonis, Andromeda, Brilliant, General Canrobert, Mdlle. Martha, Modèle, St Michael, Salamon. To these may be added of Anemone-flowered pompons—Antonius, Astrea, Calliope, Cedo Nulli (four colours), Firefly, Jean Hachette, Madame Montels, Marie Stuart, Miss Nightingale, Mr Astie, Perle, Rose Marguerite, Virginale.

Within the last few years a new type of dwarf-growing early-blooming varieties has sprung up, and these are now increasing in number. They come into flower in August and September, and are extremely useful for filling up exhausted beds in the flower garden as well as for cutting. They are cultivated exactly as the others. The following are useful sorts of this group:—Adrastus, Chromatella, Delphine Caboche, Frédéric Pelé, Madame Alphonse Dufoy, Madame Piconl, Precocité, and Scarlet Gem.

ocus. 50. The *Crocus* sets our gardens aglow with its bright colours almost as soon as winter has departed. These crocuses of the flower garden are mostly seminal varieties of C. vernus and C. aureus, the former yielding the purple and striped, and the latter the yellow varieties. The headquarters of the genus is in eastern Europe and Asia Minor, but C. vernus is found wild in some parts of England. It has been much improved by Dutch florists, and large quantities are annually imported from Holland. The crocus succeeds in any fairly good garden soil, and is usually planted near the edges of beds or borders in the flower garden, or in broadish patches at intervals along the mixed borders. The roots or corms should be planted 3 inches below the surface, and as they become crowded they should be taken up and replanted with a refreshment of the soil, at least every five or six years. Crocuses have also a pleasing effect when dotted about on the lawns and grassy banks of the pleasure ground. Some of the best of the varieties are :—

Purple: David Rizzio, Sir J. Franklin. *Shaded light blue*: Lilaceus superbus. *Blue tipped with white*: Ne plus ultra. *Striped*: Albion, La Majestueuse, Sir Walter Scott, Cloth of Silver. *White*: Caroline Chisholm. *Yellow*: Large Dutch, Cloth of Gold.

The species of Crocus are not very readily obtainable, but those who make a speciality of hardy bulbs ought certainly to search them out and grow them. They require the same culture as the more familiar garden varieties; but, as some of them are apt to suffer from excess of moisture, it is advisable to plant them in prepared soil in a raised pit, where they are brought nearer to the eye, and where they can be sheltered when necessary by glazed sashes,—which, however, should not be kept closed except when the plants are at rest. The autumn-blooming kinds include many plants of very great beauty.

Of the spring-flowering species, there are C. aureus, Susianus, stellaris, sulphureus, chrysanthus, mesiacus, Olivieri, and vitellinus, having yellow flowers of various shades; C. vernus, etruscus, Imperati, minimus, suaveolens, and veluchensis, with blue or lilac flowers; C. albiflorus, Fleischerianus, versicolor, strictus, and biflorus, with white or whitish flowers. Of the autumn-blooming species, there are C. speciosus, Clusianus, medius, Orphanidis, longiflorus (odorus), Pallasii, Thomasii, Salzmannianus, nudiflorus, autumnalis, serotinus, Sieberi, Cartwrightianus, and byzantinus, with lilac or purple flowers; C. Boryanus, vallicola, hadriaticus, cancellatus, and Cambessedianus, with white or whitish flowers; and C. Scharojani with flowers of a rich saffron yellow.

Crown Imperial. 51. The *Crown Imperial* (Fritillaria imperialis) grows up to a height of about 3 feet, the lower part of the stoutish stem being furnished with leaves, while near the top is developed a coronal of large pendent flowers surmounted by a tuft of bright green leaves like those of the lower part of the stem, only smaller. The flowers are bell-shaped, yellow or red, and in some of the forms double. The plant grows freely in good garden soil, preferring a deep well-drained loam, and is all the better for a top-dressing of manure as it approaches the flowering stage. Strong clumps of five or six roots of one kind have a very fine effect. It is a very suitable subject for the back row in mixed flower borders, or for recesses in the front part of shrubbery borders. It flowers in April or early in May. There are a few named varieties, but the most generally grown are the single and double yellow, and the single and double red, the single red having also two variegated varieties, with the leaves striped respectively with white and yellow.

Dahlia. 52. The florists' *Dahlia* (Dahlia variabilis) yields two groups or varieties, which are known as show and fancy dahlias,—the former consisting of all self-coloured flowers and those light-ground ones which are edged, tipped, or laced with a dark colour; the latter, all flowers with the colour in stripes like a carnation, and all dark-ground flowers tipped with white. Besides these there are bedding dahlias, which are dwarf-growing sorts with decided colours, much used in flower-gardens where large effects are required to be produced; and pompon dahlias, which are very symmetrical small-flowered sorts, better adapted for cutting than the more bulky flowers of the show varieties. The single-flowered D. coccinea, a most brilliant and highly effective ornamental plant, with some other allied kinds, has recently attracted much attention, and can be commended as an admirable half-hardy border flower, and well adapted for cutting to fill large vases. It is rather more delicate than the forms of D. variabilis, and the tuberous roots are very apt to be lost during winter, but it is readily raised from seeds, and if sown early flowers the same season. The varieties of the florists' dahlia selected for the flower garden should be those only which are of effective colours, whether selfs or others, and such as throw out their flower heads or long stalks clear of the foliage. The same remark applies to the pompons.

New varieties are procured from seed, which should be sown in pots or pans towards the end of March, and placed in a hotbed or propagating pit, the young plants being pricked off into pots or boxes, and gradually hardened off for planting out in June; they will flower the same season if the summer is a genial one. The older varieties are propagated by dividing the large tuberous roots, in doing which care must be taken to leave an eye to each portion of tuber, otherwise it will not grow. Rare varieties are sometimes grafted on the roots of others (see fig. 57, p. 237). The best and most general mode of propagation is by cuttings, to obtain which, the old tubers are placed in heat in February, and as the young shoots, which rise freely from them, attain the height of 3 inches, they are taken off with a heel, and planted singly in small pots filled with fine sandy soil, and plunged in a moderate heat. They root speedily, and are then transferred to larger pots in light rich soil, and their growth encouraged until the planting-out season arrives, which is about the middle of June.

Dahlias succeed best in an open situation, and in rich deep loam, but there is scarcely any garden soil in which they will not thrive, if it is manured. For the production of fine show flowers the ground must be deeply trenched, and well manured annually. The branches as well as the blossoms require a considerable but judicious amount of thinning; they also need shading in some cases, and individual protection from rain and wind. They may stand singly like common border flowers, but have the most imposing appearance when seen in masses arranged according to their height. Florists usually devote a plot of ground to them, and plant them in lines 5 to 10 feet apart. This is done about the beginning of June, sheltering them if necessary from late frosts by inverted pots or in some other convenient way. Old roots often throw up a multitude of stems, which render thinning necessary. As the plants increase in height, they are furnished with strong stakes, to secure them from high winds. Dahlias flower on till they are interrupted by frost in autumn. The roots are then taken up, dried, and stored in a cellar, or some other place where they may be secure from fros and moisture. See article DAHLIA, vol. vi. p. 762.

53. The *Delphinium*, or Bee-Larkspur, is so called from the resemblance of the petals in the original species, D. elatum, to the hairy body of a bee. Delphinium. The original had comparatively small flowers, but by hybridizing they have been very much increased in size, and improved in quality, and now constitute one of the brightest ornaments of the mixed border, or the shrubbery group, often throwing up secondary blooming stems, especially if the first are removed in good time, instead of being allowed to form seeds. The colour varies from reddish-blue to pale blue or grey, but the prevailing one is dark blue. Delphiniums need a good rich soil, that of a loamy character being the best. They must be replanted at least every second year, and the soil either renewed or well manured and thoroughly broken up. Replanting may be done equally well early in autumn or when growth recommences in spring. The commoner single varieties, such as the brilliant D. formosum, may be reproduced with but slight variation from seed, but the double ones must be propagated by division. Unless sown as soon as ripe the seed is apt to take long to vegetate. If novelties are required, the flowers can be cross-fertilized. For mere propagation the best method is division; for this purpose the stems should be cut down early, say in July, the offsets potted each into a small pot of light soil, and wintered in a frame. The plants should be well exposed to the sun, but sheltered from strong winds, and promptly and carefully staked. In a mixed border they should be planted in one of the back rows; but their spire-like inflorescence is very effective when they are planted several together in a group or bed in the front part of the shrubbery border. They vary in height from 3 to 6 feet. The following are some of the best modern varieties :—

Single-flowered.—Amabilis, Celestial, Gloire de St Mande, Madame Chaté, Madame Henri Jacotot, Mrs Gerard Leigh.

Double-flowered.—Barlowi, Clair Courant, grandiflorum plenum, Keteleeri, Manteau de Minerva, Roi Léopold.

54. The *Gladiolus*, described separately in vol. x. p. 732, has become one of our most popular flowers, and is a striking ornament of our gardens during the late summer months. Gladiolus. The modern race of flowers has sprung from G. gandavensis, but others (see separate article) are grown to a smaller extent, and come in at an earlier season. G. cardinalis, cruentus, and floribundus belong to this latter series, and are pretty subjects for the mixed borders, while for beds G. brenchleyensis, one of the early hybrids, is still one of the most brilliant and effective, the flowers being of a glowing scarlet. The choicer kinds afford a variety of colours, including white, yellow, blush, rose, salmon, cerise, scarlet, crimson, and rosy-purple, many of them being prettily striped or blotched. Being tall (3 to 4 feet), and spare of leaves, they are most effective when planted in beds

furnished below with some bushy foliage plants, between which their spikes of brilliant flowers may appear; or they may be planted in the mixed border, where clumps of half a dozen roots of one kind have a much finer appearance than when they are dotted about singly.

A deep sandy loam is the best soil for the gladiolus, and this should be trenched up in October and enriched with well-decomposed manure, consisting partly of cow dung, the manure being disposed altogether below the bulbs, a layer at the bottom of the upper trench, say 9 inches from the surface, and another layer at double that depth. The bulbs (technically, corms) should be planted in succession at intervals of two or three weeks through the months of March, April, and May. They should be planted about 3 inches deep, a little pure soil or sand being laid over each before the earth is closed in about them, an arrangement which may be advantageously followed with bulbous plants generally. In hot summer weather they should have a good mulching of half-rotten manure, and, as soon as the flower spikes are produced, liquid manure may occasionally be given them with advantage.

The gladiolus is easily raised from seeds, which should be sown in March, in pots of rich soil placed in heat, the pots being kept near the glass after they begin to grow, and the plants being gradually hardened to permit their being placed out-of-doors in a sheltered spot for the summer. In October they will have ripened off, and must be taken out of the soil, and stored in paper bags in a dry room secure from frost. They will have made little bulbs from the size of a hazel nut downwards, according to their vigour. In the spring they should be planted like the old bulbs, and the larger ones will flower during the season, while the smaller ones must be again harvested and planted out as before.

The following are good varieties of their respective colours, but new varieties are continually appearing, which have at least the merit of constitutional vigour:—

Crimson, Scarlet, Red, &c.—Horace Vernet, John Waterer, Lord Bridport, Victory, Virgil, Lord Napier, Hesperia, Magnificent, Astrea, Lycoris, Addison, Meyerbeer.

Rose, Salmon, &c.—Figaro, Mons. Legouve, Sappho, Madame Furtado, Oberon, Grandeur, Ulysse, Milton, Ninon de l'Enclos, Sir Joseph Paxton.

Purple.—Antiope, Eugène Scribe, Robert Fortune, Lacépède, Thomas Methven, Madame Vilmorin, La Favorite, Mozart.

White ground.—Accins, Mrs Reynolds Hole, Reine Blanche, Canova, Hogarth, Osci, Didon, Norma, Sylphide, Madame Adèle Souchet, Berthe Rabourdin.

Yellow.—Citrinus, Nestor, Yellow King, Ophir, Crœsus, Pactolo.

Hollyhock. 55. The *Hollyhock* (Althæa rosea), having been already treated of in this volume (page 102), it only remains to add that, though it is a perennial, it is not to be had in perfection unless a supply of young plants is raised annually. The early part of August may be considered as the season for the blooming of the hollyhock.

The following are a few good sorts for a beginner:—Acme, Black Gem, Constance, Conquest, Edward Speed, Eleanor, Emperor, Fire King, Golden Drop, Incomparable, Jessie Dean, Joshua Clarke, Marvellous, Mr Chater, Octavia, Ruby Queen, Scarlet Gem, Tyrian Prince.

Hyacinth. 56. The *Hyacinth* (Hyacinthus orientalis), noticed under the heading HYACINTH (*q.v.*), one of the most beautiful and fragrant of the spring flowers, is a native of the Levant, where it occurs abundantly, in form not unlike our common harebell. It has long been a favourite in the East; but it has been brought to its present artificial perfection in Holland, chiefly since the beginning of the last century, and the bulbs are annually imported from Haarlem and its vicinity in very large numbers.

The hyacinth delights in a rich light sandy soil. The Dutch incorporate freely with their naturally light soil a compost consisting of one-third coarse sea or river sand, one-third rotten cow dung without litter, and one-third leaf-mould. The soil thus renovated retains its qualities for six or seven years, but hyacinths are not planted upon the same place for two years successively, intermediary crops of narcissus, crocus, or tulips being taken. A good compost for hyacinths is sandy loam, decayed leaf-mould, rotten cow dung, and sharp sand in equal parts, the whole being collected and laid up in a heap and turned over occasionally. Well drained beds made up of this soil, and refreshed with a portion of new compost annually, would grow the hyacinth to perfection. The best time to plant the bulbs is towards the end of October; they should be arranged in rows, 8 inches asunder, there being four rows in each bed. The bulbs should be sunk about 3 or 4 inches deep, with a small quantity of clean sand placed below and around each of them. The beds should be covered with decayed tan-bark, or half-rotten dung litter, and in severe weather may be covered with mats supported on hoops, which may be continued at night when the plants have grown up, but they should have full exposure to daylight. As the flower-stems appear, they are tied to little rods to preserve them from accident. If the bulbs are at all prized, the stems should be broken off as soon as the flowering is over, so as not to exhaust the bulbs; the leaves, however, must be allowed to grow on till matured, but as soon as they assume a yellow colour, the bulbs may be taken up, the leaves cut off near their base, and the bulbs laid out in a dry airy shady place to ripen, after which they are cleaned of loose earth and skin, ready for storing. It is the practice in Holland, about a month after the bloom, or when the tips of the leaves assume a withered appearance, to take up the bulbs, and to lay them sideways on the ground, covering them with an inch or two of earth. About three weeks later they are again taken up and cleaned. In the store-room the roots should be kept dry, well-aired, and apart from each other.

Few plants are better adapted than the hyacinth for pot culture as greenhouse decorative plants; and by the aid of forcing they may be had in bloom as early as Christmas. They flower fairly well in 5-inch pots, the stronger bulbs in 6-inch pots. To bloom at Christmas, they should be potted early in September, in a compost resembling that already recommended for the open-air beds; and, to keep up a succession of bloom, others should be potted at intervals of a few weeks till the middle or end of November. The bulbs should be planted about level with the soil, and if a little sand is put immediately around them so much the better. The pots should be set in an open place on a dry hard bed of ashes, and be covered over to a depth of 6 or 8 inches with the same material; and when the roots are well developed, which will take from six to eight weeks, they may be removed to a frame, and gradually exposed to light, and then placed in a forcing pit in a heat of from 60° to 70°. When the flowers are fairly open, they may be removed to the greenhouse or conservatory.

The hyacinth may be very successfully grown in glasses for ornament in dwelling houses. The glasses are filled to the neck with rain water, a few lumps of charcoal being dropped into them. The bulbs are placed in the hollow provided for them, so that their base just touches the water. This may be done in September or October. They are then set in a dark cupboard for a few weeks till roots are freely produced, and then gradually exposed to light.

There are both single and double-flowered varieties, but the single are generally preferred, as the bells are arranged more closely, so that they form a better spike than the doubles. A few good sorts are named below:—

Reds.—Of singles—Cavaignac, Lina, Macaulay, Norma, Sultan's Favourite, Von Schiller, Vuurbaak, Josephine, Fabiola, Robert Steiger, Madame Hodgson, Emmeline. Of doubles—Lord Wellington, Waterloo, Milton.

Blues.—Of singles—Argus, Charles Dickens, Grand Lilas, Haydn, Lord Palmerston, Orondates, Baron von Tuyll, Bleu Morant, Leonidas, General Havelock, Feruck Khan, Von Humboldt; the last three very dark. Of doubles—Laurens Koster, Van Speyk, Bloksberg.

Whites.—Of singles—Grand Vainqueur, Mont Blanc, Queen of the Netherlands, Grand Vedette, Madame Van der Hoop, La Franchise, La Grandesse, Elfrida (blush), Grandeur à Merveille (blush), alba maxima, Mirandoline, Queen Victoria. Of doubles—La Tour d'Auvergne, Prince of Waterloo, Jenny Lind.

Yellows.—Of singles—Ida, Bird of Paradise, Duc de Malakoff (striped with red). Of doubles—Jaune Suprême, Ophir d'Or, Crœsus.

To these may be added the early-flowering single white Roman hyacinth, a small-growing pure white variety, remarkable for its fragrance, and well adapted for forcing, as it can be had in bloom if required by November. For windows it grows well in the small glasses commonly used for crocuses; and for decorative purposes should be planted about five bulbs in a 5-inch pot, or in pans holding a dozen each. If grown for cut flowers it can be planted thickly in boxes of any convenient size.

57. The *Iris* family includes a large number of kinds of various habit and character, all of them being plants of exceeding beauty, and remarkable for their brilliant colours, and for having the three outer segments of their flowers reflexed. There are two well-distinguished groups called the bulbous and the rhizomatous. The hardier bulbous irises, including the Spanish iris (I. Xiphium), and the English iris (I. xiphioides), require to be planted in thoroughly drained beds in very light open soil, moderately enriched, and should have a rather sheltered position. Both these present a long series of beautiful varieties of the most diverse colours, flowering in June and July, the smaller Spanish iris being the earlier of the two. There are many other smaller species of bulbous iris. Being liable to perish from excess of moisture, they should have a well-drained bed of good but porous soil made up for them, in some sunny spot, and in winter should be protected by a 6-inch covering of half-decayed leaves or fresh cocoa-fibre refuse. To this set belong I. persica, reticulata, filifolia, Histrio, juncea, and others. Iris.

The herbaceous perennial irises, known commonly as the flag irises, are for the most part of the easiest culture; they grow in any good free garden soil, the smaller and more delicate species only needing the aid of turfy ingredients, either peaty or loamy, to keep it light and open in texture. The earliest to bloom are the forms of Iris pumila, which blossom during March, April, and May, and are quite dwarf in habit. I. susiana and I. iberica, with singularly mottled flowers, also dwarf in habit, bloom in April and May; and during the latter month and the following one most of the larger species, such as I. germanica, florentina, pallida, variegata, amœna, flavescens, sambucina, neglecta, ruthenica, &c., produce their gorgeous flowers. Of many of the foregoing there are, besides the typical form, a considerable number of named garden varieties.

The beautiful Japanese Iris Kæmpferi is of comparatively modern introduction, and though of a distinct type is equally beautiful with the better known species. In their outer segments they are rather spreading than deflexed, forming an almost circular flower, which becomes quite so in some of the very remarkable duplex varieties, in which six of these broad segments are produced instead of three. Of this too there are numberless varieties cultivated under names. They require a sandy peat soil, on a cool moist subsoil.

Lily. 58. The *Lily* (Lilium) is a very popular family of hardy bulbous flowers, and one which takes a high position in public estimation. The species are very handsome, and some of them have long been grown. They are so numerous and varied that no general cultural instructions will be alike suitable to all. Some species, as L. Martagon, candidum, chalcedonicum, Szovitzianum, and others, will grow in almost any good garden soil, and succeed admirably in loam of a rather heavy character. L. chalcedonicum has an especial dislike to peat, which on the other hand suits the tiger lily (L. tigrinum) well, and is indispensable for the beautiful American L. superbum and canadense. The choice and more delicate species, such as the grand L. auratum, speciosum, and Krameri, which have come to us in recent times from Japan, the Californian L. Humboldtii, pardalinum, &c., and the splendid hybrid L. Parkmanni, are more particular as to soil, and require a deep bed of mixed turfy loam and peat, with plenty of sharp grit, and a cool moist bottom. The margin of rhododendron beds, where there are sheltered recesses amongst the plants, suit many of the more delicate species well, partial shade and shelter of some kind being essential. The bulbs should be planted about 6 inches below the surface, which should at once be mulched over with half-decayed leaves or cocoa-fibre to keep out frost.

Dr Wallace, who has paid much attention to the culture of these plants, remarks, in his *Notes on Lilies*, that—

"Lilies require, so far as their roots are concerned, a cool bottom, abundant moisture, and for most kinds a free drainage." He also recommends to "plant deeply, say 6 to 8 inches, so that the roots may easily get into a moist subsoil, and be sheltered from the scorching drying influence of the sun's rays, to plant early in the autumn, so that the roots may be at work all the winter, and to plant in a cool shady border, not exhausted by the roots of trees, where the roots may always obtain moisture, and yet not be saturated."

The noble L. auratum, with its large white flowers, having a yellow band and numerous red or purple spots, is a magnificent plant when grown to perfection; and so are the varieties called rubro-vittatum and cruentum, which have the central band crimson instead of yellow. Of L. speciosum, also Japanese, the true typical form and the red-spotted and white varieties are grand plants for late summer blooming in the conservatory. The tiger lily, L. tigrinum, and its varieties Fortunei, splendidum, and flore-pleno, are amongst the best species for the flower garden, L. Thunbergianum and its many varieties being also good border flowers. The pretty L. Leichtlinii and colchicum, with drooping yellow flowers, and the scarlet drooping-flowered L. tenuifolium make up, with those already mentioned, a series of the finest hardy flowers of the summer garden. The Indian L. giganteum is perfectly distinct in character, having broad heart-shaped leaves, and a noble stem 10 feet high, bearing a dozen or more large deflexed, funnel-shaped, white, purple-stained flowers; and the Chinese L. cordifolium is similar in character, but dwarfer in habit.

For pot culture, the soil should consist of three parts turfy loam to one of leaf-mould and thoroughly rotted manure, adding enough pure grit to keep the mass porous. If leaf-mould is not at hand, turfy peat may be substituted for it. The plants should be potted in October. The pots should be plunged in a cold frame and protected from frost, and about May may be removed to a sheltered and moderately shady place out-doors to remain till they flower, when they may be removed to the greenhouse. This treatment suits the gorgeous L. auratum, the splendid varieties of L. speciosum, and also the chaste-flowering trumpet-tubed L. longiflorum and its varieties.

Lobelia. 59. The *Lobelia* is familiar in gardens under two very different forms, that of the dwarf-tufted plants used for summer bedding, and that of the tall showy perennials. Of the former the best type is L. Erinus, growing from 4 to 6 inches high, with many slender stems, bearing through a long period a profusion of small but bright blue two-lipped flowers. That which is called speciosa offers the best strain of the dwarf lobelias, but the actual varieties are being constantly superseded by new sorts. A good variety will reproduce itself sufficiently true from seed for ordinary flower borders, but for formal bedding arrangements it is necessary to secure exact uniformity by propagating from cuttings.

The herbaceous lobelias, of which L. fulgens may be taken as the type, may be called hardy except in so far as they suffer from damp in winter; they throw up a series of short rosette-like suckers round the base of the old flowering stem, and these sometimes, despite all the care taken of them, rot off during winter. The roots should either be taken up in autumn, and planted closely side by side in boxes of dry coal ashes, these being set for the time they are dormant either in a cold frame or in any airy place in the greenhouse; or they may be left in the ground, in which case a brick or two should be put beside the plants, some coal ashes being first placed round them, and slates to protect the plants being laid over the bricks, one end resting on the earth beyond. About February they should be placed in a warm pit, and after a few days shaken out and the suckers parted, and potted singly into small pots of light rich earth. After being kept in the forcing pit until well established, they should be moved to a more airy greenhouse pit, and eventually to a cold frame preparatory to planting out. They should have a loamy soil, well enriched with manure; they require copious waterings when they start into free growth. These tall-growing lobelias make good pot plants, for which purpose the suckers should be parted and the strong ones only potted singly in autumn; they should be placed in a warm pit to induce them to root freely, transferred when well established to an airy greenhouse shelf, and shifted on frequently during spring till they occupy pots a foot in diameter. The soil should be a very rich loam, top-dressing being given when they are coming into flower, and a very free supply of water is essential. They may be raised from seeds, which, being very fine, require to be sown carefully; but they do not flower usually till the second year except they are sown very early in heat. A few good sorts are—Carminata, Distinction, Excellent, Peach-blossom, Ruby, and Victoria Regina.

60. The *Narcissus* is a garden flower of great beauty and considerable variety of form. The species are all bulbous plants of low stature, and are with few exceptions perfectly hardy. There are five well-marked sections. Narcissus.

The Hoop-petticoat Narcissi, sometimes separated as the genus *Corbularia*, are not more than from 3 to 6 inches in height, and possess grassy foliage and yellow or white flowers. These have the coronet in the centre of the flower very large in proportion to the other parts, and much expanded, like the old hooped petticoats. The common hoop-petticoat, N. Bulbocodium, has comparatively large bright yellow flowers; N. tenuifolius is smaller and somewhat paler; N. citrinus is paler and larger; while N. monophyllus is white. The small bulbs should be taken up in autumn and replanted in January or February, according to the state of the season. They bloom about March or April. The soil should be free and open, so that water may pass off readily.

A second group is that of the Pseudo-Narcissi, constituting the genus *Ajax* of some botanists, of which the daffodil, N. Pseudo-Narcissus, is the type. In this the corona is also very large and prominent, but is more elongated and trumpet-shaped. Of this group the most striking species perhaps is N. bicolor, which has the perianth almost white, and the coronet deep yellow; it yields two fine varieties, Horsfieldii and Empress. N. cernuus (moschatus) and N. cernuus plenus are double and single forms of a cream-coloured species of great beauty; and besides these there are N. lobularis, nobilis, obvallaris, Telamonius, maximus, and others, amongst the most stately of the species, besides N. minor and minimus, which are miniature repetitions of the daffodil. All these grow well in good garden soil, and blossom from March onwards, coming in very early in genial seasons.

Another group, the Mock Narcissi, with coronets of medium size, includes the fine varieties of N. incomparabilis, one of which is known as butter-and-eggs, N. poculiformis (montanus), N. odorus and odorus minor (Queen Ann's jonquil), N. juncifolius, and others. The hardier forms of this set thrive in the open border, but the smaller sorts, like Queen Ann's jonquil, are better taken up in autumn, and replanted in February; they bloom freely about April or May.

The Polyanthus Narcissi form another well-marked group, whose peculiarity of producing many flowers on the stem is indicated by the name. In these the corona is small and shallow as compared with the perianth. Some of the hardier forms, as N. Tazetta itself, the type of the group, succeed in the open borders in light well-drained soil, but the bulbs should be deeply planted, not less than 6 or 8 inches below the surface, to escape risk of injury from frost. Many varieties of this form of narcissus are grown. They admit of being forced into early bloom, like the hyacinth and tulip. They vary with a white creamy or yellow perianth, and a yellow, lemon, primrose, or white cup or coronet; and, being richly fragrant, they are general favourites amongst spring flowers. The jonquils, noticed above, as well as the double white narcissus, are also grown in pots for early flowering; and the polyanthus narcissi are sometimes used for bedding out in the spring garden. The following varieties are good:—Bazelman major, Gloriosa, Sir Isaac Newton, white with yellow cup; Grand Monarque and White Pearl, white with pale yellow cup; Paper White, pure white, early; Bathurst, Perle d'Amour, and Sulphurine, yellow with yellow or orange cup; and Grand Primo, a very fine yellow. These are planted or potted about October, and treated in the same way as the hyacinth.

There remains another little group, the Pheasant's-eye Narcissi (N. poeticus), in which the perianth is large, spreading, and conspicuous, and the coronet or cup very small and shallow. These pheasant's-eye narcissi, of which there are several species or well-marked varieties, as N. radiiflorus, poetarum, recurvus, &c., blossom in succession during April and May, and all do well in the open borders as permanent hardy bulbs. N. biflorus, the primrose peerless, a two-flowered whitish yellow-cupped species, is equally hardy and easy of culture; N. gracilis is yellow-flowered and blooms later, as does the yellow-flowered N. Jonquilla, better known as the jonquil, of which there are single and double flowered varieties, the latter species being a great favourite.

61. The *Pæony* is a remarkably showy plant, of which two very distinct types occur in gardens:—one the stout-growing herbaceous Pæony.

perennials, with fleshy tuberiform roots and annual stems, which have sprung mainly from Pæonia albiflora and P. officinalis; the other called the tree pæony, stiff growing plants with half-woody permanent stems, which have sprung from the Chinese P. Moutan.

The herbaceous pæonies usually grow from 2 to 3 feet in height, and have large much-divided leaves, and ample flowers of varied and attractive colours, and of a globular form in the double varieties which are those most prized in gardens. They blossom about the months of May and June as well as later in the summer, and as ornaments for large beds in pleasure grounds, and for the front parts of shrubberies, few flowers equal them in gorgeous effect. A good loamy soil—rather light than heavy—suits them best, and a moderate supply of manure is beneficial. They are impatient of frequent transplantings or repeated divisions for purposes of propagation, but when necessary they may be multiplied by this means, care being taken that a sound bud is attached to each portion of the tuberous roots.

The older varieties of P. albiflora include candida, festa, fragrans, Humei, Pottsii, Reevesii, rubescens, vestalis, Whitleyi, &c.; those of P. officinalis embrace albicans, anemoniflora, Baxteri, blanda, rosea, Sabini, &c. The garden varieties of modern times are, however, still more beautiful, the flowers being in many instances delicately tinted with more than one colour, such as buff with bronzy centre, carmine with yellowish centre, rose with orange centre, white tinted with rose, &c. We name a selection of a few of the light and dark coloured sorts, the former including tinted whites and yellows, and the latter crimsons, roses, pinks, &c.:—

Light-coloured Varieties:—Aurora, Boule de Neige, candida plena, carnea plena, Chamois, Cleopatra, delicata, festiva maxima, Impératrice Charlotte, Leonie, Madame Calot, Madame Vilmorin, magnifica, Marie Lemoine, Virginie.

Dark-coloured Varieties:—Ambroise Verschaffelt, atrosanguinea, Bossuet, Dr Bretonneau, Gloire de Douai, Jeanne d'Arc, Madame Furtado, Modeste-Guérin, Mons. de Villeneuve, Oberlin, Prince Troubetskoi, purpurea superba, Reine des Roses, Souvenir de l'Exposition Universelle, Surpasse Pottsii, Victoire d'Alma.

The Siberian P. tenuifolia, with finely-cut leaves, and crimson flowers, is a graceful border plant, and its double-flowered variety is perhaps the most elegant of its race.

The Moutans or Tree Pæonies are remarkable for their sub-shrubby habit, forming vigorous plants sometimes attaining a height of 6 to 8 feet, and producing in April or May magnificent flowers which vary in colour from white to lilac, purple, and rose. These are produced on the young shoots, which naturally bud forth early in the spring, and are in consequence liable, unless protected, to be cut off by spring frosts. They require to be thoroughly ripened in summer, and therefore a hot season and a dryish situation are desirable for their well-being; and they require perfect rest during winter. Small plants with a single stem, if well matured so as to ensure their blossoming, make very attractive plants when forced. They are increased by grafting in autumn on the roots of the herbaceous pæonies.

Of the older varieties the most conspicuous is papaverifolia, while the following are of more recent acquisition:—Atrosanguinea, globosa, lilacina, picta, Reevesiana, salmonea, and versicolor. Other garden varieties are—Gloria Belgarum, alba grandiflora, Emperor of China, lactea, ocellata, purpurea, atropurpurea, Rollissoni, violacea purpurea, violacea plena, unicolor purpurea, Beauty of Canton, Blanche de Noisette, Comte de Flandre, Elizabeth d'Italie, Hendersoni, Impératrice, Joséphine, Leopoldii, Madame Stuart Low, Mandarin, Professeur Morren, Robert Fortune, Triomphe de Gand, and Souvenir de Gand.

Pansy.

62. *The Pansy.*—This popular flower, also called heartsease, has sprung from the native British Viola tricolor, which has probably been crossed with some of the allied species of this large and varied genus. The modern varieties of the pansy consist in the main of three types:—the show varieties; the fancy varieties, obtained a few years ago from Belgium, and now very much improved; and the bedding varieties, which are free-blooming sorts marked rather by effectiveness of colour in the mass than by quality in the individual flower. The latter are extremely useful in spring flower gardening.

The pansy flourishes in well enriched garden soil, in an open but cool situation, a loamy soil being preferable. Cow dung is the best manure. The established sorts are increased by cuttings, whilst seeds are sown to procure novelties. The cuttings, which should consist by preference of the smaller growths from the centre of the plant, may be planted early in September, in sandy soil, under a hand light or in boxes under glass, and as soon as rooted should be removed to a fresh bed of fine sandy soil. The seeds may be sown in August or September. The bed may be prepared early in September, to be in readiness for planting, by being well manured with cow dung and trenched up to a depth of 2 feet. The plants should be planted in rows at about a foot apart. In spring they should be mulched with half-rotten manure, and the shoots as they lengthen should be pegged down into this enriched surface to induce the formation of new roots. If the blooms show signs of exhaustion by the inconstancy of their colour or marking, all the flowers should be picked off, and this top-dressing and pegging down process performed in a thorough manner, watering in dry weather, and keeping as cool as possible. Successional beds may be put in about February, the young plants being struck later, and wintered in cold frames. The fancy pansies require similar treatment, but are generally of a more vigorous constitution.

When grown in pots in a cold frame, about half a dozen shoots filling out a 6-inch pot, pansies are very handsome decorative objects. The cuttings should be struck early in August, and the plants shifted into their blooming pots by the middle of October; a rich open loamy compost is necessary to success, and they must be kept free of aphides. Both the potted plants and those grown in the open beds are benefited by the use of liquid manure.

The bedding pansies possess a dwarf compact free-branched habit of growth, which results in the production of a constant succession of flowers. They are a hardy race, flowering freely from the early spring onwards. These, with the varieties of Viola lutea and Viola cornuta, have latterly acquired great prominence from their utility in furnishing early flowers for the spring garden, and novelties are being rapidly produced.

63. *The Pentstemon.*—Many species of Pentstemon have been introduced to our gardens, and rank amongst the finest of all the herbaceous perennials. The pentstemon of the florist has, however, sprung from P. Hartwegii, a suffruticose species, which has been more or less hybridized with P. gentianoides, P. Cobæa, and possibly some others. The plants are not absolutely hardy, but endure English winters unharmed in favoured situations. They are freely multiplied by cuttings, selected from the young side shoots, planted early in September, and kept in a close cold frame or under a hand light till rooted. They should then be potted singly in small pots, and wintered in a cold frame, the pots being plunged in ashes or cocoa-nut refuse, in order to keep the soil from drying too rapidly, and to prevent the frost from injuring the young roots. To obtain strong plants, they should be shifted into 5-inch pots early in March, and kept growing in well-ventilated frames until May. They flower freely in July and August and onwards till cut down by frosts. Smaller plants may be had by leaving the cuttings in the cutting pot during the winter, and introducing them to the propagating pit in February or March, when their young shoots can be taken off, struck, potted, and grown on in frames till about May. Seedlings, if raised in heat in February or early in March, and pricked out and forwarded under glass till May, will flower the same year, but probably not so early as those raised from cuttings. Pentstemon.

The following are good kinds, and varied in colour and character, but new ones appear every season, and sometimes show a marked advance on the older sorts:—Andrew Hunter, Apollon, Countess of Eglinton, Bon Villageois, Col. Long, The Bride, Dr St Paul, John F. Kinghorn, John M'Pherson, Lady Coutts Lindsay, Molière, Mrs A. Sturry, W. P. Laird, Le Khédive, Black Knight, Stanstead Rival, Souvenir de St Paul, Georges Sand.

64. The *Phlox*, with its modern improvements, constitutes one of the finest of hardy herbaceous plants. There are two types—the pyramidalis or early-flowering sorts, which appear to grow best in the northern districts, and the decussata or late-flowering sorts, which are taller and are those most frequently grown in English gardens. Phlox.

The early-flowering phloxes are increased by division of the root or by cuttings which may be obtained about the middle or end of March, and strike readily under a hand glass. They should be grown in beds, and will make good blooming plants for the following year. The older or blooming plants should be grown in beds of deep rich loamy soil, mulched with half-rotten dung as they come on towards flowering. They should have abundance of water in dry weather. It is not advisable to allow more than five stems to grow up to flower. The varieties of this section flower a month or six weeks earlier than those of the decussata group, and are at the height of their bloom in July.

A few good sorts are—Duchess of Athole, Lady Napier, Miss Robertson, Perfection, Waverley, Stella, Alexandra, Iona, Marquis, James Mitchell, Elvina, James Neilson, Miss Hunter, Bayard, Purple Emperor, Mauve Queen.

The late-flowering phloxes may be raised either from cuttings or by division. From cuttings in early spring vigorous young plants may be obtained which flower well the following season. By division of the older plants into separate rooted portions, plants are obtained which flower well the same year. The latter require a deeply trenched soil, thoroughly manured, and should be well watered in dry weather; indeed, as they grow up to bloom, manure water may be given judiciously with advantage.

A good selection of these are—A. F. Barron, Liervalli, Lothair, Roi des Roses, Lucien Tisserand, Madame la Comtesse de Turenne, Madame Domage, Menottii, Mons. H. Low, Coccinea, Mrs Laing, Rêve d'Or, Marie Saisson, Madame Thibaut, Madame Rœmpler, Gloire de Neuilly, J. K. Lord, La Candeur, Mons. Malet, Chanzy, Queen of Whites.

65. The *Pink* of the garden has resulted from the cultivation and improvement of Dianthus plumarius. The pink is a great favourite with florists, those varieties being preferred which have the margin of the petals entire, and which are well marked in the centre with bright crimson or dark purple. Its grassy but glaucous foliage is much like that of the carnation, but the whole plant is smaller, and the greater portion of the colouring of the flowers forms a blotch near the base of the petal, instead of being laid on in stripes as in the carnation, or confined to the outer edge as in the picotee. Pink.

Pinks require a free loamy soil deeply trenched, and well enriched with cow dung. They are readily increased by pipings (fig. 60, *d*), taken off during the flowering period, and planted in light soil under a hand light, or in the open ground in a shady situation; they may be planted an inch apart in rows 2 or 3 inches asunder, and should be pressed firmly into the soil. When rooted, which will be about August, they should be planted 4 inches apart in a nursery bed, where they may remain till the latter part of September or the early part of October. The chief attention required during winter is to press them down firmly should they become lifted by frosts, and in spring the ground should be frequently stirred and kept free from weeds. As the flowering stems grow up they should be supported by sticks, and when the buds appear they should be assisted to burst regularly by tying a soft ligature round them. The pink is also raised from seeds, not only to obtain new varieties, but to keep up a race of vigorous growing sorts. The seeds may be sown in March or April, in pots in a warm frame, and the young plants may be pricked off into boxes and sheltered in a cold frame. They should be planted out in the early part of the summer in nursery beds, in which, if they have space, they may remain to flower, or the alternate ones may be transplanted to a blooming bed in September or the early part of October; in either case they will bloom the following summer. These will grow in any good garden soil, but the richer it is the better.

There is also a number of varieties which are useful for forcing during the early spring months. These are propagated from early pipings, and grown in nursery beds, being taken up in October, and potted in a rich loamy compost, and wintered in a cold pit till required for the forcing house. The varieties named Anne Boleyn, Lady Blanch, Lord Lyons, Mrs Pettifer, and Coccinea are good useful forcing sorts.

Of choice florists' varieties the number is not very large. The following would form a good selection:—Turner's Boiard, Dr Masters, Dr Maclean, Shirley Hibberd, Lord Kirkaldy, Godfrey, and Bertram; Maclean's Annie, Beauty, John Ball, and New Criterion; Marris's Excelsior and Vesta; Kirtland's Rev. G. Jeans; Bragg's Nonpareil and Goliath; and Hooper's Beauty of Bath.

P-
nthus. 66. The *Polyanthus* is one of the oldest of the florists' flowers, and is no doubt an umbellate form of the primrose, Primula vulgaris. For some time it has been held in low repute, but is now coming into greater favour, and novelties are being slowly produced. The florists' polyanthus has a golden margin, and is known as the gold laced polyanthus, the properties being very distinctly laid down and rigidly adhered to. The chief of these are—a clear unshaded blackish or reddish ground colour, an even margin or lacing of yellow extending round each segment and cutting through its centre down to the ground colour, and a yellow band surrounding the tube of exactly the same hue as the yellow of the lacing. The plants are quite hardy, and grow best in strong loamy soil, tolerably well enriched with dung and leaf-mould; they should be planted about October. Plants for exhibition present a much better appearance if kept during winter in a cold well-aired frame. Of these, Cheshire Favourite, Earl of Lincoln, and Criterion, with black grounds, and Exile, Lancer, and Sunrise, with red grounds, are amongst the best.

For the flower borders what are called fancy polyanthuses are adopted. These are best raised annually from seed, the young crop each year blooming in succession. The seed should be sown as soon as ripe, the young plants being allowed to stand through the winter in the seed bed. In April or May they are planted out in a bed of rich garden soil, and they will bloom abundantly the following spring. A few of the better thrum-eyed sorts should be allowed to ripen seed; the rest may be thrown away.

Pon-
til 67. The *Potentilla*, as a specialty, is a flower of modern times. The double-flowered varieties are especially remarkable for their ornamental qualities. A soil of a good loamy staple, enriched with rotten dung, will grow the potentilla to perfection. They may be increased, though not very freely, by parting them into as many pieces as there are crowns, the side growths being those which can usually be thus separated. This may be done in autumn or spring, and the plants will generally bloom the following season. The plants like an open situation, and are well suited for filling a small or moderate-sized bed, as the foliage is of a neat and pleasing character when the plants are not in bloom.

The following are good named sorts:—Chromatella, Le Vésuve, Louis Van Houtte, Meteor, Pluton, Vulcan, Le Dante, Mars, Nigra, Caméléon, Fénelon, Etna.

Primrose. 68. The *Double Primrose* is closely allied to the polyanthus. There are some very handsome varieties grown, as the crimson, white, yellow, purple, blue, and others. These all succeed under the treatment given to the choicer kinds of polyanthus (par. 66).

Py-
thrum. 69. The *Pyrethrum* is quite a modern garden flower, extremely useful as blooming in the early summer months, and remarkable for its neat habit and the great variety of character and colour which it presents. The type forms are the P. roseum and P. carneum of botanists, hardy perennials, with finely cut leaves, and large flower-heads, having in the one case a ray of deep rose-coloured and in the other of flesh-coloured ligulate florets surrounding the centre or disk. They bloom during the months of May and June, as well as later on, and are always most welcome ornaments for the flower borders, and useful for cutting for decorative purposes.

The pyrethrum grows best in soil of a loamy texture; this should be well manured and deeply trenched up before planting, and should be mulched in the spring by a surface dressing of half-decayed manure. The plants may be increased by division, the side shoots being taken off early in autumn with a portion of roots attached. They may be placed either in separate beds or in the mixed flower border as may be required. In beds they can be supplemented as the season passes on by the intermixture of later-blooming subjects, such as gladioli. Slugs are often destructive to the young shoots. Seeds should be sown in spring in a cold frame, and the young plants should be put out into beds when large enough, and should flower the following May.

The following will make a useful selection of sorts:—Aurora, Bonamy, Boule de Neige, Brilliant, carminatum plenum, Charles Baltet, delicatum, Émile Lemoine, floribundum plenum, Gloire d'Italie, Hermann Stenger, Iveryanum, La Vestale, Le Dante, Madame Billiard, Minerva, Ne plus ultra, Prince of Wales, Solfaterre, Titiens.

70 The *Ranunculus* (R. asiaticus), a native of the Levant, is one of the older florists' flowers, which has sported into numberless varieties, but was formerly held in much greater esteem than it is at the present time. According to the canons of the florists, the flowers, to be perfect, should be of the form of two-thirds of a ball, the outline forming a perfect circle, with the centre close, the petals smooth-edged, the colour dense, and the marking uniform. Ranunculus.

The ranunculus requires a strong and moist soil, with a fourth of rotten dung. The soil should be from 18 inches to 2 feet deep, and at about 5 inches below the surface there should be placed a stratum 6 or 8 inches thick of two-year-old rotten cow dung, mixed with earth, the earth above this stratum, where the roots are to be placed, being perfectly free from fresh dung. The tubers are planted in rows 5 or 6 inches apart, and 3 or 4 inches separate in the rows, the turban sorts in October, the more choice varieties in February. They should be so close that the foliage may cover the surface of the bed. The autumn-planted roots must be sheltered from frost by old tan or sifted coal ashes. The plants when in flower should be covered with an awning; when the leaves wither, the roots are to be taken up, dried, and stored. The ranunculus is readily propagated from seed obtained from semi-double sorts, which are often of themselves very beautiful flowers. It is generally sown in boxes in autumn or spring. The young plants thus raised flower often in the second, and always in the third year.

The turban varieties, which are very showy for the borders, are of a few positive colours, as scarlet, yellow, brown, carmine, and white. The florists' varieties have been bred from the Persian type, which is more delicate.

The following sorts may be taken as the foundation of a collection:—Apollo, Eliza, Marquis of Hertford, Helena, Interestor, Sincerity, Garibaldi, Enchanter, Flaminius, Coronation, Strephon, Melanchthon.

71. The *Tulip* (Tulipa Gesneriana) is a native of the East, whence it was introduced into Europe about the middle of the 16th century. About the year 1635 its culture was very engrossing; and, indeed, the rage for possessing rare sorts had become so great in Holland as to give rise to a strange species of gambling, known to the collectors of literary and scientific anecdotes by the name of Tulipo-mania. At present, though not to be met with in every garden, the finer tulips have yet some ardent cultivators, while certain varieties, as the early Duc Van Thol and its allies, and the double tulips of the Tournesol type, are much used for general garden decoration, and for forcing. The latter, however, spring from other species of the genus. Tulip.

The florists' varieties of tulips, which have sprung from Tulipa Gesneriana, are arranged in separate classes named bizarres, byblœmens, and roses, according to their colour and marking. Tulips are readily raised from seeds, and the seedlings when they first flower are of one colour,—that is, they are self-coloured. Judged by the florists' rules, they are either good or bad in form, and pure or stained (white or yellow) at the base; the badly formed and stained flowers are thrown away, while the good and pure are grown on, these being known as "breeder" tulips. The breeder bulbs and their offsets may grow on for years producing only self-coloured flowers, but after a time, which is varied and indefinite, some of the progeny "break," that is, produce flowers with the variegation which is so much prized. The flower is then said to be "rectified"; it is a *bizarre* when it has a yellow ground marked with purple or red, a *byblœmen* when it has a white ground marked with violet or purple, or a *rose* when it has a white ground marked with rose colour. One of the most important of the properties of a fine florists' tulip is that the cup should form, when expanded, from half to a third of a hollow ball, the divisions of the perianth being six in number, broad at the ends, and smooth at the edges, so that the divisions may scarcely show an indenture. Another is that the ground colour should be clear and distinct, whether white or yellow. The least stain at the base of the flower, technically called the "bottom," would render a tulip comparatively valueless. What are called feathered flowers are those which have an even close feathering, forming an unbroken edging of colour all round, flamed flowers being those which have a beam or bold mark down the centre, not reaching to the bottom of the cup. Some flowers are both feathered and flamed, and in all cases the colour must be uniformly distributed.

Tulips are usually grown in beds, which should be made up, to the depth of about 2 feet, with a rich compost of about four parts loam to one of leaf-mould and one of thoroughly decomposed manure, which should have been well mixed some time before required for use. The bottom of the bed must be thoroughly drained, and so arranged that the water may not only soak down to the bottom, but find egress there. New soil is not required every year, but it should be deeply turned up and laid in ridges, and every third year it should be renewed to about a foot in depth, and the new soil well mixed with the old. The bed should be in an open but sheltered position, and should be got ready in September or early in October, the bulbs being planted in October or early in November, 6 inches apart, and 3 or 4 inches deep. The bed should be 4 feet wide—sufficient to take seven rows of bulbs, a little river sand being placed about each. An awning should be placed over the bed when the buds show colour, in order to lengthen the duration of the flowers, and removed when the flowers fade. After the flowers have fallen, the seed-vessels are broken off close by the stem, to prevent the plant from exhausting itself in perfecting seed, and to direct its energies to the forming of the new bulb, and when the leaves and stalks turn brown the bulbs are taken up and laid out for a few days in a cool airy place, when they should be stored in drawers till planting time, being occasionally examined in case any of them decay.

Tulips are readily propagated by offsets, which are taken off from the parent bulbs, and nursed in separate beds till they be full grown. New varieties are raised from seed, and are from five to seven years old before they flower.

The following are a good selection of show tulips:—

Bizarres.—Feathered: Demosthenes, Sir Joseph Paxton, Garibaldi, Commander, Sulphur, George Hayward. *Flamed*: Excelsior, Dr Hardy, Surpass Polyphemus, Masterpiece, Ajax, William Lea.

Byblœmens.—Feathered: William Bentley, Friar Tuck, David Jackson, Dessie, Mrs Cooper, Talisman. *Flamed*: Duchess of Sutherland, Nimbus, Talisman, Bacchus, Adonis, Carbuncle.

Roses.—Feathered: Charmer, Industry, Nanny Gibson, Lady Wilton, Mrs Lea, Madame St Arnaud. *Flamed*: Annie Macgregor, Lady Sefton, Mrs Barlow, Sarah Headly, Adair, Triomphe Royale.

For decorative purposes, as forcing and spring bedding, the following are some of the best sorts grown:—

Singles.—Canary Bird, Couleur Cardinal, Couronne Pourpre, Duc Van Thol, Duchesse de Parma, Keizerskroon, Proserpine, Roi Pépin, Bride of Haarlem, Pottebakker, White Pottebakker, Thomas Moore, Vermillon Brillant, Yellow Prince.

Doubles.—Couronne des Roses, Duke of York, Gloria Solis, Imperator Rubrorum, Mariage de ma Fille, Overwinnar, Rex Rubrorum, Tournesol, Yellow Tournesol, La Candeur.

Hardy trees and shrubs. 72. HARDY TREES AND SHRUBS.—Much of the beauty of the pleasure garden depends upon the proper selection and disposition of ornamental trees and shrubs. It is to be regretted that this department of the garden is often greatly neglected, and the many ornamental subjects introduced during the last half century are too frequently overlooked by planters and garden artistes. We can only afford space here for lists of some of the better and more useful and ornamental trees and shrubs, old and new, supplemented by a brief notice of the rhododendron and its congeners, and of the rose.

The following list, which is not exhaustive, furnishes material from which a selection may be made to suit various soils and situations. The shrubs marked * are climbers.

Hardy Deciduous Trees.

Acer—Maple.
Æsculus—Horse-Chestnut.
Ailantus—Tree of Heaven.
Alnus—Alder.
Amygdalus—Almond.
Betula—Birch.
Carpinus—Hornbeam.
Carya—Hickory.
Castanea—Chestnut.
Catalpa.
Celtis—Nettle Tree.
Cerasus—Cherry.
Cercis—Judas Tree.
Cotoneaster.
Cratægus—Thorn.
Diospyrus.
Fagus—Beech.
Fraxinus—Ash.
Ginkgo—Maidenhair Tree.
Gleditschia—Honey Locust.
Gymnocladus—Kentucky Coffee Tree.
Juglans—Walnut.
Kölreuteria.
Laburnum.
Larix—Larch.
Liriodendron—Tulip.
Magnolia.
Morus—Mulberry.
Negundo—Box-Elder.
Ostrya—Hop Hornbeam.
Paulownia.
Planera.
Platanus—Plane.
Populus—Poplar.
Ptelea—Hop Tree.
Pyrus—Pear, &c.
Quercus—Oak.
Rhus—Sumach.
Robinia—Locust Tree.
Salix—Willow.
Sophora.
Taxodium—Deciduous Cypress.
Tilia—Lime.
Ulmus—Elm.
Virgilia.
Xanthoceras.

Hardy Evergreen Trees.

Abies—Silver Fir.
Araucaria—Chili Pine.
Arbutus—Strawberry Tree.
Biota—Arbor Vitæ.
Buxus—Box.
Cedrus—Cedar.
Cephalotaxus.
Cryptomeria—Japan Cedar.
Cupressus—Cypress.
Ilex—Holly.
Juniperus—Juniper.
Laurus—Bay Laurel.
Libocedrus.
Magnolia.
Picea—Spruce Fir.
Pinus—Pine.
Quercus—Oak.
Retinospora.
Sciadopitys—Umbrella Pine.
Sequoia (Wellingtonia).
Taxus—Yew.
Thuiopsis.
Thuya—Arbor Vitæ.
Tsuga.

Hardy Deciduous Shrubs.

Abelia.
Acer—Maple.
Æsculus—Horse-Chestnut.
Amelanchier.
Ampelopsis.*
Amygdalopsis.
Aralia.
Aristolochia.*
Berberis—Berberry.
Bignonia*—Trumpet Flower.
Calophaca.
Calycanthus—Carolina Allspice.
Caragana.
Cerasus—Cherry.
Chimonanthus.
Clematis.*
Colutea—Bladder Senna.
Cornus—Dogwood.
Cotoneaster.
Cratægus—Thorn.
Cydonia—Japan Quince.
Cytisus—Broom, &c.
Daphne.
Deutzia.
Edwardsia.
Elæagnus.
Euonymus—Spindle Tree.
Forsythia.*
Fremontia.
Genista.
Halesia—Snowdrop Tree.
Hamamelis—Wych Hazel.
Hibiscus—Althæa frutex, &c.
Hippophae—Sea Buckthorn.
Hypericum—St John's Wort.
Jasminum*—Jasmine.
Kerria.
Laurus—Laurel.
Ligustrum—Privet.
Lonicera*—Honeysuckle
Lycium.*
Magnolia.
Menispermum*—Moonseed.
Periploca.*
Philadelphus—Mock Orange.
Rhus—Wig Tree, &c.
Ribes—Flowering Currant.
Robinia—Rose Acacia, &c.
Rosa—Rose.
Rubus*—Bramble.
Spartium—Spanish Broom.
Spiræa.
Staphylæa—Bladder-Nut.
Symphoricarpus—Snowberry.
Syringa—Lilac.
Tamarix—Tamarisk.
Viburnum—Guelders Rose, &c.
Vitis—Vine.
Weigela.

Hardy Evergreen Shrubs.

Akebia.*
Arbutus.
Aucuba—Japan Laurel.
Azara.
Bambusa—Bamboo.
Berberidopsis.*
Berberis—Berberry.
Buddleia.
Bupleurum.
Buxus—Box.
Ceanothus.
Cerasus—Cherry-Laurel, &c.
Cistus—Sun-Rose.
Cotoneaster.
Cratægus—Thorn.
Daphne.
Desfontainea.
Erica—Heath.
Escallonia.
Euonymus.
Fabiana.
Fatsia (Aralia).
Garrya.
Griselinia.
Hedera*—Ivy.
Hypericum—St John's Wort.
Ilex—Holly.
Jasminum*—Jasmine.
Kadsura.*
Lardizabala.*
Laurus—Sweet Bay.
Ligustrum—Privet.
Lonicera*—Honeysuckle.
Magnolia.
Osmanthus.
Pernettya.
Phillyrea.
Photinia.
Retinospora.*
Rhamnus—Alaternus.
Rhododendron—Rose-Bay.
Rosa*—Rose.
Ruscus.
Skimmia.
Smilax.*
Stauntonia.*
Ulex—Furze.
Viburnum—Laurustinus.
Vinca—Periwinkle.
Yucca—Adam's Needle.

73. *The Rhododendron.*—In places where the soil is suitable, the rhododendron, on account of its flowering qualities, is fast taking the place of the laurel in the mixed shrubbery. This plant, with its associates the azalea, kalmia, andromeda, and the like, requires, generally speaking, a peaty soil, and a cool, rather moist situation; but, though a peaty soil is preferable, especially for the choice kinds, it is not essential. When, however, the soil is loamy, it must have incorporated with it a liberal portion of leaf-mould and decayed manure, cow dung being preferable, and, if at all heavy, some clean road grit. The plants do not thrive in soil which contains calcareous matter. Rhododendron.

These subjects, in view of the source of most of the originals, are commonly called American plants; and a separate plot (called the American garden) is often set apart for them. For such a plot the catawbiense type of rhododendron is preferable, being hardier, producing better foliage, and comprising many of the finest flowering sorts. Such varieties as Sir Thomas Sebright, Old Port, Mrs Heneage, Michael Waterer, H. W. Sargent, Alexander Dancer, Brayanum, Scipio, Everestianum, Minnie, Mrs John Clutton, J. Marshall Brooks, Sigismund Rucker, Mrs Milner, and fastuosum flore-pleno, may be counted on as sterling sorts, which will always give satisfaction. The varieties of *Azalea*, though deciduous in habit, are desirable on account of their brilliant and effective colours, and with them may be associated such subjects as Andromeda, Cassandra, Leucothoe, Dabeocia, Daphne Cneorum, the hardy Heaths, Gaultheria, Kalmia, Ledum, Pernettya, Rhodora, Vaccinium, and Zenobia.

74. *The Rose.*—The rose is so universal a favourite that some portion of the garden must necessarily be devoted to it, if the situation be at all favourable. Roses will not, however, thrive in the vicinity of large towns, since they require a pure air, and do not endure a smoky atmosphere. The best soil for them is a deep rich strong loam free from stagnant moisture. Very light sandy or gravelly soils, or soils which are clayey and badly drained, are not suitable, and both must be greatly improved if rose-growing on them is attempted. Light soils would be improved by a dressing of strong loam in conjunction with cow dung or nightsoil; the latter, provided it is properly prepared and not too fresh, is indeed the very best manure for roses in all but soils which are naturally very rich. Heavy soils are improved by adding burned earth or gritty refuse, with stable manure and leaf-mould or cocoa-fibre refuse; and damp soils must necessarily be Rose.

drained. Roses require a constant annual supply of manure, and, if this is given as a mulching in autumn, it serves to protect their roots through the winter. They also require liberal supplies of water during the growing season, and especially to be kept clear of aphides and other insect pests, which may be done by dusting them with snuff while moist, and washing it off with the syringe next day, or by syringing with dilute tobacco water or some of the many insecticides now provided to facilitate this rather troublesome task.

Some growers prefer roses grown on their own roots, some on the Manetti, and others on the brier stock. There is this to be said in favour of their own roots that, if the tops are killed down by accident or by severe weather, the roots will usually throw up new shoots true to their kind, which cannot be looked for if they are worked, though it is sometimes recommended to plant deep in order that the rose itself may learn to do without its foster parent the stock. Too often, however, in the case of persons unfamiliar with roses, the choice rose dies, and the stock usurps its place.

An open situation, not shaded, but sheltered from strong winds, is what the rose prefers. October and November are the best months for planting the hardy kinds. The tender varieties are better laid in in a sheltered place, and the planting deferred till March or April. In regard to pruning, roses vary considerably, some requiring close cutting and others only thinning out; some again may be safely pruned in autumn, and others are better left till spring. Instructions on this point as to the several groups of varieties will be found in most rose catalogues.

Where dwarf beds of roses are required, a good plan is to peg down to within about 6 inches from the ground the strong one year old shoots from the root. In due time blooming shoots break out from nearly every eye, and masses of flowers are secured, while strong young shoots are thrown up from the centre, the plant being on its own roots. Before winter sets in the old shoots which have thus flowered and exhausted themselves are cut away, and three or four or more of the strongest and best ripened young shoots are reserved for pegging down the following season, which should be done about February. In the meantime, after the pruning has been effected, plenty of good manure should have been dug in about the roots. Thus treated, the plants never fail to produce plenty of strong wood for pegging down each succeeding season.

ding lts. 75. BEDDING PLANTS.—This term is chiefly applied to those summer-flowering plants, such as pelargoniums, petunias, dwarf lobelias, verbenas, &c., which are employed in masses for filling the beds of a geometrical parterre. Of late years, however, more attention has been bestowed on arrangements of brilliant flowering plants with those of fine foliage, and the massing also of hardy early-blooming plants in parterre fashion has been very greatly extended. Bedding plants thrive best in maiden soil, and therefore the beds should be occasionally wholly or partly renovated with fresh earth. A light loam, liberally manured with thoroughly rotten dung from an old hotbed or thoroughly decomposed cow droppings and leaf-mould, forms the best kind of compost, but in the case of free-growing plants, like pelargoniums, over-richness must be avoided.

76. *Spring Bedding.*—For this description of bedding, hardy plants only must be used; but even then the choice is tolerably extensive. For example, there are the Alyssums, of which A. saxatile and A. gemonense are in cultivation; Antennaria tomentosa; Arabis albida; Aubrietias, of which the best sorts are A. Campbelliæ and A. grandiflora; the double Bellis perennis or Daisy; the Wallflowers, including Cheiranthus Cheiri (the Common Wallflower), C. alpina, and C. Marshallii; Hepaticas, the principal of which are the varieties of H. triloba, and the blue H. angulosa; Iberis or Candytuft; Lithospermum fruticosum; Myosotis or Forget-me-not, including M. alpestris, M. dissitiflora, M. azorica, and M. sylvestris; Phloxes, like P. subulata, with its varieties setacea, Nelsoni, nivalis; the single-flowered varieties of the Primrose, Primula vulgaris; Pyrethrum Parthenium aureum, called Golden Feather; Sempervivum calcareum; the pink-flowered Silene pendula; self-coloured varieties of the Pansy, V. tricolor, and of V. lutea and V. cornuta, as well as some recent hybrids. Besides these there are the various spring-flowering bulbs, such as the varieties of Hyacinthus, Tulipa, Narcissus, Fritillaria, Muscari or Grape Hyacinth, Crocus, Scilla, and Galanthus or Snowdrop.

77. *Summer Bedding.*—There is great variety amongst the plants which are used for bedding out in the garden during the summer months, but we can note only some of the most important of them. Amongst them are the Ageratums, the old tall-growing sorts of which have been superseded by dwarfer varieties, as Imperial Dwarf and Swanley Blue; Alternantheras, the principal of which are A. amœna, amœna spectabilis, magnifica, paronychioides major aurea, and amabilis; Alyssum maritimum variegatum; some of the named varieties of Antirrhinum majus, especially the dwarf varieties; Arundo Donax variegata; Begonias; Calceolarias; Cannas; Centaurea ragusina; Clematises, of which the hybrids of the Jackmanni type are best; Dahlia variabilis, and the single-flowered forms of D. coccinea; Echeverias, of which E. secunda and E. metallica are much employed; Gazanias; Heliotropium peruvianum; Iresine; the Lantanas; Lobelias; Mesembryanthemum cordifolium variegatum; Pelargoniums, of which the various classes of zonal or bedding varieties are unapproachable for effect and general utility; Petunias; Phloxes; Polemonium cœruleum variegatum; Pyrethrum Parthenium aureum, especially useful as an edging to define the outline of beds upon grass; Tropæolums, especially some of the varieties of T. Lobbianum; and Verbenas, the offspring of Tweedieana, chamædrifolia, and others. Few bulbs come into the summer flower gardens, but amongst those which should always be well represented are the Gladiolus, the Lilium, and the Tigridia.

78. *Subtropical Bedding.*—A few years ago the late Mr John Gibson, then superintendent of Battersea Park, introduced the style of planting known as subtropical gardening, from the use that is made of subtropical plants. In the climate of London and the south and west of England this new feature proved very successful, but less so in the north of England and in Scotland, except in very favoured localities. These subtropical materials may be used either in masses of one kind, or in groups arranged for contrast, or as the centres of groups of less imposing or of dwarfer-flowering subjects; or they may be planted as single specimens in appropriate open spaces, in recesses, or as distant striking objects terminating a vista. Some of the finest of these plants of bold and striking habit are found in the Aralia or Fatsia, the Wigandia, the Montagnæa, the Uhdea, and the Ferdinanda; Aralia japonica and papyrifera are very fine, and so are Wigandia caracasana and Vigieri, Montagnæa heracleifolia (also known as Polymnia grandis), Uhdea bipinnatifida, and Ferdinanda eminens. Many palms, some tree ferns, and the noble Musas, especially Musa Ensete, do fairly well in sheltered situations. The Cannas afford great variety of size, form, and colour. The different forms of Ricinus, which are of the bolder type of subjects, the more elegant Arundo Donax and its variegated variety, and the very graceful Arundo conspicua may also be named. Arundinaria falcata and other Bamboos, if grown in large pots or tubs and plunged in shady sheltered places during summer, give a striking tropical effect; and in warm situations some of these may be introduced as permanent plants. Of lesser subjects Centaurea ragusina and gymnocarpa, Erythrinas, Funkias, Gunnera scabra, and some of the Solanums, as S. marginatum and robustum, are all useful and effective; and many others might be added.

79. *Carpet Bedding* or *Mosaiculture* consists in covering the surface of a bed, or a series of beds forming a design, with close low-growing plants, in which certain figures are brought out by means of plants of a different habit or having different-coloured leaves. Sometimes, in addition to the carpet or ground colour, individual plants of larger size and handsome appearance are dotted symmetrically over the beds, an arrangement which is very telling. Some of the best plants for carpeting the surface of the beds are—Antennaria tomentosa, white; Sedum corsicum and glaucum, grey; and Sedum Lydium, Mentha Pulegium gibraltaricum, and Herniaria glabra, green. The Alternantheras, Amaranthuses, Iresines, and Coleuses furnish high and warm colours; while Pyrethrum Parthenium aureum yields greenish yellow; Mesembryanthemum cordifolium variegatum, creamy yellow; Centaureas and others, white; and the succulent Echeverias and Sempervivums, glaucous rosettes, which last add much to the general effect.

80. GREENHOUSE PLANTS.—These are plants requiring the shelter Green-of a glass house, provided with a moderate degree of heat, of which house 35° Fahr. may be taken as the minimum. The house should be plants. opened for ventilation in all mild weather in winter, and daily throughout the rest of the year.

The following is a select list of miscellaneous decorative plants in addition to special subjects which will be noticed separately:—

Abutilon Boule de Neige has pure white drooping bell-shaped flowers.

Acacias are remarkably profuse-flowering plants with yellow flowers. A. armata and A. Drummondii are flowering bushes; A. lophantha has ample fern-like leaves; A. Riceana has pale yellow flowers in early spring, and is well suited for training up rafters or pillars.

Adenandra fragrans produces highly fragrant pink star-shaped flowers in May and June.

Agapanthus is very ornamental and easily grown, A. umbellatus having a large umbel of pale blue flowers, and A. umbellatus albiflorus white flowers.

Aphelexis embraces various species of close-growing plants, half procumbent in habit, producing handsome purplish-crimson and rosy-pink everlasting flowers freely on the points of the shoots in May and June.

Aralias have large palmate leaves.

Araucaria excelsa has regularly spreading branches resembling gigantic ostrich feathers.

Begonias. The new tuberous-rooted hybrids are very showy, and continue to flower all through the summer and autumn.

Boronias are a fine group of hard-wooded shrubs, having chiefly pink flowers, which bloom profusely from the mature wood; the best examples of the family are B. pinnata, Drummondii, and serrulata.

Chorozemas are quick-growing slender-habited plants, with highly-coloured red and yellow pea-shaped flowers, produced in racemes from the axils of the leaves; C. varium, cordatum, and spectabile are fine and distinct.

Cordylines are stately plants, of which the principal are C. indivisa, with a noble crown of glaucous leaves marked by orange ribs, and C. australis with narrower leaves.

Cytisus racemosus is one of the best subjects for early spring blooming, of dense bushy habit, and bearing yellow flowers; C. Everestianus has flowers of a deep orange.

Daphne indica is unsurpassed for its perfume.

The Dasylirions have stout woody stems and large heads of narrow leaves.
Epacris is a winter-flowering genus, easily grown and free-blooming, the principal sorts being E. hyacinthiflora candidissima, hyacinthiflora carminata, miniata, and the pure white onosmaeflora flore-pleno nivalis.
Grevilleas are shrubs of slender habit, some having handsome flowers, while G. robusta and others almost rival the ferns in the elegance of their leaves.
Hydrangea Hortensia produces immense heads of bloom of a delicate pink, which continue long in flower, and may be changed to blue by the admixture of iron filings with the soil.
Imantophyllum miniatum is a grand plant, the umbels of pale flame-red flowers being produced at various seasons.
Kalosanthes consists of splendid flowering plants, which, however, rarely bloom well two years in succession.
Lachenalia pendula, luteola, and tricolor are exceedingly pretty dwarf bulbs, useful about April and May.
Lapageria rosea is one of the very finest greenhouse climbers in existence, and bears waxy bell-shaped red flowers, mottled with white; L. rosea alba is still more beautiful, a clear waxy white.
Lilium auratum, speciosum, and Krameri are fine, L. auratum being one of the noblest flowering plants in existence.
Mandevilla suaveolens, a strong-growing climber, bears beautiful, fragrant, trumpet-shaped white blossoms in August and September.
The Neriums are tall strong-growing subjects, with flowers of great beauty, produced in cymes from the points of the mature shoots.
The Passifloras produce their showy singularly-formed flowers most profusely, and are very suitable for decorating the roof of a conservatory.
Pimeleas are free-growing, compact-habited plants, producing flower-heads from the points of the shoots; P. spectabilis rosea has flower-heads, white flushed with rose, almost as large as those of a guelder-rose; P. Hendersoni has deep pink, P. hispida white, and P. elegans straw-coloured flowers.
Pleroma elegans is a free-flowering melastomaceous shrub, producing in succession its lovely saucer-shaped flowers of the most intense purple hue, from June to September.
Plumbago capensis is another abundant bloomer, and one of the very best of greenhouse climbers, with large bunches of delicate grey-blue flowers.
The Rhododendron furnishes a large contingent, of which the most suitable are Countess of Haddington, Dalhousie, Edgworthii, Gibsoni, Thompsoni, javanicum, with jasminiflorum and its beautiful varieties, Princess Royal, Princess Alexandra, Princess of Wales, and Duchess of Edinburgh.
Statices include some very highly ornamental plants, especially S. brassicæfolia, profusa, and imbricata.
Tacsonias are magnificent climbers; indeed, T. Van Volxemii is one of the very finest of the climbing plants which flower in autumn.
Trachelospermum jasminoides, better known as Rhynchospermum, very fragrant, and moderately vigorous, is suitable for a pillar, and produces white flowers in May and June.
Tropæolums are charming pot climbers, of which may be mentioned T. azureum, brachyceras, speciosum, tricolorum, and Jarrattii.
Vallota is a very choice evergreen bulb, V. purpurea producing highly-coloured scarlet flowers, in umbels, in August and September.

Agave. 81. *Agave.*—Bold-habited succulent plants, some of the larger of which are well adapted for conservatory decoration and prominent situations on terraces, &c. The American Aloe, Agave americana, with its varieties variegata and mediopicta, all require to be kept moderately dry and safe from frost during the winter, and grow well in strong loam, sand, and rotten manure. Among others of the larger varieties are A. potatorum and miradorensis, and of the smaller ones, A. filifera, applanata, Verschaffeltii, and schidigera. Still smaller dense-growing sorts are A. Richardii, horrida, Victoriæ Reginæ, and Bessereriana.

Aloe. 82. *Aloe.*—Succulent plants, extremely variable in character. They all thrive best in a sandy loam, well drained, and not over watered. The old Partridge-breast Aloe, A. variegata, is well adapted for a window; A. ferox, supralævis, and arborescens are tall plants; A. saponaria, mitræformis, albocincta, and lineata are smaller; A. serra, variegata, humilis, and serrulata are dwarf. The Fan Aloe, A. plicatilis, produces its flowers in winter. A group of dwarf showy-flowered aloes, often separated under the name of Gasteria, flower in early spring. The following are of a spiral habit of growth—G. spiralis, obliqua, undata, and carinata; while, of those of distichous growth, G. nigricans, lingua, verrucosa, and intermedia may be recommended. Besides these there are the Apieras and the Haworthias, all formerly known as aloes, which are very dwarf.

Azalea. 83. *Azalea.*—The beautiful varieties now in cultivation have been bred from a few originals, natives of the hilly regions of India and China. They are perhaps unequalled as indoor decorative plants. The Chinese species, A. vittata, will commence to open its blooms in September, and other sorts keep up a succession for several months, for some of the varieties may be forced into bloom during the winter, and others flower through the spring up to May and June. They are usually increased by grafting the half-ripened shoots on the stronger-growing kinds, the shoots of the stock and the grafts being in a similarly half-ripened condition, and the plants being placed in a moist heat of 65°. Large plants of inferior kinds, if healthy, may be grafted all over with the choicer sorts, so as to obtain a large specimen in a short time. They require a rich and fibrous peat soil, with a mixture of sand to prevent it getting water-logged. The best time to pot azaleas is three or four weeks after the blooming is over. The soil should be made quite solid to prevent its retaining too much water. To produce handsome plants, they must while young be stopped as required. Specimens that have got leggy may be cut back just before growth commences. The lowest temperature for them during the winter is about 35°, and during their season of growth from 55° to 65° at night, and 75° by day, the atmosphere being at the same time well charged with moisture. They are liable to the attacks of thrips and red spider, which do great mischief if not promptly destroyed.

84. *Calceolaria.*—Originally introduced under various specific forms from Chili and Peru, the calceolaria of the present day has been developed into a highly decorative plant, in which the herbaceous habit has preponderated. The plants are now very generally raised annually from seed, which is sown about the end of July in a mixture of loam, leaf-mould, and sand, and, being very small, must only be slightly covered. When the plants are large enough to handle they are pricked out an inch or two apart into 3-inch or 5-inch pots; when a little more advanced they are potted singly. They should be wintered in a greenhouse with a night temperature of about 40°, occupying a shelf near the light. By the end of February they should be moved into 8-inch or 10-inch pots, using a compost of three parts good turfy loam, one part leaf-mould, and one part thoroughly rotten manure, with a fair addition of sand. They need plenty of light and air, but must not be subjected to draughts. When the pots get well filled with roots, they must be liberally supplied with manure water. In the early stages of growth the plants are subject to the attacks of the green fly, for which they must be fumigated. Named varieties are not now grown, as a good strain of seed will yield satisfactory flowers. Calceolaria.

The shrubby calceolarias used for bedding are increased from cuttings, planted in autumn in cold frames, where they can be wintered, by the use of mats and a good layer of litter placed over the glass and round the sides as a protection from frost.

85. *Camellia.*—This favourite plant, a native of Japan, is deservedly popular, on account of its glossy foliage and magnificent flowers. It is usually propagated by cuttings, to furnish stocks on which the choicer kinds are grafted. It will succeed either in peat or loam or a mixture of both, but in any case an addition of turfy fibre and of sand is also necessary. The plants should have abundance of water, especially in the growing season, and should be potted as they complete their growth and are about to set their flowers; they do not, however, require repotting so often as most plants. Fire heat need only be employed when the object is to obtain flowers in the autumn and winter months. To produce them at this season it becomes necessary to start the plants into growth correspondingly early. When grown in cold houses, they do not generally flower until about February or March, at which stage the plants enjoy a temperature of 45° or 50°. When fire heat is applied to assist the opening of the flowers, it should not much exceed 55°, and whilst the plants are subjected to this heat the atmosphere must on no account be allowed to become dry, or the buds will probably drop. When making their growth they need an abundant supply of water at the roots, as well as copious syringings twice a day, but as terminal buds become visible they should be kept drier. Liquid manure is of great assistance to plants that have flowered very heavily, while they are making their growth, and the addition of a little soot imparts a dark-green colour to the leaves. If grown in an open-roofed light house, shade will be required during very bright weather whilst the young shoots are being developed, but if grown in a lean-to house facing the north, shade will not be required. It is sometimes necessary to move the plants out of the house after they have set their flowers, to keep them from coming on too rapidly. In this case they should have placed over them a light framework and movable screen. Camellia.

The scale is the most troublesome insect which attacks the camellia. To remove the white scale, the plants should be washed with a sponge and solution of soft soap as soon as their growth is completed, and again before the buds begin to swell. The brown scale may be got rid of by repeated washings with one of the many insecticides, such as Fowler's, but it should be applied at a temperature of 90°. See CAMELLIA, vol. iv. p. 737.

Some of the best varieties are—Alba plena (old double white), Bealii, Bonomiana, candidissima, Chandler's Elegans, Contessa Lavinia Maggi, Countess of Ellesmere, Donckelaari, eximia, fimbriata, Henri Favre, imbricata, imbricata alba, Jubilee, Madame Ambroise Verschaffelt, Mathotiana, Mathotiana alba, Princess Mary, reticulata flore-pleno, Saccoi nova, and Valtavaredo.

86. *Cinerarias* can be raised freely from seeds, and though there are named varieties in existence, a good strain of seed will yield flowers almost as fine. They must be kept, especially while young, free from aphides, to which they are more than ordinarily subject. For spring flowering the seeds may be sown in April or May in well-drained pots or pans, in soil of three parts loam to two parts leaf-mould, with one-sixth sand; cover the seed thinly with fine soil, and press the surface firm. When the seedlings are large enough to handle, prick them out in pans or pots of similar soil, and when more advanced pot them singly in 4-inch pots, using soil a trifle less sandy. They should be grown in shallow frames facing the north, and, if so situated that the sun shines upon the plants in the middle of the day, they must be slightly shaded; give plenty of air, and never allow them to get dry. When well established with roots, shift them into 6-inch pots, which should be liberally supplied with manure water as they get filled with roots. In winter they should be removed to a pit or house, where a little heat can be supplied whenever there is a risk of their getting frozen. They should stand on a moist bottom, but must not be subjected to cold draughts. When the flowering stems appear, give manure water at every alternate watering. Seeds sown in March, and grown on in this way, Cineraria.

will be in bloom by Christmas if kept in a temperature of from 40° to 45° at night, with a little more warmth in the day; and those sown in April and May will succeed them during the early spring months, the latter set of plants being subjected to a temperature of 38° or 40° during the night.

rea. 87. *Correa.*—This genus of Australian plants is extremely useful for winter flowering. The best of them is C. cardinalis, which affords a succession of tube-shaped crimson flowers during the whole of the winter. They are increased by cuttings, and grown in rough peaty soil, with a slight addition of loam and sand. After the plants have done flowering, they should all get a little artificial warmth, plenty of moisture, and a slight shade, while they are making their growth, during which period the tips of the young shoots should be nipped out when 6 or 8 inches long. When the growth is complete, a half-shady place outdoors during August and September will be suitable, with protection from parching winds and hot sunshine.

cla n. 88. *Cyclamen.*—Of late years this flower has been so much improved that no plant of moderate size can be made to contribute more floral display in winter. It is raised from seeds in various shades of colour, from the purest white to a deep purple. The seeds should be sown in October or November, in well-drained seed-pans, in an equal mixture of fine loam and leaf-mould with an addition of sand, the seeds slightly covered, and the pans placed near the light in a temperature of 50°. When the seedlings appear, they must be pricked out into 5-inch pots, six or eight in each, and wintered in a similar temperature and situation. In spring they must be potted singly in 3-inch pots, and thinly shaded during bright weather. When they have filled their pots with roots they should be repotted, using similar soil, into 4-inch pots, in which they are to flower. In potting, the corms or tuberous roots should not be more than half covered with the soil. A low house or pit is the best place in which to grow them, shading them if requisite, giving plenty of air, watering regularly, and syringing overhead in the afternoon to keep down thrips and red spider. The temperature should range from 45° to 50°, with plenty of air. They should flower in February and March. After blooming they should be placed in a pit where they can be shaded as required, and as they show signs of going to rest they should receive less water, but should not be allowed to get quite dry. In autumn they may be shifted into pots a size larger, and they will come into flower earlier than in the first year. It is not advisable to keep them after the third season. Some growers recommend after flowering to turn the plants out of their pots into a bed of prepared peat or leaf-soil in some half-shady spot, where they can be sprinkled overhead every afternoon during dry sunny weather, so as to encourage plenty of healthy foliage. In this case they should be lifted early in the autumn.

n. 89. *Erica.*—The species of heaths cultivated in English greenhouses are mostly South African, or have sprung from South African originals. They are of dense twiggy growth, with needle-shaped leaves, and beautiful wax-like flowers, which in some or other of the kinds are produced almost throughout the year. During the winter and early months E. caffra, gracilis, vernalis, hiemalis, melanthera, persoluta, rubens, Willmorei, Sindryana, and others produce their blossoms; later on bloom E. florida, affinis, Cavendishiana, exquisita, ventricosa and its many varieties, and the charming aristata; next come E. Savileana, Irbyana, Austiniana, Jacksoni, retorta major, and others, which last on till September, a few continuing till the end of the year. Heaths are propagated under bell-glasses by cuttings, which should be taken as soon in the spring as the wood is sufficiently firm, and planted in silver sand, the lower leaves having been removed; they should be kept in a temperature of 60°, and the glasses must be wiped occasionally to prevent the plants from damping off. When rooted they should be gradually inured to the air by the occasional removal of the glasses. In the spring following they should be potted singly into thumb pots, and kept close and moist until they take to the new soil. Heaths require peat soil, which for hard-wooded slow-growing kinds should be of a close hard texture, while for soft-wooded slow-growing sorts a mixture of two-thirds of hard peat with one of a softer nature, and for the soft-wooded quick-growing varieties equal quantities of hard and soft peat should be used, with silver sand according to the composition of the peat. The pots must always be well drained, and the plants must never be allowed to become pot-bound. The best season for potting is in March and April, or in September when the summer heats are over. The new soil must be made as firm as the old ball, so as to retain the water. A low span-roofed house, admitting abundance of light, is most suitable for these plants; and they require air in abundance, especially during the season of active growth. They have so great a dislike to fire heat that any degree of cold short of actual frost is preferable to it. When they have grown into specimen plants they should be set out of doors, from the latter part of July till the beginning of September, in order to enable them to resist the attacks of mildew. Water should never be given before the soil has got sufficiently dry to need it, nor should the plants be syringed overhead summer or winter. Especially is this the case with the hard-wooded kinds. See HEATH, vol. xi. p. 589.

Some of the best of the earlier flowering heaths are—E. affinis, aristata, Bergiana, Candolleana, Cavendishiana, Devoniana, florida, hiemalis, Lindleyana, Massoni major, mutabilis, propendens, Sindryana, tortiliflora, ventricosa and its varieties, Victoria, and Willmorei. The later ones are well represented by E. Austiniana, ampullacea and its varieties, Aitoniana Turnbullii, ferruginea superba, gemmifera elegans, Hartnelli, Irbyana, jasminiflora alba, Marnockiana, obbata, Parmentieriana rosea, Paxtoni, Savileana major, Spenceriana, Shannoni, tricolor and its varieties, and vestita and its varieties.

90. *Fuchsia.*—This well-known decorative soft-wooded plant comes from the temperate parts of South America, but has been improved by selection and hybridization. Fuchsias strike readily from cuttings, the most usual method being to place old plants in warmth about February, and as soon as they have pushed shoots a couple of inches or so in length, to take them off and put them in small pots, in a temperature of 60°; they will root in two or three weeks, when they should be moved singly into 3-inch pots; and they must be again shifted into 8-inch or 9-inch pots as soon as those they already occupy are moderately filled with roots. The leading shoot, as well as the side branches, should be topped two or three times during the spring, and a single stick placed to the main stem so as to keep it upright. They should be syringed in the afternoons, to promote growth and to keep down aphides and red spider. By the end of June or July such plants will be disposed to flower. A good compost for fuchsias consists of four parts good fibrous loam to two parts well-rotted manure and leaf-mould, with a fair sprinkling of sand. When larger plants are required the cuttings should be struck about the end of July or beginning of August, and kept gently growing through the autumn and winter in 6-inch pots on a shelf near the glass, with a night temperature of 50°. At the end of February they should be shifted into 10-inch or 12-inch pots, and by the end of April they will be in a condition to move to 16-inch or 18-inch pots, and the temperature should be raised to 55°. The shape of the plants should be regulated by timely pinching of the shoots, the pyramidal and standard forms being the most elegant. The old plants may be kept during winter in any dryish place free from frost; prune them back in spring, and repot in fresh soil. The varieties are constantly changing through the introduction of novelties. See FUCHSIA, vol. ix. p. 806. Fuchsia.

91. *Heliotropium.*—The Peruvian Heliotrope, Heliotropium peruvianum, is a great favourite with cultivators, on account of the delicious fragance of its blossoms, which has obtained for it the popular name of "cherry pie." The plants are easily increased by cuttings, which are struck in July and August, or from young shoots obtained in heat in early spring; when rooted they should be potted singly into small pots, using as a compost fibry loam, sandy peat, and well-decomposed stable manure from an old hotbed. The plants soon require to be shifted into a pot a size larger. To secure early-flowering plants, cuttings should be struck in August, potted off before winter sets in, and kept in a warm greenhouse. In the spring larger pots should be given, and the plants shortened back to make them bushy. They require frequent shiftings during the summer, to induce them to bloom freely. There are many varieties, differing in habit and in the colour of their flowers. Heliotropium.

The heliotrope makes an elegant standard. The plants must in this case be allowed to send up a central shoot, and all the side growths must be pinched off until the necessary height is reached, when the shoot must be stopped and lateral growths will be produced to form the head. During winter they should be kept somewhat dry, and in spring the ball should be reduced and the plants repotted, the shoots being slightly pruned, so as to maintain a symmetrical head. When they are planted out against the walls and pillars of the greenhouse or conservatory an abundance of highly-perfumed blossoms will be supplied all the year round. See HELIOTROPE, vol. xi. p. 633.

92. *Mesembryanthemum.*—These are interesting Cape plants, some of them of a very showy character, and others remarkable as curiosities. They belong to the class of succulents, and with the exception of the curious sorts, all grow and strike freely in a mixture of loam and leaf-mould with a dash of sand. The flowering kinds should be kept only two or three years. Cuttings should be put in about May, and well exposed. They will stand a few degrees of frost, but should be kept from growing in winter. Mesembryanthemum.

The best flowering sorts, most of which are adapted for window-boxes, are—M. barbatum, blandum, candens, conspicuum, curviflorum, falcatum, formosum, glaucum, polyanthum, reflexum, retroflexum, roseum, and spectabile. These can be used for sunny summer beds very well, as those that require it can be pegged down. Of the curious varieties, some of the choicest are M. agninum, albinum, caninum, felinum, murinum, tigrinum, vulpinum, dolabriforme, densum, fissum, linguaeforme, minimum, obconellum, and octophyllum. These are all dwarf growers, and require more sand and some brick rubbish in the soil; they should also have less water.

93. *Pelargonium.*—The various races of pelargoniums have sprung from the intermixture of some of the species obtained from the Cape. The older show-flowered varieties have been gradually acquired through a long series of years. The fancy varieties, as well as the French spotted varieties and the market type, have been evolved from them. The zonal race, on the other hand, has been perfected within the last quarter of a century. In all the sections the varieties are of a highly ornamental character, but for general culti- Pelargonium.

vation the market type is preferable for indoor purposes, while the zonals are effective either in the greenhouse or flower garden. Some of the Cape species are still in cultivation,—the leaves of many of them being beautifully subdivided, almost fern-like in character, and some of them deliciously scented. A few of these are well adapted for bedding out.

Some of the most striking of this set are—P. Blandfordianum, echinatum, graveolens, melananthum, and Schottii; while the following have finely-scented leaves:—P. capitatum, citriodorum, crispum, and odoratissimum. To these may be added, from amongst the earlier hybrids, those named Lady Plymouth, Fair Helen, ignescens, Moore's Victory, Pretty Polly, quercifolium and its varieties, Shrubland Pet, and the various sports from Unique.

The best soil for pelargoniums is a mellow fibrous loam with good stable manure in about the proportion of one-fifth; when used it should not be sifted, but pulled to pieces by the hand, and as much sand should be added as will allow the water to pass freely through it. The large-flowered and fancy kinds cannot bear so much water as most soft-wooded plants, and the latter should have a rather lighter soil.

All the pelargoniums are readily increased by cuttings made from the shoots when the plants are headed down after flowering, or in the spring, when they will root freely in a temperature of 50°. They must not be kept too close, and must be very moderately watered. When rooted they may be moved into well-drained 3-inch pots, and should have the points pinched out in order to induce them to push out several shoots near the base. These shoots are, when long enough, to be trained in a horizontal direction; and when they have made three joints they should have the points again pinched out. These early-struck plants will be ready for shifting into 6-inch pots by the autumn, and should still be trained outwards. The show varieties after flowering should be set out of doors in a sunny spot to ripen their wood, and should only get water enough to keep them from flagging. In the course of two or three weeks they will be ready to cut back within two joints of where these were last stopped, when they should be placed in a frame or pit, and kept close and dry until they have broken. When they have pushed an inch or so, turn them out of their pots, shake off the old soil, trim the straggling roots, and repot them firmly in smaller pots if practicable; keep them near the light, and as the shoots grow continue to train them outwardly. They require to be kept in a light house, and to be set well up to the glass; the night temperature should range about 45°; and air should be given on all mild days, but no cold currents allowed, nor more water than is necessary to keep the soil from getting parched. The young shoots should be topped about the end of October, and when they have grown an inch or two beyond this, they may be shifted into 7-inch pots for flowering. The shoots must be kept tied out so as to be fully exposed to the light. If required to flower early they should not be stopped again; if not until June they may be stopped in February.

The zonal varieties, which are almost continuous bloomers, are of much value as decorative subjects; they seldom require much pruning after the first stopping. For winter flowering, young plants should be grown on during the summer, and not allowed to flower. When blossoms are required, they should be placed close up to the glass in a light house with a temperature of 60°, only just as much water being given as will keep them growing. For bedding purposes the zonal varieties are best struck towards the middle of August in the open air, taken up and potted or planted in boxes as soon as struck, and preserved in frames or in the greenhouse during winter.

The fancy varieties root best early in spring from the half-ripened shoots; but they are slow growers, rather delicate in constitution, and very impatient of excess of water at the root.

Petunia. 94. *Petunia.*—The varieties of petunia, especially the double forms, make admirable specimens for pot culture. These and the other named varieties are propagated by cuttings taken from stock plants kept through the winter on a dry warm shelf, and moved into a brisk moist heat in early spring; the young shoots are planted in pans or pots filled with sandy soil, and, aided by a brisk bottom heat, strike root in a few days. They are then potted singly into thumb-pots, and when once established are gradually hardened off, and afterwards repotted as required. The shoots should be topped to make bushy plants, and their tops may be utilized as cuttings. The single varieties are raised from seeds sown in light sandy soil in heat, in the early spring, and very slightly covered. The plants need to be pricked out or potted off as soon as large enough to handle. Good strains of seeds supply plants suitable for bedding; but, as they do not reproduce themselves exactly, any sorts particularly required must be propagated, like the double ones, from cuttings.

Primula. 95. *Primula.*—One of the most popular of winter and early spring decorative plants is the Chinese Primrose, Primula sinensis, of which some superb strains have during the last few years been obtained. For ordinary purposes young plants are raised annually from seeds, sown about the beginning of March, and again for succession in April, and if needed in May. The seed should be sown in well-drained pans, in a compost of three parts light loam, one part well-rotted leaf-mould, and one part clean gritty sand, as it does not germinate freely if the soil contains stagnant moisture. The surface should be pressed smooth and gently watered before sowing, and the seeds should be only just covered with some very fine compost, half soil half sand, and over that a thin layer of chopped sphagnum to keep it damp, and obviate the necessity of watering. When the seeds germinate, remove the moss, and place them in a well-lighted position near the glass, shading them from the sun with thin white paper, and giving water moderately as required. When they are large enough to handle, prick them out in pans or shallow boxes, and, as soon as they have made leaves an inch long, pot them singly in 3-inch pots, using in the soil a little rotten dung. They should then be placed in a light frame near the glass in an open situation, facing the north. When their pots are filled with roots they should be moved into 6-inch or 7-inch pots. The soil should now consist of three parts good loam broken with the hand, one part rotten dung and leaf-mould, and as much sand as will keep the whole open. They should be potted firmly, and kept in frames close up to the glass till September, excess in watering being carefully avoided. In the autumn they should be transferred to a light house and placed near the glass, the atmosphere being kept dry by the occasional use of fire heat. The night temperature should be kept about 45°. When the flowering stems are growing up, manure water once or twice a week will be beneficial. The semi-double varieties are increased from seeds, but the fully double ones and any particular sort can only be increased by cuttings made by dividing the crowns with a portion of stem attached, the plants being first well dried, almost to shrivelling; the cuttings should be placed in small pots in sandy soil, put in a moderate dryish heat, and only just watered enough to prevent flagging. When they are well rooted, they may be potted like the others. In winter they require an intermediate temperature of 45° or 50° at night, and a little higher in the day, with air when the weather is suitable.

96. *Richardia.*—This plant, R. æthiopica, called also Calla æthiopica and the Nile Lily, is a fine subject for greenhouse decoration during the spring months. It is a stately tuberous-rooted perennial, with broad arrow-shaped leaves, and large white flower-spathes, that last long in beauty. The plants should be carefully divided about March, and planted out during May in well-enriched shallow trenches. Being semi-aquatics, they cannot be kept too moist all through the summer months. Plants kept in pots are generally neglected in this way, and hence are rarely seen in really first-class condition. The richardias are hardy if their crowns are kept under water; but a very little frost disfigures the foliage, and therefore they should be placed in the pits or the greenhouse towards the end of October. They may be had in flower during the winter, but in that case they must have a little warmth to give them a start. Richardia.

97. *Salvia.*—Some of the Salvias or Sages are among the best and most showy among soft-wooded winter-flowering plants, the blossoms being of a bright-glowing scarlet. The three most useful species are S. splendens, S. Heeri, and S. gesneræflora, the first commencing to flower early in the autumn and lasting till Christmas, while the others follow immediately in succession, and continue in full beauty till April. Young plants should be propagated annually about February, and after nursing through the spring should be grown outdoors in a fully exposed situation, where they can be plunged in some non-conducting material, such as half-decomposed leaves. The young shoots should be stopped to secure bushy plants, but not later than the middle of August. The most suitable compost for them is a mixture of mellow fibry loam enriched with a little mild thoroughly decomposed manure, made sufficiently porous by the addition of sand or grit. In spring, and during the blooming period, the temperature should be intermediate between that of a stove and greenhouse. There are other very ornamental species of easy growth, increased by cuttings in spring, and succeeding well in ordinary rich loamy soil. Of these S. angustifolia bears spikes of fine bright-blue flowers in May or June; S. chamædryoides, a dwarfish subject, has deep-blue flowers in August; S. fulgens produces scarlet flowers in August; and S. involucrata produces fine red flowers during the autumn. S. patens is a lovely blue free-blooming sort, flowering in August, the colour being unique. Salvia.

98. STOVE PLANTS.—For the successful culture of stove plants two houses at least, wherein different temperatures can be maintained, should be devoted to their growth. The temperature during winter should range at night from about 55° in the cooler to 65° in the warmer house, and from 65° to 75° by day, allowing a few degrees further rise by sun heat. In summer the temperature may range 10° higher by artificial heat, night and day, and will often by sun heat run up to 90° or even 95°, beyond which it should be kept down by ventilation. During the growing period the atmosphere must be kept moist by damping the walls and pathways, and by syringing the plants, according to their needs; when growth is completed less moisture will be necessary. Watering, which, except during the resting period, should generally be copious, is best done in the forenoon; while syringing should be done early in the afternoon to admit of the foliage drying moderately before night. When the pots become filled with roots, waterings of weak liquid manure Stove plants.

help very much towards a successful blooming. In ventilating, cold draughts must be avoided.

The following are select miscellaneous stove plants:—

Acalypha tricolor (Wilkesiana).
Æschynanthus Boschianus, Lobbianus, and splendens.
Allamanda Chelsoni, Schottii, grandiflora, Hendersoni, and nobilis.
Alocasia Jenningsii, Lowii, Veitchii, macrorrhiza variegata, and metallica.
Anthurium crystallinum, regale, Warocqueanum, Veitchii, magnificum, Scherzerianum, and Andréanum.
Aphelandra nitens and Roezlii.
Aralia elegantissima, filicifolia, and Veitchii.
Ardisia crenulata and Oliveri.
Aristolochia Duchartrei and floribunda.
Bertolonia superbissima and Van Houttei.
Bignonia Chamberlaynii and venusta.
Bougainvillea glabra and spectabilis.
Centropogon Lucyanus.
Cissus discolor.
Clerodendrum fallax, Balfourianum, and splendens.
Combretum purpureum.
Croton angustifolius, trilobus Disraeli, Andréanus, gloriosus, majesticus, undulatus, Weismanni, spiralis, and Williamsii.
Cyanophyllum magnificum.
Dieffenbachia Bausei, Leopoldii, Carderi, and splendens.
Dipladenia Brearleyana, regina, and amabilis.
Ficus elastica (India-rubber Plant).
Franciscea eximia, calycina, magnifica, and confertiflora.
Gardenia Stanleyana, citriodora, and florida.
Gesnera Cooperii, Donckelaari, and superba.
Hibiscus rosa sinensis miniatus semiplenus, and its varieties—refulgens, zebrinus, puniceus, Collerii, fulgidus, schizopetalus, and Cooperii.
Hoya imperialis, carnosa, campanulata, and bella.
Ipomœa Horsfalliæ and Learii.
Ixora coccinnea, Colei, javanica, splendens, regina, and Williamsii.
Luculia gratissima.
Maranta fasciata, albo-lineata, roseolineata, Makoyana, regalis, roseopicta, Veitchii, zebrina, and Massangeana.
Medinilla magnifica and amabilis.
Nelumbium speciosum.
Nepenthes (Pitcher-Plant) Veitchii, sanguinea, lævis, Stewartii, Williamsii, Hookeri, and Rafflesiana.
Nymphæa Devoniana, dentata, and cœrulea.
Pandanus graminifolius, elegantissimus, Vandermeerschii, and Veitchii.
Passiflora Raddiana (kermesina), Decaisneana, Buonapartea, Hahnii, edulis, and princeps racemosa.
Pavetta borbonica.
Pentas carnea rosea.
Plumbago rosea.
Rogiera cordata and gratissima.
Rondeletia speciosa major.
Stephanotis floribunda.
Sphærogyne latifolia.
Thyrsacanthus rutilans.
Tillandsia musaica, tessellata, Lindeniana, and Zahnii.
Tornelia fragrans (Monstera deliciosa).
Victoria regia.
Vinca rosea, rosea oculata, and rosea alba.

99. *Achimenes* have scaly tubers, which are kept dry and in a state of rest in a temperature of 55° during the winter months, and started into growth about March, a second batch being started in April. They should be placed 6 inches asunder in pans filled to within 1½ inches of the rim with leaf-mould or cocoa-refuse, made rather sandy, and slightly covered with the soil. The pans should be set in a warm pit or frame, and the soil kept slightly moistened, and when the young shoots are a couple of inches long they may be placed six or eight in a 6-inch pot, in a soil of three parts fibrous loam and two parts leaf-mould, mixed with a little sand. The temperature should be from 65° to 70°, and they should be well exposed to light. When 6 inches long, pinch out the points to induce them to branch, and give more water, syringing overhead to keep red spider in check. As soon as the flower buds appear, give weak manure water two or three times a week. They should all through their growth have sufficient air to keep them from getting drawn, and when the flowers begin to open should be gradually inured to bear the temperature of the conservatory. When they show signs of going to rest, less water may be given; and after the tops have died down, the tubers may be stored in dry sand in a temperature of about 55°. Achimenes have also a fine effect grown in wire baskets from the roof of the plant house.

The following are good kinds:—Ambroise Verschaffelt, belmontensis, Firefly, longiflora alba, longiflora major, Mauve Queen, Parsonsii, Rose Queen, Stella, and Williamsii.

100. *Amaryllis.* This genus, also called Hippeastrum, consists of splendid bulbous plants, of easy culture and free-blooming habit. Like other bulbs they are increased by offsets, which should be carefully removed when the plants are at rest, and should be allowed to attain a fair size before removal. These young bulbs should be potted singly in February or March, in mellow loamy soil with a moderate quantity of sand, about two-thirds of the bulb being kept above the level of the soil, which should be made quite solid. They should be removed to a temperature of 60° by night and 70° by day, very carefully watered until the roots have begun to grow freely, after which the soil should be kept moderately moist. As they advance the temperature should be raised to 70° at night, and to 80° or higher with sun heat by day. They do not need shading, but should have plenty of air, and be syringed daily in the afternoon. When growing they require a good supply of water. After the decay of the flowers they should be returned to a brisk moist temperature of from 70° to 80° by day during summer to perfect their leaves, and then be ripened off in autumn. Through the winter they should have less water, but must not be kept entirely dry. The minimum temperature should now be about 55°, to be increased 10° or 15° in spring. As the bulbs get large they will occasionally need shifting into larger pots.

A few of the best sorts are—Ackermanni pulcherrima, aulica, conspicua, Duchess of Connaught, Hercules, Leopoldii, Meteor, Mrs Baker, Mrs Morgan, Oriflamme, pardina, pyrrochroa, Queen Victoria, striata superba, Thalia, Unique, Virgil, and vittata. New varieties are being constantly raised.

101. *Begonias* are represented by numerous species, herbaceous and subshrubby. There are several free-flowering hybrids, such as B. weltoniensis, Saundersii, fuchsioides, prestoniensis, ascotiensis, &c.; there is the group of ornamental-leaved kinds represented by B. Rex; and there is the tuberous-rooted free-blooming brilliant race, developed recently, mainly from B. boliviensis and B. Veitchii. Begonia.

Cuttings from flowering begonias root freely in sandy soil, placed in heat at any season when moderately firm, and as soon as rooted should be potted singly into 3-inch pots, in sandy loam mixed with leaf-mould and sand. They should be stopped to keep them bushy, placed in a light situation, and thinly shaded in the middle of very bright days. In a few weeks they will require another shift. They should not be overpotted, but instead assisted by manure water. The pots should be placed in a light pit near the roof glass. The summer-flowering kinds will soon commence blooming, but the autumn and winter-flowering sorts should be kept growing on in a temperature of from 55° to 60° by night, with a few degrees more in the day. The tuberous-rooted sorts require to be kept at rest in winter, in a medium temperature, almost but not quite dry. In February they should be potted in a compost of sandy loam and leaf-mould, and placed in a temperate pit until May or June, when they may be moved to the greenhouse for flowering. If they afterwards get at all pot-bound, weak manure should be applied. After blooming the supply of water must be again slackened, and in winter the plants should be stored in a dry place, secure from frost; they are increased by late summer and autumn cuttings, after being partially cut down.

102. *Bouvardia.*—These plants are best increased by cuttings taken off in April, and placed in a brisk heat in a propagating frame with a close atmosphere. When rooted they should be potted singly into 3-inch pots in fibrous peat and loam, mixed with one-fourth leaf-mould, and a good sprinkling of sand, and kept in a temperature of 70° by night and 80° during the day; shade when required; syringe overhead in the afternoon, and close the house with sunheat. The plants should be topped to ensure a bushy habit, and as they grow must be shifted into 6-inch or 7-inch pots. After midsummer they should be moved to a cool pit, where they may remain till the middle of September, receiving plenty of air and space. They should then be removed to a house, and a portion of the plants should be put at once in a temperature of about 70° at night, with a few degrees higher in the day time, to bring them into flower. Others must be moved into heat to supply flowers in succession through the winter and spring. Some of the best kinds are B. elegans, Hogarth, jasminiflora, Maiden's Blush, and Vreelandii. Bouvardia.

103. *Cactus.*—This old-fashioned name includes many modern genera of handsome or interesting succulents, the principal of which are briefly mentioned below. *Cereus* is well represented by C. speciosissimus, a quadrangular-stemmed spiny plant, requiring stove heat, and a loamy soil freely mixed with hard drainage material; it must not be overpotted. *Echinocactus* is a genus of dwarf fleshy spiny plants, which are slow growers, and must have plenty of sun heat; they require sandy loam, with a mixture of sand and bricks finely broken, and must be potted firmly, and kept dry in winter. *Echinopsis* is a group of dwarfish plants resembling the Echinocacti, which bear flowers about a foot long, varying from white to deep rose. *Epiphyllum* is a group of handsome plants easily increased from cuttings, but from their drooping habit they are better adapted for grafting on the *Pereskia*, so as to form small standards. The Pereskia stocks are struck during the winter or spring from cuttings placed in heat, and should be grown in sandy loam, the pots being well drained; these must be kept to a single stem, and when a foot or 18 inches high, and of a firm woody texture, should be grafted with small pieces of the Epiphyllum. They may be grown for a considerable time in 6-inch or 7-inch pots, but must have free drainage. After grafting they should be grown on in heat and in plenty of light through the summer, but by the autumn should have less warmth and moisture. A winter temperature of 50° will be sufficient, but in January a portion may be started in a temperature of 60°, in which they will soon show flower. This treatment being continued they will last for many years, and go on increasing in size. There are a number of varieties of E. truncatum, differing chiefly in the amount and shade of rose colour or crimson in the flowers. *Mammillaria* consists of very interesting dwarf globular or cylindrical plants, remarkable for the beautiful colour of their numerous spines, and the irregular arrangement of the mammillæ into which their surface is broken up. They grow freely in a cool greenhouse, and require moderate watering in summer, with occasional syringing overhead. The spines are in some species white, in others yellow, or red, or brown, or almost black. *Opuntia* is the prickly pear of southern Europe, or Indian fig of South America; the species are scarcely ornamental plants, but are interesting on account of their variable development. The cochineal insect is reared on some of the larger-growing sorts. O. vulgaris and Rafinesquiana are hardy in the south of England. *Phyllocactus* is one of the most ornamental genera of cacti, and is of easy culture, requiring dry stove treatment. Cuttings strike readily in spring before growth has commenced; they should be potted in 3-inch or 4-inch pots, well-drained, in loamy soil made very porous by the admixture of finely-broken crocks and Cactus.

sand, and placed in a temperature of 60°; when these pots are filled with roots they are to be shifted into larger ones, but overpotting must be avoided. During the summer they need considerable heat, all the light possible, and plenty of air. In winter a temperature of 45° or 50° will be sufficient, and they must be kept tolerably dry at the root. By the spring they may have larger pots if required, and should be kept in a hot and fairly moistened atmosphere; and by the end of June, when they have made new growth, they may be turned out under a south wall in the full sun, water being given only as required. In autumn they are to be returned to a cool house, and wintered in a dry stove. The turning of them outdoors to ripen their growth is the surest way to obtain flowers, but they do not take on a free blooming habit until they have attained some age. Amongst the best sorts are P. Ackermanni, Jenkinsoni, crenatus, and speciosus.

Caladium. 104. *Caladium.*—These beautiful arads are increased by division of the young growths made in the spring. They should be potted in small pots in fibrous sandy peat, well drained, and kept in a temperature of 65° by night; afterwards they should be changed into larger ones, using lumpy soil. The summer temperature may range about 68° or 70° by night, with an increase of 10° by day. The plants will go to rest towards autumn, and when the leaves have all died away the soil may be allowed to become nearly dry, and the pots may be set on a shelf, in a temperature of about 55°, till February.

Coleus. 105. *Coleus.*—These are very ornamental plants, the colour of their leaves being exceedingly varied, and often very brilliant. They are of the easiest culture. The cuttings of young shoots should be propagated every year, about March, being planted in thumb pots, in sandy loam, and placed in a close temperature of 70°. After taking root they should be shifted into 6-inch pots, using ordinary light loamy compost, containing abundance of leaf-mould and sand, and keeping them near the light. They may be passed on into larger pots as often as required, but 8-inch pots will be large enough for general purposes, as they can be fed with liquid manure. The young spring-struck plants like a warm growing atmosphere, but by midsummer they will bear more air and stand in a greenhouse or conservatory. They should be wintered in a temperature of 60° to 65°. The stopping of the young shoots must be regulated by the consideration whether bushy or pyramidal plants are desired.

Dracæna. 106. *Dracæna.*—These are extremely useful as decorative stove plants, and are easy to grow. They may be increased by cuttings planted in sandy soil in a temperature of from 65° to 70° by night, the spring being the best time for propagation. The old stems laid flat in a propagating frame will push young shoots, which may be taken off with a heel when 2 or 3 inches long, and planted in sandy peat in 3-inch pots; the tops can also be taken off and struck. The established plants do best in fibry peat made porous by sand. In summer they should have a day temperature of 75°, and in winter one of 65°. Shift as required, using coarser soil as the pots become larger. By the end of the summer the small cuttings will have made nice plants, and in the spring following they can be kept growing by the use of manure water twice a week. Those intended for the conservatory should be gradually inured to more air by midsummer, but kept out of cold draughts. When the plants get too large they can be headed down and the tops made cuttings. D. terminalis, with its bronzy leaves and rosy variegation, still ranks amongst the best sorts, but there are also many novel varieties of great merit and beauty. D. Goldieana is a grandly variegated species from tropical Africa, and requires more heat.

Eucharis. 107. *Eucharis.*—This is the most chastely beautiful of all decorative plants, having white flowers, of a very distinct character. It is a bulbous plant, and is propagated by removing the offsets, which may be done in spring, potting them singly in 6-inch pots. It requires good loamy soil, with sand enough to keep the compost open, and should have a good supply of water and a temperature of 65° to 70° during the night, with a rise of 8° or 10° in the day. During summer, growth is to be encouraged by repotting, but the plants should afterwards be slightly rested by removal to a night temperature of about 60°, water being withheld for a time, though they must not go too long dry, the plant being an evergreen. By the turn of the year they may again have more heat and more water, and this will probably induce them to flower. After this is over they may be shifted and grown again as before; and, as they get large, they can either be divided to form new plants or allowed to develop into nobler specimens. With a stock of the smaller plants to start them in succession, they may be had in flower all the year round.

Gloxinia. 108. *Gloxinia.*—The gloxinia, a charming decorative plant, may be grown much in the same way as the achimenes. A good strain of seed will produce many superb and charmingly coloured varieties, and if sown early in spring, in a temperature of 65° at night, they may be shifted on into 6-inch pots, and in these may be flowered during the summer. The bulbs are kept at rest through the winter in a dry sand, in a temperature of 50°, and to yield a succession should be started at intervals, say at the end of February and the beginning of April. To prolong the blooming season, use weak manure water when the flower-buds show themselves.

109. *Poinsettia.*—The Poinsettia pulcherrima, with its brilliant scarlet bracts, stands unrivalled amongst decorative plants. The white-bracted sort, P. p. alba, is not so effective, but the double-flowered P. p. plenissima, in which the cymose inflorescence is branched, is as brilliant as the type, and keeps long in flower. They are increased by cuttings in spring, which when taken off with a heel strike freely in a brisk heat. They require good turfy loam, with an addition of one-sixth of leaf-mould and a little sand, and should be kept in a heat of from 65° to 70° at night, with a rise of 10° by day. To prevent their growing lanky, they should be kept with their heads almost touching the glass; and as the pots get filled with roots they must be shifted into others, 8 inches or 10 inches in diameter. About August they may be inured to a heat of 50° at night, and should be brought to bear air night and day whilst the weather is warm, or they may be placed out of doors for a month under a south wall in the full sun. This treatment matures and prepares them for flowering. In autumn they must be removed to a house where the temperature is 50° at night, and by the end of September some of them may be put in the stove, where they will come into flower, the remainder being placed under heat later for succession. When in bloom they may be kept at about 55° by night, and so placed will last longer than if kept in a higher temperature. Poinsettia.

Tydæa. 110. *Tydæa.*—These handsome plants, which have sprung from the beautiful Achimenes picta, require similar treatment to achimenes, except that, being winter bloomers, they must be started into growth at a different season, namely, the later spring months, as April and May. The summer-blooming sorts, which should be started earliest, should, as they come into flower, be removed to the conservatory. The autumn and winter flowering sorts, being at first grown slowly in a gentle heat, must as they show flower have a nice growing temperature of 70° or 75° afforded them with abundance of light; manure water may be given once a week. The tubers should be stored away dry in winter, like those of achimenes.

Orchids. 111. ORCHIDS.—For the successful cultivation of a mixed collection of tropical orchids, it is necessary that two or three houses, in which different temperatures can be maintained, should be provided. The greater number of them are epiphytes or air plants, and heat and moisture afford all or nearly all the nourishment they require. The plants themselves are the better for being associated with such objects as ferns and palms, and the appearance of the houses is greatly improved by their being thus grouped.

The East Indian orchid house takes in those species which are found in the warm parts of the eastern hemisphere, as well as those from the hottest parts of the western, and its temperature should range from about 75° to 85° during the summer or growing season, and from 65° to 70° during winter. The Mexican or Brazilian orchid house accommodates the plants from the warm parts of South America, and its temperature should range from about 65° to 75° during summer, and from 60° to 65° in winter. A structure called the cool orchid house is set apart for the accommodation of the many lovely mountain species from South America and India, such as odontoglossums, masdevallias, &c., and in this the more uniform the temperature can be kept the better, that in summer varying between 60° and 70°, and in winter from 45° to 60°. A genial moist atmosphere must be kept up in the hottest houses during the growing season, with a free circulation of air admitted very cautiously by well-guarded ventilators. In winter, when the plants are at rest, little water will be necessary; but in the case of those plants which have no fleshy pseudobulbs to fall back upon for sustenance, they must not be suffered to become so dry as to cause the leaves to shrivel. In the Mexican house the plants will generally be able to withstand greater drought occasionally, being greatly assisted by their thick pseudobulbs. In the cool or odontoglossum house a considerable degree of moisture must be maintained at all times, for in these the plants keep growing more or less continuously.

For potting or basketing purposes, or for plants requiring block-culture, the only materials admissible are light fibrous peat and living sphagnum moss, which supply free drainage for the copious supply of water required. The water should, however, be so used as not to run down into the sheathing bases of the leaves. While in flower, orchids may with advantage be removed to a drier and cooler situation, and may be utilized in the drawing-room or boudoir.

From amongst the great wealth of tropical orchids, now in cultivation, the following is a very limited selection of some of the most useful:—

Ada.—Epiphytal: A. aurantiaca.
Aerides.—Epiphytal: A. affine, crassifolium, crispum, Fieldingii, Lobbii, nobile, odoratum, and suavissimum.
Angræcum.—Epiphytal: A. sesquipedale.
Anguloa.—Terrestrial: A. Clowesii and Ruckeri.
Barkeria.—Cool epiphytal: B. elegans, Skinneri, and spectabilis.
Bollea.—Epiphytal: B. Backhousiana, cœlestis, Lalindei, and Patinii.
Calanthe.—Terrestrial: C. Masuca, Veitchii, and vestita.
Cattleya.—Epiphytal: C. amethystoglossa, bulbosa, Dowiana, exoniensis, gigas, labiata, lobata, Mossiæ, quadricolor, Skinneri, superba, and Trianæ.
Cœlogyne.—Epiphytal: C. barbata, cristata, Gardneriana, Lowii, pandurata, and speciosa.
Cymbidium.—Terrestrial: C. eburneum, Lowianum, and Mastersii.
Cypripedium.—Terrestrial: C. Argus, barbatum superbum, caudatum, con-

color, Dayanum, Harrisianum, insigne Maulei, lævigatum, Lowii, niveum, Schlimmi, Stonei, and superbiens.

Dendrobium.—Epiphytal: D. aggregatum majus, Ainsworthii, barbatulum, Bensoniæ, chrysotis, chrysotoxum, crassinode, crystallinum, Devonianum, Falconeri, fimbriatum oculatum, formosum giganteum, lituiflorum, nobile, Paxtoni, pulchellum, suavissimum, and Wardianum.

Dendrochilum.—Epiphytal: D. filiforme and glumaceum.

Disa.—Cool terrestrial: D. grandiflora and Barrellii.

Epidendrum.—Epiphytal: E. dichromum, Frederici Guilielmi, ibaguense, macrochilum, nemorale majus, and vitellinum majus.

Lælia.—Epiphytal: L. anceps, autumnalis, cinnabarina, elegans, harpophylla, majalis, Perrinii, purpurata, and superbiens.

Limatodes.—Terrestrial: L. rosea.

Lycaste.—Cool epiphytal: L. Skinneri, with its many variations.

Masdevallia.—Cool epiphytal: M. Davisii, Harryana, ignea, Lindeni, tovarensis, and Veitchiana.

Mesospinidium.—Cool epiphytal: M. sanguineum and vulcanicum.

Miltonia.—Epiphytal: M. spectabilis, with its fine variety Moreliana.

Odontoglossum.—Cool epiphytal: O. Alexandræ (crispum), Andersonianum, citrosmum, cirrhosum, grande, Hallii, Insleayi, membranaceum, Pescatorei, Phalænopsis, Roezlii, triumphans, vexillarium.

Oncidium.—Epiphytal: O. ampliatum majus, Barkeri, crispum, cucullatum, curtum, macranthum, Marshallianum, ornithorrhynchum, roseum, Papilio majus, sarcodes, and varicosum Rogersii.

Pescatoria.—Epiphytal: P. Dayana, lamellosa, Roezlii, and Wallisii

Phajus.—Terrestrial: P. grandifolius and Wallichii.

Phalænopsis.—Epiphytal: P. amabilis, grandiflora, and Schilleriana.

Pleione (Indian Crocus).—Epiphytal: P. Hookeriana, humilis, lagenaria, maculata, præcox, Reichenbachiana, and Wallichiana.

Renanthera.—Epiphytal: R. coccinea and Lowii.

Saccolabium.—Epiphytal: S. ampullaceum, Blumei majus, curvifolium, guttatum, miniatum, and retusum.

Sobralia.—Terrestrial: S. macrantha splendens.

Sophronitis.—Epiphytal: S. grandiflora.

Stanhopea.—Epiphytal: S. grandiflora, insignis, oculata, and tigrina.

Thunia.—Terrestrial: T. alba and Bensoniæ.

Trichopilia.—Epiphytal: T. crispa, marginata, suavis, and tortilis.

Vanda.—Epiphytal: V. Cathcartii, cœrulea, cœrulescens, suavis, and tricolor.

Zygopetalum.—Epiphytal: Z. Gautieri, Mackayi, maxillare, and rostratum.

Palms. 112. PALMS, while quite young, form charming ornaments for the drawing-room and the dinner table. When more fully developed, and long before their full growth is attained, they are among the best ornamental foliaged conservatory plants. For the most part they are stove plants (75° to 80°), but after the growth is matured, many of them thrive for some time in the temperature of a dwelling house. They are of very easy cultivation, but require plenty of water and thorough drainage. The soil should consist of equal parts of loam, peat, and vegetable mould, with abundance of sand, and they thrive best in comparatively small pots. See PALMS.

The following is a selection of useful species:—

Acanthophœnix.—Pinnate: A. crinita and Herbstii.

Acanthorrhiza.—Fan-leaved: A. stauracantha and Warscewiczii.

Areca. Pinnate: A. alba, aurea, lutescens, and rubra.

Astrocaryum.—Pinnate: A. acaule, Murumuru, and rostratum.

Attalea.—Pinnate: A. funifera, nucifera, and speciosa.

Bactris.—Pinnate: B. baculifera, integrifolia, and simplicifrons.

Brahea.—Fan-leaved: B. filamentosa (a Californian species, having the edges of the leaf-segments developed into long threadlike pendent filaments) and B. Roezlii.

Calamus.—Pinnate, and exceedingly handsome as young plants, but afterwards assuming the habit of climbers: C. adspersus, asperrimus, ciliaris, Flagellum, Impératrice Marie, Jenkinsianus, melanochætes, palembanicus, plumosus, and viminalis.

Caryota.—Pinnate: C. Cumingii is the dwarfest of the species, bipinnate, the leaves from 3 to 6 feet long; C. urens.

Ceroxylon.—Pinnate: C. andicola is a majestic species.

Chamædorea.—Pinnate, and well suited for indoor decoration during the winter months: C. Arenbergiana, desmoncoides, elegans, Ernesti-Augusti, glaucifolia, graminifolia, microphylla, and Warscewiczii.

Chamærops.—Fan-leaved, comparatively dwarf, and admirably adapted for decoration: C. excelsa, Fortunei, humilis, and Martiana.

Cocos.—Pinnate: Shade-loving plants, some of which are most charming, especially C. Bonneti, elegantissima, plumosa, and Weddelliana.

Cyphokentia.—Pinnate: C. gracilis and macrocarpa (Kentia Lindeni).

Euterpe.—Pinnate: E. edulis

Geonoma.—Pinnate: Small-growing and nearly all very handsome while young, especially G. congesta, elegans, gracilis, macrostachys, Martiana, Porteana, pumila, and Schottiana

Hyophorbe.—Pinnate: H. amaricaulis, indica, and Verschaffeltii.

Jubæa.—Pinnate: the Chilian J. spectabilis is highly decorative, and may be grown in the open during summer.

Kentia.—Pinnate: K. Baueri, Belmoreana, Fosteriana, sapida, and Wendlandiana are ornamental greenhouse palms.

Latania. Fan-leaved: L. aurea, Commersoni, and rubra.

Licuala.—Fan-leaved: L. acutifida, elegans, and peltata.

Livistonia.—Fan-leaved, and of robust constitution: L. altissima, australis, Hoogendorpii, olivæformis, and sinensis (Latania borbonica).

Malortiea.—Pinnate, dwarf elegant palms, well adapted for table decoration: M. gracilis and simplex.

Martinezia.—Pinnate, with singular erose leaflets: M. erosa, granatensis, and Lindeniana.

Oncosperma.—Pinnate: O. Van Houtteanum, a splendid plant for exhibition purposes.

Oreodoxa.—Pinnate, and while young beautiful as table plants, standing long in a room without injury: O. oleracea and regia.

Phœnicophorium.—Entire-leaved, magnificent ornaments in the stove: P. sechellarum, known also as Stevensonia grandifolia.

Phœnix.—The Date Palm of commerce, P. dactylifera, although common, is extremely ornamental, and so hardy that it may be used in almost any situation during the summer months; other fine sorts are P. reclinata, rupicola, sylvestris, and tenuis.

Pritchardia.—Fan-leaved: P. aurea, grandis, macrocarpa, Martiana, and pacifica.

Ptychosperma.—Pinnate, and of robust constitution: P. Alexandræ, Cunninghamii (Seaforthia elegans), and rupicola.

Rhapis.—Fan-leaved, slender-stemmed, and of hardy constitution: R. flabelliformis and humilis.

Sabal.—Fan-leaved, noble plants reaching gigantic proportions: S. Blackburniana and umbraculifera.

Thrinax.—Fan-leaved, with slender petioles, and leaves much divided; peculiarly light and elegant for table or other decoration: T. arborea, barbadensis, elegans, graminifolia, multiflora, parviflora, and radiata.

Trithrinax.—Fan-leaved: T. mauritiæformis.

Verschaffeltia.—Entire-leaved, in the way of Phœnicophorium, and requiring strong moist heat: V. melanochætes and splendida (Regelia majestica) are remarkable for their long needle-like black spines.

Welfia.—Pinnate: W. regia.

113. FERNS.—These popular plants are usually increased by means of their spores, the "dust" produced on the back of their fronds. Ferns. The spores should be sown in well-drained pots or seed pans on the surface of a mixture of fibrous sifted peat and small broken crocks or sandstone; this soil should be firmly pressed and well-watered, and the spores scattered over it, and at once covered with propagating glasses or pieces of sheet glass, to prevent water or dry air getting to the surface. The pots should be placed in pans full of water, which they will absorb as required. A shady place is desirable, with temperature of 50° to 55° by night and 65° to 70° by day, or they may be set on a shelf in an ordinary propagating pit. The spores may be sown as soon as ripe, and when the young plants can be handled, or rather can be lifted with the end of a pointed flat stick, they should be pricked out into well-drained pots or pans filled with similar soil, and should be kept moist and shady. As they become large enough, pot them singly in 3-inch pots, and when the pots are fairly filled with roots shift on into larger ones.

The best time for a general repotting of ferns is in spring, just before growth commences. Those with creeping rhizomes can be propagated by dividing these into well-rooted portions, and, if a number of crowns is formed, they can be divided at that season. In most cases this can be performed with little risk, but the gleichenias, for example, must only be cut into large portions, as small divisions of the rhizomes are almost certain to die; in such cases, however, the points of the rhizomes can be led over and layered into small pots, several in succession, and allowed to remain unsevered from the parent plant until they become well-rooted. In potting the well-established plants, and all those of considerable size, the soil should be used in a rough turfy state, not sifted but broken, and one-sixth of broken crocks or charcoal and as much sand as will insure free percolation should be mixed with it.

The stove ferns require a day temperature of 65° to 75°, but do not thrive in an excessively high or close dry atmosphere. They require only such shade as will shut out the direct rays of the sun, and, though abundant moisture must be supplied, the atmosphere should not be loaded with it. The water used should always be at or near the temperature of the house in which the plants are growing. Some ferns, as the different kinds of Gymnogramma and Cheilanthes, prefer a drier atmosphere than others, and the former do not well bear a lower winter temperature than about 60° by night. Most other stove ferns, if dormant, will bear a temperature as low as 55° by night and 60° by day from November to February. About the end of the latter month the whole collection should be turned out of the pots, and redrained or repotted into larger pots as required. This should take place before growth has commenced. Towards the end of March the night temperature may be raised to 60°, and the day temperature to 70° or 75°, the plants being shaded in bright weather. Such ferns as Gymnogrammas, which have their surface covered with golden or silver powder, and certain species of scaly-surfaced Cheilanthes and Nothochlæna, as they cannot bear to have their fronds wetted, should never be syringed; but most other ferns may have a moderate sprinkling occasionally (not necessarily daily), and as the season advances, sufficient air and light must be admitted to solidify the tissues.

Space will only permit that we should append a list of choice ferns, which, however, might be much extended. We shall arrange them under the heads of stove, greenhouse, and hardy.

Select Stove Ferns.

Acrophorus affinis, chærophyllus, and immersus (Leucostegia).

Acrostichum aureum.

Adiantum æmulum, cardiochlæna, caudatum, concinnum, cristatum, cuneatum, curvatum, farleyense, gracillimum, Henslovianum, lunulatum, macrophyllum, mundulum, peruvianum, polyphyllum, princeps, pulverulentum, Seemanni, subcordatum, tenerum, trapeziforme, Veitchianum, villosum, and Williamsii.

Alsophila armata, aspera, glauca, philippensis, pruinata, pycnocarpa, radens, and Tænitis.

Aglaomorpha Meyenianum.

Anemia adiantifolia, cheilanthoides, collina, and mandioccana.

Anemidictyon Phyllitidis, and its several forms—fraxinifolium, laciniatum, longifolium, and tessellatum.

Aspidium trifoliatum.

Asplenium alatum, caudatum, cicutarium, erectum, Fabianum, ferulaceum, formosum, heterocarpum, horridum, laserpitiifolium, longissimum, myriophyllum, neo-caledonicum, planicaule, rachirhizon, rhizophorum, schizodon, serra, Veitchianum (Belangeri), and viviparum.

Blechnum brasiliense, gracile, Lanceola, longifolium, occidentale, and orientale.

Campyloneurum lucidum, repens, nitidum, and decurrens.

Ceratopteris thalictroides, an aquatic sub-annual species with proliferous sterile fronds.

Cheilanthes Borsigiana, cuneata, elegans, farinosa, frigida, pulveracea, radiata, spectabilis, and viscosa.

Cibotium Barometz, Chamissoi, glaucum, Menziesii, pruinosum, regale, and Schiedei.
Cionidium Moorei.
Cyathea arborea, canaliculata, excelsa, insignis (Cibotium princeps), and serra.
Davallia aculeata, bullata, dissecta, divaricata (polyantha), elata, elegans, fijiensis, Mooreana, ornata, pentaphylla, solida, and tenuifolia.
Dennstædtia cicutaria.
Deparia prolifera.
Dicksonia chrysotricha.
Dictyoxiphium panamense.
Didymochlæna lunulata.
Diplazium alternifolium, celtidifolium, grandifolium, Shepherdii, striatum, sylvaticum, and zeylanicum.
Doryopteris collina, nobilis, palmata, and sagittæfolia.
Drynaria coronans, diversifolia, morbillosa, and quercifolia.
Elaphoglossum cuspidatum, L'Herminieri, scolopendrifolium, squamosum, and numerous other species.
Gleichenia dichotoma, furcata, pectinata, and pubescens.
Goniophlebium appendiculatum, colpodes, lachnopus, Lepidopteris, loriceum, squamatum, subauriculatum, and verrucosum.
Goniopteris asplenioides, crenata, Ghiesbreghtii, refracta, and reptans.
Gymnogramma chrysophylla and its variety Parsonsii; flexuosa, L'Herminieri, Pearcei, peruviana and its variety argyrophylla; pulchella, sulphurea, tartarea, trifoliata, and Wettenhalliana.
Hemitelia grandifolia, horrida, Karsteniana, and speciosa.
Humata alpina, heterophylla, and pedata.
Hymenodium crinitum.
Hymenophyllum, any of the species.
Hymenostachys elegans.
Hypolepis repens.
Lastrea augescens, deltoidea, patens, recedens, and strigosa (crinita).
Lindsæa cultrata, guianensis, and trapeziformis.
Litobrochia aurita, denticulata, macroptera, podophylla, and tripartita.
Lomaria attenuata, fraxinifolia, L'Herminieri, and onocleoides.
Lygodictyon Forsteri.
Lygodium flexuosum, venustum, and volubile.
Microlepia hirta cristata.
Nephrodium articulatum, cyatheoides, Hookerii, pteroides, truncatum, unitum, and venustum.
Nephrolepis davallioides and its variety furcans; Duffii, ensifolia, exaltata, pectinata, pluma, tuberosa, and undulata.
Niphobolus costatus, Gardneri, and pertusus.
Nothochlæna flavens, nivea, rufa, sinuata, and trichomanoides.
Oleandra articulata, neriiformis, and nodosa.
Olfersia cervina.
Onychium auratum.
Osmunda palustris (evergreen).
Phlebodium areolatum, aureum, pulvinatum, and sporadocarpum.
Platycerium alcicorne and its variety majus; biforme, grande, Hillii, Stemmaria, Wallichii, and Willinckii.
Pleocnemia Leuzeana.
Pleopeltis albo-squamata, incurvata, leiorhiza, longissima, and Phymatodes.
Polybotrya caudata and osmundacea.
Polypodium Dianæ, Paradiseæ, pectinatum, and Schkuhrii.
Polystichum coniifolium, denticulatum, lentum, ordinatum, triangulum, and viviparum.
Pteris argyrea, aspericaulis, longifolia, quadriaurita, semipinnata, tricolor, serrulata and its many varieties.
Sadleria cyatheoides.
Sagenia cicutaria, macrophylla, Pica, and repanda.
Schizæa dichotoma and elegans.
Stenosemia aurita.
Thamnopteris australasica and Nidus.
Thyrsopteris elegans.
Trichomanes, any of the species.

Select Greenhouse Ferns.

Acrophorus hispidus (Davallia Novæ-Zelandiæ).
Adiantum affine, assimile, cuneatum, decorum, excisum and its variety multifidum; formosum, glaucophyllum, hispidulum, reniforme, and sulphureum.
Alsophila australis, capensis, excelsa, and Leichardtiana.
Asplenium appendiculatum, bulbiferum, Colensoi, compressum, dimorphum, Dregeanum, flabellifolium, flaccidum, Hemionitis (palmatum), lucidum, monanthemum, obtusatum, polyodon, and præmorsum.
Balantium Culcita.
Blechnum australe and serrulatum.
Ceterach aureum.
Cheilanthes alabamensis, argentea, capensis, fragrans, hirta Ellisiana, micromera, microphylla, pteroides, and tenuifolia.
Cyathea Burkei, Cunninghamii, dealbata, Dregei, medullaris, and Smithii.
Cyrtomium caryotideum, falcatum, and Fortunei.
Davallia canariensis and pyxidata.
Dennstædtia davallioides Youngii.
Dicksonia antarctica, Berteroana, Sellowiana, squarrosa, and Youngii.
Doodia aspera and its varieties multifida and corymbifera; blechnoides, caudata and its variety confluens; and media.
Gleichenia circinata and its variety glauca; Cunninghamii, dicarpa, flabellata, hecistophylla, rupestris, semivestita, and Speluncæ.
Humata Tyermanni.
Hymenophyllum æruginosum, crispatum, cruentum, demissum, dilatatum, flabellatum, flexuosum, fuciforme, polyanthos, pulcherrimum, and scabrum.
Hypolepis Bergiana, distans, Millefolium, and tenuifolia.
Lastrea aristata variegata, decomposita, decurrens, elongata, erythrosora, glabella, hispida, laserpitiifolia, Sieboldii, and varia.
Litobrochia comans, macilenta, and vespertilionis.
Llavea cordifolia.
Lomaria australis, blechnoides, capensis, ciliata, discolor and its variety bipinnatifida; dura, fluviatilis, Fraseri, gibba and its variety Bellii; Gilliesii, lanceolata, magellanica, nuda, obtusata, Patersoni, and procera.
Loxsoma Cunninghamii.
Microlepia cristata, platyphylla, scabra, and strigosa.
Niphobolus heteractis, Lingua, and rupestris.
Nothochlæna canariensis, Eckloniana, lævis, lanuginosa, and Marantæ.
Platyloma atropurpureum, bellum, Brownii, Calomelanos, cordatum, falcatum, flexuosum, and rotundifolium.
Pleopeltis Billardieri and pustulata.
Polystichum capense, falcinellum, frondosum, lepidocaulon, proliferum, tripteron, venustum, and vestitum.
Pteris arguta, crenata, cretica albo-lineata, hastata, Kingiana, longifolia, semipinnata, serrulata and its many garden sports (angustata, Applebyana, corymbifera, cristata, cristata variegata, Goeziana, polydactyla, semifastigiata, Leyi, and fimbriata), tremula, and umbrosa.
Todea barbara (africana), Fraseri, hymenophylloides (pellucida), and superba.
Trichomanes elongatum, reniforme, and venosum.
Woodsia mollis.
Woodwardia orientalis, and radicans with its variety cristata.

Select Hardy Ferns.

Adiantum Capillus Veneris and the varieties incisum, magnificum, and cornubiense; and pedatum.
Allosorus crispus.
Asplenium Adiantum nigrum and the variety grandiceps; alternans, angustifolium, ebeneum, fontanum; lanceolatum and the variety microdon; marinum and the varieties ramosum, trapeziforme, subbipinnatum, and crenatum; Trichomanes and the varieties incisum, Moulei, ramosum, multifidum, and cristatum.
Athyrium Filix fœmina and the varieties corymbiferum, crispum, Frizelliæ, Applebyanum, grandiceps, plumosum, Victoriæ, apiculatum, acrocladon, apuæforme, coronatum, Elworthii, gracillimum, Grantiæ, marinum, multiceps, multifidum, polyclados, polydactylon, thyssanotum, &c.; and Goringianum pictum.
Blechnum Spicant and the varieties imbricatum, multifurcatum, ramosum.
Camptosorus rhizophyllus.
Ceterach officinarum.
Cyrtomium falcatum.
Cystopteris bulbifera, fragilis and the varieties angustata and Dickieana; montana, and sudetica.
Dennstædtia punctilobula (Dicksonia pilosiuscula).
Dictyogramma japonica.
Diplazium lanceum and thelypteroides.
Gleichenia alpina.
Hymenophyllum tunbridgense and unilaterale.
Lastrea æmula (fœniseeii), atrata, cristata; dilatata and its varieties Chanteriæ, dumetorum, lepidota; erythrosora; Filix mas and the varieties Bollandiæ, cristata, cristata angustata, grandiceps, paleacea, Pinderi; Goldieana, marginalis; montana and the varieties crispa, cristata, Nowelliana; noveboracensis, remota, rigida, spinulosa and Thelypteris.
Lomaria alpina and chilensis.
Lygodium palmatum.
Nothochlæna Marantæ and vestita.
Onoclea sensibilis.
Onychium lucidum (japonicum).
Osmunda cinnamomea, spectabilis, gracilis, Claytoniana (interrupta), regalis and its variety cristata.
Polypodium alpestre and its variety flexile; Dryopteris, Krameri, Phegopteris, Robertianum (calcareum), vulgare and its varieties cambricum, cristatum, omnilacerum, pulcherrimum, semilacerum, and cornubiense.
Polystichum acrostichoides; aculeatum and its varieties lobatum, multifidum, acrocladon, &c.; angulare and its varieties cristatum, grandiceps, Holeanæ, parvissimum, Pateyi, polydactylum, proliferum, proliferum Wollastoni, rotundatum, grandidens, imbricatum, plumosum, Kitsoniæ, pterophorum, tripinnatum, &c.; falcinellum, Lonchitis, and setosum.
Pteris aquilina, cretica albo-lineata, and scaberula.
Scolopendrium vulgare and its varieties acrocladon, Claphamii, columnare, Coolingii, crispum, crispum fertile, crispum minus, crispum latum, cristatum, laceratum, marginatum, multifidum, Stansfieldii, and many others.
Struthiopteris germanica, japonica, and pennsylvanica.
Trichomanes radicans.
Woodsia alpina, ilvensis, obtusa, and polystichoides Veitchii.
Woodwardia areolata, japonica, and virginica.

See FERNS, vol. ix. pp. 100-107.

VI. *Fruits.*

114. *Fruit Tree Borders.*—No pains should be spared, in the preparation of fruit tree borders, to secure their thorough drainage. The soil is sometimes placed upon a pavement flooring supported by stone or brick piers, with a cavity below of 18 inches or 2 feet deep, into which air is admitted by small vertical eyes, placed along the edges of the walk, and covered with open iron gratings. This arrangement is expensive, and the same advantages can generally be secured by placing over the sloping bottom a good layer of coarse rubbly material, communicating with a drain in front to carry off the water, while earthenware drain tubes may be laid beneath the rubble from 8 to 10 feet apart, so as to form air drains, and provided with openings both at the side of the walk and also near the base of the wall. Over this rubbly matter, rough turfy soil, grass-side downwards, should be laid, and on this the good prepared soil in which the trees are to be planted. Such an elaborate system of drainage is necessary only in the case of adhesive clayey subsoils.

The borders should consist of three parts rich turfy calcareous loam, the top spit of a pasture, and one part light gritty earth, such as road-grit, with a small portion (one-sixth) of fine lime and brick rubbish. They should not be less than 12 feet in breadth, and may vary up to 15 or 18 feet, with a fall from the wall of about 1 inch in 3 feet. The border itself should be raised a foot or more above the general level. The bottom of the border as well as that of the drain must be kept lower than the general level of the subsoil, else the soakage will gather in all the little depressions of its surface. Fruit-tree borders should not be at all cropped with culinary vegetables, or very slightly so, as the process of digging destroys the roots of the trees, and drives them from near the surface, where they ought to be.

Shallow planting, whether of wall trees or standards, is generally to be preferred, a covering of a few inches of soil being sufficient for the roots, but a surface of at least equal size to the surface of the hole should be covered with dung or litter so as to restrain evaporation and preserve moisture. In the case of wall trees, a space of 5 or 6 inches is usually left between the stem at the insertion of the roots and the wall, to allow for increase of girth. Young standard trees should be tied to stakes so as to prevent their roots being ruptured by the wind-waving of the stems.

In the selection and distribution of fruit trees regard must of course be had to local situation and climate. The best walls having a south or south-east aspect are devoted to the peach, apricot, and fig. Cherries and the generality of plums succeed very well either on an east or a west aspect. In Scotland the mulberry requires the protection of a wall, and several of the finer apples and pears do not arrive at perfection without this help, and a tolerably good aspect. The wall-trees intended to be permanent are called dwarfs, from their branches springing from near the ground. Between these, trees with tall stems, called riders, are planted as temporary occupants of the upper part of the wall. The riders should have been trained in the nursery into good-sized trees, in order that when planted out they may come into bearing as speedily as possible.

Standard Fruit Trees should not be planted, if it can be avoided, in the borders of the kitchen garden, but in the outer slips, where they either may be allowed to attain their full size, or may be kept dwarfed. Each sort of fruit should be planted by itself, for the sake of orderly arrangement, and in order to facilitate protection when necessary by a covering of nets. Their produce is often superior in flavour to that of the same kind of fruit grown on walls.

.lmond. 115. The *Almond*, Amygdalus communis, is very ornamental in respect to its flowers in the early spring months, but of little value for its fruit. There are two varieties, one producing large flowers and sweet-kernelled fruits, and the other small flowers and bitter kernels. Every good garden should contain a tree or two, especially of the sweet almond, for their ornamental aspect in spring. The almond requires a warm light soil, well drained, and a sheltered position and warm aspect. It is propagated by budding on the seedling almond, or for heavier soils on the plum stock. See ALMOND, vol. i. p. 594.

.pple. 116. The *Apple*, Pyrus Malus, is amongst the most useful of all our hardy fruits, and succeeds in localities too cold for either the pear or the plum, while from its flowering later in the spring it is less liable to be cut off by frosts.

It may be propagated by seeds to obtain stocks for grafting, and also for the production of new varieties. The established sorts are usually increased by grafting, the method called whip-grafting being preferred. The stocks should be at least as thick as the finger; and should be headed back to where the graft is to be fixed in January, unless the weather is frosty, but in any case before vegetation becomes active. The scions should be cut about the same time, and laid in firmly in a trench, in contact with the moist soil, until required.

The apple-tree will thrive in any good well-drained soil, the best being a good mellow calcareous loam, while the less iron there is in the subsoil the better. The addition of marl to soils that are not naturally calcareous very much improves them. The trees are liable to canker in undrained soils or those of a hot sandy nature. Where the soil is not naturally rich enough, it should be well manured, but not to the extent of encouraging over-luxuriance. It is better to apply manure in the form of a compost than to use it in a fresh state or unmixed.

To form an orchard, standard trees should be planted at from 25 to 40 feet between the rows, according to the fertility of the soil and other considerations. The trees should be selected with clean, straight, self-supporting stems, and the head should be shapely and symmetrical, with the main branches well balanced. In order to obtain such a stem, all the leaves on the first shoot from the graft or bud should be encouraged to grow, and in the second season the terminal bud should be allowed to develop a further leading shoot, while the lateral shoots should be allowed to grow, but so that they do not compete with the leader, on which the growth of leaves should be encouraged in order that they may give additional strength to the stem below them. The side shoots should be removed gradually, so that the diminution of foliage in this direction may not exceed the increase made by the new branches and shoots of the upper portion. Dwarf pyramids, which occupy less space than open dwarfs, if not allowed to grow tall, may be planted at from 10 to 12 feet apart. Dwarf bush trees may be planted from 10 to 15 feet apart, according to the variety and the soil. Dwarf bushes on the Paradise stock are both ornamental and useful in small gardens, the trees being always conveniently under control. These bush trees, which must be on the proper stock—the French Paradise—may be planted at first 6 feet apart, with the same distance between the rows, the space being afterwards increased, if desired, to 12 feet apart, by removing every alternate row.

"Cordons" are trees trained to a single shoot, the laterals of which are kept spurred. They are usually trained horizontally, at about $1\frac{1}{2}$ feet from the ground, and may consist of one stem or of two, the stems in the latter case being trained in opposite directions. In cold districts the finer sorts of apples may be grown against walls as upright or oblique cordons. From these cordon trees very fine fruit may often be obtained. The apple may also be grown as an espalier tree, a form which does not require much lateral space. The ordinary trained trees for espaliers and walls should be planted 20 feet apart.

The fruit of the apple is produced on spurs which form on the branchlets of two years old and upwards, and continue fertile for a series of years. The principal pruning should be performed in summer, the young shoots if crowded being thinned out, and the superabundant laterals shortened by breaking them half through. The general winter pruning of the trees may take place any time from the beginning of November to the beginning of March, in open weather. The trees are rather subject to the attacks of the American blight (*Eriosoma mali*), which may be removed by scrubbing with a hard brush, by painting the affected spots with any bland oil, or by washing them with dilute paraffin and soft soap.

The following are a few of the most approved varieties of the apple tree, arranged in the order of their ripening, with the months in which they are in use:—

Dessert Apples.

White Juncating	July.	Ribston Pippin	Nov.-Mar.
Early Red Margaret	Aug.	Golden Pippin	Nov. Apr.
Irish Peach	Aug.	Golden Reinette	Nov.-Apr.
Devonshire Quarrenden	Aug., Sept.	Northern Spy	Nov.-Apr.
Duchess of Oldenburg	Aug., Sept.	Rosemary Russet	Nov.-Apr.
Oslin	Aug., Sept.	Ashmead's Kernel	Nov.-May.
Red Astrachan	Sept.	Aromatic Russet	Dec.-Feb.
Kerry Pippin	Sept., Oct.	White Winter Calville (grown under glass)	Dec.-Mar.
Peasgood's Nonesuch	Sept., Oct.		
King of the Pippins	Oct.-Jan.	Braddick's Nonpareil	Dec.-Apr.
Cox's Orange Pippin	Oct.-Feb.	Court-pendû Plat	Dec.-Apr.
Court of Wick	Oct.-Mar.	Wyken Pippin	Dec.-Apr.
Blenheim Pippin	Nov.-Feb.	Cornish Gilliflower	Dec.-May.
Sam Young	Nov.-Feb.	Golden Harvey	Dec.-May.
Sykehouse Russet	Nov.-Feb.	Scarlet Nonpareil	Jan.-Mar.
Fearn's Pippin	Nov.-Mar.	Cockle's Pippin	Jan.-May.
Herefordshire Pearmain	Nov.-Mar.	Lamb Abbey Pearmain	Jan.-May.
Mannington's Pearmain	Nov.-Mar.	Old Nonpareil	Jan.-May.
Margil	Nov.-Mar.	Sturmer Pippin	Feb.-June.

Kitchen Apples.

Keswick Codlin	Aug., Sept.	Gloria Mundi	Nov.-Jan.
Lord Suffield	Aug., Sept.	Blenheim Pippin	Nov.-Feb.
Manks Codlin	Aug.-Oct.	Tower of Glammis	Nov.-Feb.
Ecklinville Seedling	Aug.-Nov.	Warner's King	Nov.-Mar.
Stirling Castle	Aug.-Nov.	Alfriston	Nov.-Apr.
Stone's	Aug.-Nov.	London Pippin	Nov.-Apr.
Emperor Alexander	Sept.-Dec.	Northern Greening	Nov.-Apr.
Waltham Abbey Seedling	Sept.-Jan.	Reinette de Canada	Nov.-Apr.
Cellini	Oct., Nov.	Bess Pool	Nov.-May.
Gravenstein	Oct.-Dec.	Royal Russet	Nov.-June.
Hawthornden	Oct.-Dec.	Gooseberry	Nov.-July.
Baumann's Red Winter Reinette	Oct.-Jan.	Winter Greening	Nov.-July.
		Rhode Island Greening	Dec.-Apr.
Mère de Ménage	Oct.-Jan.	Rymer	Dec.-Apr.
Beauty of Kent	Oct.-Feb.	Lane's Prince Albert	Jan.-June.
Yorkshire Greening	Oct.-Feb.	Norfolk Beaufin	Jan.-June.

See APPLE, vol. ii. p. 211.

117. The *Apricot*, Prunus Armeniaca or Armeniaca vulgaris, is Aprico propagated by budding on the mussel or common plum stock. The tree succeeds in good well-drained loamy soil, rather light than heavy. It is usually grown as a wall tree, the east and west aspects being preferred to the south, which induces mealiness in the fruit, though in Scotland the best aspects are necessary. The most usual and best mode of training is the fan method in the modified form represented in par. 26, under fig. 83. The fruit is produced on shoots of the preceding year, and on small close spurs formed on the two-year-old wood. The trees should be planted about 20 feet apart. The summer pruning should commence early in June, at which period all the irregular fore-right and useless shoots are to be pinched off; and, shortly afterwards, those which remain are to be fastened to the wall. At the winter pruning all branches not duly furnished with spurs and fruit buds are to be

removed. The young bearing shoots are moderately pruned at the points, care being, however, taken to leave a terminal shoot or leader to each branch. The most common error in the pruning of apricots is laying in the bearing shoots too thickly; the branches naturally diverge in fan training, and when they extend so as to be about 15 inches apart, a fresh branch should be laid in, to be again subdivided as required. The blossoms of the apricot open early in spring, but are more hardy than those of the peach; the same means of protection when necessary may be employed for both. If the fruit sets too numerously, it is thinned out in June and in the beginning of July, the later thinnings being used for tarts. In the south of England, where the soil is suitable, the hardier sorts of apricot, as the Breda and Brussels bear well as standard trees in favourable seasons. In such cases the trees may be planted from 20 to 25 feet apart.

Forcing.—The ripening of the fruit of the apricot may be accelerated by culture under glass, the trees being either planted out like peaches, or grown in pots on the orchard-house system. They must be very gently excited, since they naturally bloom when the spring temperature is comparatively low. At first a maximum of 40° only must be permitted; after two or three weeks it may be raised to 45°, and later on to 50° and 55°, and thus continued till the trees are in flower, air being freely admitted, and the minimum or night temperature ranging from 40° to 45°. After the fruit is set the temperature should be gradually raised, being kept higher in clear weather than in dull. When the fruit has stoned, the temperature may be raised to 60° or 65° by day and 60° by night; and for ripening off it may be allowed to reach 70° or 80° by sun heat.

The Moorpark is undoubtedly the best apricot in cultivation, and should be planted for all general purposes; the Peach is a very similar variety, not quite identical; and the Hemskerk is also similar, but hardier. The Large Early, which ripens in the end of July and beginning of August, and the Kaisha, a sweet-kernelled variety, which ripens in the middle of August, are also to be recommended. For standard trees in favourable localities the Breda and Brussels may be added. See APRICOT, vol. ii. p. 214.

Cherry. 118. The *Cherry*, Cerasus avium and C. vulgaris, is increased by budding on the wild gean, obtained by sowing the stones of the small black or red wild cherries. To secure very dwarf trees, the Cerasus Mahaleb has been used for the May Duke, Kentish, Morello, and analogous sorts, but it is not adapted for strong-growing varieties like the Bigarreaus. The stocks are budded, or, more rarely, grafted, at the usual seasons. The cherry prefers a free, loamy soil, with a well-drained subsoil. Stiff soils and dry gravelly subsoils are both unsuitable, though the trees require a large amount of moisture, particularly the large-leaved sorts, such as the Bigarreaus. For standard trees, the Bigarreau section should be planted 30 feet apart, or more in rich soil, and the May Duke, Morello, and similar varieties 20 or 25 feet apart; while, as trained trees against walls and espaliers, from 20 to 24 feet should be allowed for the former, and from 15 to 20 feet for the latter.

In forming the stems of a standard tree, the temporary side-shoots should not be allowed to attain too great a length, and should not be more than two years old when they are cut close to the stem. The first three shoots retained to form the head should be shortened to about 15 inches, and two shoots from each encouraged, one at the end, and the other 3 or 4 inches lower down. When these have become established, very little pruning will be required, and that chiefly to keep the principal branches as nearly equal in strength as possible for the first few years.

Espalier trees should have the branches about a foot apart, starting from the stem with an upward curve, and then being trained horizontally. In summer pruning the shoots on the upper branches must be shortened at least a week before those on the lower ones. After a year or two clusters of fruit buds will be developed on spurs along the branches, and those spurs will continue productive for an indefinite period.

For wall trees any form of training may be adopted; but as the fruit is always finest on young spurs, fan-training is probably the most advantageous. A succession of young shoots should be laid in every year. The Morello, which is of twiggy growth, and bears on the young wood, must be trained in the fan form, and care should be taken to avoid the very common error of crowding its branches.

Forcing.—The cherry will not endure a high temperature nor a close atmosphere. A heat of 45° at night will be sufficient at starting, this being gradually increased during the first few weeks to 55°, but lowered again when the blossom buds are about to open. After stoning the temperature may be again gradually raised to 60°, and may go up to 70° by day, or 75° by sun heat, and 60° at night. The best forcing cherries are the May Duke and the Royal Duke, the Duke cherries being of more compact growth than the Bigarreau tribe, and generally setting better; nevertheless a few of the larger kinds, such as Bigarreau Napoléon, Black Tartarian, and St Margaret's, should be forced for variety. The trees may be either planted out in tolerably rich soil, or grown in large pots of good turfy friable calcareous loam mixed with rotten dung. If the plants are small, they may be put into 12-inch pots in the first instance, and after a year shifted into 15-inch pots early in autumn, and plunged in some loose or even very slightly fermenting material. The soil of the pots should be protected from snow-showers and cold rains. Occasionally trees have been taken up in autumn with balls, potted, and forced in the following spring; but those which have been established a year in the pots are to be preferred. Such only as are well furnished with blossom-buds should be selected. The trees should be removed to the forcing house in the beginning of December, if fruit be required very early in the season. During the first and second weeks it may be kept nearly close; but, as vegetation advances, air becomes absolutely necessary during the day, and even at night when the weather will permit. If forcing is commenced about the middle or third week of December, the fruit ought to be ripe by about the end of March. After the fruit is gathered, the trees should be duly supplied with water at the root, and the foliage kept well syringed till the wood is mature.

The following are some of the best varieties now in cultivation. B. signifies that they belong to the Bigarreau, D. to the May Duke, and M. to the Morello section; K. indicates that they are specially adapted for culinary purposes; and b., m., and e. show that they are in use at beginning, middle, and end respectively of the month stated:—

Belle d'Orleans, B.	b. m. June.	Archduke, D.	m. July.
Early Purple Gean, B.	m. June.	Royal Duke, D.	m. July.
Early Red Bigarreau, B.	m.e. June.	Joc-o-sot, B.	m. July.
Early Jaboulay, B.	e. June.	Büttner's Yellow, B.	m. July.
Early Lyons, B.	e. June.	Büttner's Black Heart, B.	m. July.
Early Rivers, B.	e. June.	Bigarreau, B.	m. July.
Black Tartarian, B.,	e. June. b. July.	Mammoth, B.	m. e. July.
Bigarreau Noir de Schmidt, B.,	July.	Reine Hortense, D.	m. e. July.
Frogmore Early, B.	b. July.	Kentish, M., K.	m. e. July.
Elton, B.	b. July.	Morello, M., K.	July–Oct.
Black Eagle, B.	b. July.	Bigarreau Napoléon, B.	e. July.
Governor Wood, B.	b. July.	Duchesse de Pallnau, D.	e. July.
May Duke, D. (on walls)	e. June. b. July.	St Margaret's, B.	e. July, b. Aug.
		Florence B.	m. e. Aug.
		Büttner's October, D. K.	October.

See CHERRY, vol. v. p. 586.

Cranberry. 119. *The Cranberry.*—The American cranberry, Oxycoccus macrocarpus, grows freely in beds of peat soil or bog earth formed for their reception in any damp situation. Beds are often prepared around the edges of a pond by depositing a layer of rubble or stones at the bottom, and over these a good thickness of peat or bog earth mixed with sand, extending about 6 inches below and about 4 inches above the usual level of the water surface. On this bed the cranberry plants should be put in at 2 feet apart, in autumn or spring; spreading in all directions, they will soon cover the whole surface with a dense mat of trailing shoots.

The common cranberry, Oxycoccus palustris, a native of Britain, bears fruit which is inferior to that of the American cranberry in size and quality. The plants may be treated in the same manner, and in some places are very successfully cultivated. See CRANBERRY, vol. vi. p. 545.

Currants. 120. The *Currants* are among the most useful of small fruits. The red and the white currant are included as varieties under Ribes rubrum, the white being a pale-fruited variety of the red. The black currant is the produce of Ribes nigrum. Of both types there are several greatly improved varieties.

Red and white currants are readily propagated by cuttings. They succeed in any well-enriched garden soil, but thrive best in warm moist situations, where they enjoy an abundance of air; occasionally they are trained perpendicularly against low walls or fences. As bushes they are best planted in compartments by themselves, at about 5 or 6 feet apart each way, and should be on clean single stems some 8 or 10 inches long. They are sometimes trained as standards on single stems, 3 or 4 feet high, in which form the fruit is more accessible. The winter pruning consists in shortening the young bearing wood on the sides of the branches so as to form spurs of an inch or two in length. The leading shoots are left about 6 inches long. Some cultivators reduce the young shoots to about half their length as soon as the fruit begins to colour, which is found to increase the size and improve the flavour of the berries.

The black currant thrives best in a moist deep soil and shady situation. Its culture is much the same as that of the other currants, but the young shoots are not spurred, all the pruning necessary being to keep the branches thinned out so as to stand clear of each other, and to promote the formation of young wood. If the fruit is intended for preserving, it should not be gathered while wet, nor, if it can be avoided, immediately after a wet period.

Aphides often cluster in vast numbers at the extremities of the summer shoots, especially of red and white currants, and should be destroyed by cutting off and burning the parts infested, or by applying some of the many insecticides.

The following are the best sorts of currants for general purposes:—

Red.—Red Dutch, Knight's Large Red, Houghton Seedling or Orangefield (late), Gondouin or Raby Castle (late), Lace-leaved or Large Sweet Red, Champagne (flesh-coloured).
White.—White Dutch, Wilmot's Large White.
Black.—Black Naples, Black Grape or Ogden's, Lee's Prolific.
See CURRANTS, vol. vi. p. 715.

g. 121. The *Fig*, Ficus Carica, lives to a great age, and along the southern coast of England bears fruit abundantly as a standard; but in Scotland and in many parts of England a south wall is indispensable for its successful cultivation out of doors.

Fig trees are propagated by cuttings, which should be put into pots, and placed in a gentle hotbed. They may be obtained more speedily from layers, which should consist of two or three years old shoots, and these, when rooted, will form plants ready to bear fruit the first or second year after planting. The best soil for a fig border is a friable loam, not too rich, but well drained; a chalky subsoil is congenial to the tree, and, to correct the tendency to over-luxuriance of growth, the roots should be confined within spaces surrounded by a wall enclosing an area of about a square yard. The sandy soil of Argenteuil, near Paris, suits the fig remarkably well; but the best trees are those which grow in old quarries, where their roots are free from stagnant water, and where they are sheltered from cold, while exposed to a very hot sun, which ripens the fruit perfectly. The fig succeeds well planted in a paved court against a building with a south aspect.

The fig tree naturally produces two sets of shoots and two crops of fruit in the season. The first shoots generally show young figs in July and August, but these in the climate of England very seldom ripen, and should therefore be rubbed off. The late or midsummer shoots likewise put forth fruit-buds, which, however, do not develop themselves till the following spring; and these form the only crop of figs on which the British gardener can depend.

The fig tree grown as a standard should get very little pruning, the effect of cutting being to stimulate the buds to push shoots too vigorous for bearing. When grown against a wall, it has been recommended that a single stem should be trained to the height of a foot. Above this a shoot should be trained to the right, and another to the left; from these principals two other subdivisions should be encouraged, and trained 15 inches apart; and along these branches, at distances of about 8 inches, shoots for bearing, as nearly as possible of equal vigour, should be encouraged. The bearing shoots produced along the leading branches should be trained in at full length, and in autumn every alternate one should be cut back to one eye. In the following summer the trained shoots should bear and ripen fruit, and then be cut back in autumn to one eye, while shoots from the bases of those cut back the previous autumn should be trained for succession. In this way every leading branch will be furnished alternately with bearing and successional shoots.

When protection is necessary, as it may be in severe winters, though it is too often provided in excess, spruce branches have been found to answer the purpose exceedingly well, owing to the fact that their leaves drop off gradually when the weather becomes milder in spring, and when the trees require less protection and more light and air. The principal part requiring protection is the main stem, which is more tender than the young wood.

Forcing.—The fig requires more heat than the vine to bring it into leaf. It may be subjected to a temperature of 50° at night, and from 60° to 65° in the day, and this should afterwards be increased to 60° and 65° by night, and 70° to 75° by day, or even higher by sun heat, giving plenty of air at the same time. In this temperature the evaporation from the leaves is very great, and this must be replaced and the wants of the swelling fruit supplied by daily watering, by syringing the foliage, and by moistening the floor, this atmospheric moisture being also necessary to keep down the red spider. When the crop begins to ripen, a moderately dry atmosphere should be maintained, with abundant ventilation when the weather permits.

The fig tree is easily cultivated in pots, and by introducing the plants into heat in succession the fruiting season may be considerably extended. The plants should be potted in turfy loam mixed with charcoal and old mortar rubbish, and in summer top-dressings of rotten manure, with manure water two or three times a week, will be beneficial. While the fruit is swelling, the pots should be plunged in a bed of fermenting leaves.

The following are a few of the best figs; those marked F. are good forcing sorts, and those marked W. suitable for walls:—

Agen: brownish-green, turbinate.
Angélique (Madeleine), F., W.: yellow, turbinate.
Brown Ischia, F.: chestnut-coloured, roundish-turbinate.
Brown Turkey (Lee's Perpetual), F., W.: purplish-brown, turbinate
Brunswick, W.: brownish-green, pyriform.
Col di Signora Blanca, F.: greenish-yellow, pyriform.
Col di Signora Nero: dark chocolate, pyriform.
Datte: pale dingy brown, pyriform.
Early Violet, F.: brownish-purple, roundish.
Grizzly Bourjassotte: chocolate, round.
Grosse Monstreuse de Lipari: pale chestnut, turbinate.
Lucrezia: dull white, roundish.
Negro Largo, F.: black, long pyriform.
Royal Vineyard: purple, long pyriform.
White Ischia, F.: greenish-yellow, roundish-obovate.
White Marseilles, F., W.: pale green, roundish-obovate.

See FIG, vol. ix. p. 153.

se- 122. The *Gooseberry* has a double parentage, Ribes Grossularia
y. being the parent of the rough or hairy-fruited sorts, and R. Uva-crispa that of the smooth-fruited ones. It prefers a loose rich soil, which readily imbibes, but does not retain, much moisture. The plant is propagated by cuttings, and should be transplanted early in autumn, the trees, like those of the currant, being ranged in lines or grouped in compartments. The trees should be formed with single stems a foot high; and the suckers, if any spring up from the roots, should be carefully removed. Formerly it was the practice in Scotland to spur all the annual wood; but now the black currant system of pruning is more generally and advantageously followed. The ground on which the bushes stand should be forked over once a year, but only slightly, so as not to disturb the roots, and manure should be applied either as a top-dressing or in a liquid form. The caterpillars which attack the plant may be destroyed by dusting the leaves with powdered white hellebore, which seems to be the only certain remedy, as even hand-picking fails in some seasons when the caterpillars are very abundant, and the trees are numerous.

The gooseberry, like the currant, may be trained on walls or espaliers, to accelerate the ripening or increase the size of the fruit. The following is a good limited selection of sorts:—

Hairy Reds.—Red Champagne, Red Warrington, Keens' Seedling, Rough Red, Lord Derby, Henson's Seedling, Crown Bob, Companion.
Hairy Yellows.—Yellow Champagne, Early Sulphur (very early), Catharina, Fanny, Broom Girl.
Hairy Greens.—Early Green Hairy, Glenton Green, Thunder.
Hairy Whites.—White Champagne, Bright Venus, White Lion, Transparent, Snowdrop, Fascination, Antagonist.
Downy Whites.—Whitesmith, Cheshire Lass, Maid of the Mill, Early White.
Smooth Reds.—London (very large), Plough Boy, Small Red Globe, Turkey Red.
Smooth Yellows.—Smiling Beauty, Leveller, Gipsy Queen, Leader, Ringer.
Smooth Greens.—Pitmaston Green-gage, Telegraph, Heart of Oak, Green Overall, Shiner, General Markham.
Smooth Whites.—White Honey, White Fig, Careless, Freedom.

See GOOSEBERRY, vol. x. p. 779.

123. The *Medlar*, Mespilus germanica, is a deciduous tree, native Medlar.
of the middle and south of Europe, and found in hedges and woods in England. Its fruit is hard, acid, and unfit for eating till it loses its green colour and becomes "bletted," in which state it acquires an agreeably acid and somewhat astringent flavour.

The medlar is propagated by budding or grafting upon the whitethorn, which is most suitable if the soil is dry and sandy, or on the quince if the soil is moist. It produces the best fruit in rich, loamy, somewhat moist ground. The tree may be grown as a standard, and chiefly requires pruning to prevent the branches from crossing and rubbing each other. The fruit should be gathered in November, on a dry day, and laid out upon shelves in the fruit room. It becomes bletted and fit for use in the course of two or three weeks.

124. The *Melon*, Cucumis Melo, is an annual tropical plant of Melon.
climbing or trailing habit, extensively cultivated in Persia and some parts of India. The plant requires artificial heat to grow it to perfection, the rock and cantaloup varieties succeeding with a bottom heat of 70° and an atmospheric temperature of 75°, rising with sun heat to 80°, and the Persian varieties requiring a bottom heat of 75°, gradually increasing to 80°, and an atmospheric temperature ranging from 75° to 80° when the fruit is swelling, as much sun heat as the plants can bear being allowed at all times. The melon grows best in rich turfy loam, somewhat heavy, with which a little well-rotted dung, especially that of pigeons or fowls, should be used, in the proportion of one-fifth mixed in the compost of loam. Melons are grown on hotbeds of fermenting manure, when the soil should be about a foot in thickness, or in pits heated either by hot water or fermenting matter, or in houses heated by hot water, in which case the soil bed should be 15 or 18 inches thick. The fermenting materials should be well prepared, and, since the heat has to be kept up by linings, it is a good plan to introduce one or two layers of faggots in building up the bed. A mixture of dung and leaves gives a more subdued but more durable heat.

For all ordinary purposes February is early enough for sowing the first crop, as well-flavoured fruits can scarcely be looked for before May. The seeds may be sown singly in 3-inch pots in a mixture of leaf-mould with a little loam, the pots being plunged in a bottom heat of 75° to 80°, and as near the glass as possible, in order that the young plants may not be drawn up. The hill or ridge of soil should be about a foot in thickness, the rest of the surface being afterwards made up nearly to the same level. If the fruiting bed is not ready when the roots have nearly filled the pots, they must be shifted into 4-inch pots, for on no account must they be allowed to get starved or pot-bound. Two or three plants are usually planted in a mound or ridge of soil placed in the centre of each light, and the rest of the surface is covered over to a similar depth as soon as the roots have made their way through the mound.

The mode of pruning and training is similar whether the plants are grown on a trellis or on the surface of a bed, with this difference that in the former case the main stem has to be carried up to a sufficient height to reach the trellis before it is stopped. When the plants are trained on the surface of the beds the tops should be pinched off as soon as the second rough leaf is fairly formed, the stopping being effected either long enough before planting to allow the buds to break, or not until the plants have taken fresh root after planting. One branch will thus be developed from the axil of each of the two leaves, and they should be trained one towards the front and the other towards the back of the frame, before reaching which the points should be pinched off and lateral fruit-bearing shoots will then be produced.

The melon being one of those plants which produce distinct male and female flowers (diœcious), it is necessary to its fertility that both should be produced, and that the pollen of the male flower should, either naturally by insect agency, or artificially by the cultivator's manipulation, be conveyed to the stigma of the female flower; this setting of the fruit is often done by stripping a male flower of its corolla, and inverting it in the centre of the fruit-bearing flower. After the fruit has set and has grown to the size of an egg, it should be preserved from contact with the soil by placing it on a piece of tile or slate; or if grown on a trellis by a little swinging wooden shelf, just large enough to hold it. In either case the material used should be tilted a little to one side, so as to permit water to drain away. Before the process of ripening commences, the roots should have a sufficient supply of moisture, so that none may be required from that time until the fruit is cut.

When the melon is grown in a house there should be a good depth of drainage over the tank or other source of bottom heat, and on this should be placed turfs, grass side downwards, below the soil, which should not be less than 15 and need not be more than 18 inches in thickness. The compost should be made moderately firm, and only half the bed should be made up at first, the rest being added as the roots require it. The melon may also be grown in large pots, supplied with artificial manure or manure water. The stems may be trained up the trellis in the usual way, or the rafters of a pine stove may be utilized for the purpose. If the trellis is constructed in panels about the width of the lights, it can be taken down and conveniently stowed away when not in use.

The presence of too much moisture either in the atmosphere or in the soil is apt to cause the plants to damp off at the neck, but the evil, if it appears, may be checked by applying a little fresh-slaked lime round the stem of the plant.

The varieties of melon are continually receiving additions which are more or less permanent. A great deal depends on getting the varieties true to name, as they are very liable to get cross-fertilized by insect agency. Some of the best are—

Scarlet-fleshed.—Scarlet Gem, and Read's Scarlet-fleshed.
White-fleshed.—Colston Basset Seedling, and Queen Emma.
Green-fleshed.—Victory of Bath, Eastnor Castle, and Egyptian.

Mulberry.

125. The *Mulberry*, Morus nigra, is a deciduous tree, with monœcious flowers, and oblong compound fruits, having a rich aromatic flavour and a fine subacid juice. The fruit is in request for the dessert during the months of August and September. It is a native of Persia, and succeeds well as a standard in the warmer parts of England, especially in sheltered situations, but in the north of England and the less favoured parts of Scotland it requires the assistance of a wall. The standard trees require no other pruning or training than an occasional thinning out of the branches, and are generally planted on grassy lawns, to prevent the fruit being damaged when it falls.

The tree succeeds best in a rich, deep, and somewhat moist loam, but grows well in any good garden ground. It is usually propagated either by cuttings or layers, which latter, if made from the older branches of the tree, come sooner into bearing. Cuttings planted in the spring should consist of well-ripened shoots of the preceding year, with a joint of two-year-old wood at their base, or if planted in autumn should have the shoots well matured, and furnished with a heel of two-year-old wood. The branches and even stout limbs are sometimes employed as cuttings instead of the younger shoots, especially when the object is to obtain a bearing tree quickly. The branch should be planted deeply in autumn in good soil, and if necessary supported in an upright position by a stake. The most common mode of propagation, however, is by layering the young branches. The mulberry may be grown in pots, and gently forwarded in an orchard house, and under these conditions the fruit acquires a richness of flavour and a melting character which is unknown in the fruit ripened outdoors. If cultivated in this way it requires abundance of water while the fruit is swelling, and also frequent dressings of artificial fertilizers or doses of liquid manure.

Nectarine.

126. The *Nectarine* is merely a smooth-skinned variety of the peach, and will be included under that head (see par. 129).

Nut.

127. The *Nut*, Corylus Avellana, or hazel-nut, one of our indigenous shrubs, is the parent of the Filberts, Cob Nuts, and other improved varieties which are met with under cultivation. These succeed best in a rich dry loam, deeply worked, and should receive from time to time a slight manuring. They are generally planted in the slip, but thrive best in an open quarter by themselves. The different varieties are propagated by layers, or more generally by suckers; or, if required, they may be grafted. The Cosford is a favourite kind, being a thin-shelled nut, and having a kernel of high flavour. If either this or the filbert be grafted on small stocks of the Spanish nut, which grows fast, and does not send out suckers, dwarfish prolific trees may be obtained; and, by pruning the roots in autumn, the trees may be kept quite neat and bushy.

The county of Kent has long been celebrated for the culture of nuts for the London market. The young plants are almost always suckers from old bushes, and are planted from 10 to 12 feet apart, being subsequently kept from crowding or shading each other by pruning. They are suffered to grow without restraint for about three years, and then, being cut down to within 12 or 18 inches of the ground, they will push out from near the top five or six shoots, which at the winter pruning in their second year are shortened one-third. A hoop of sufficient diameter is then placed within the branches, and the shoots are fastened to it at about equal distances. In the spring of the fourth year all the laterals are cut back nearly to the principal stems, and from these cut-back laterals short shoots proceed, on which fruit may be expected in the following year. Those which have borne fruit are afterwards removed by the knife. The leading shoots are always shortened about two-thirds. Every bearing twig is deprived of its top, and all suckers are carefully rooted out.

The nut being a monœcious plant, it is necessary in the winter or spring pruning to take care that a sufficiency of the male flowers—those produced in pendulous catkins—are preserved. The female flowers, which produce the fruit, are not visible till spring, and appear in the form of plump buds, producing from their apex several deep crimson threads, which are the styles to which the pollen from the catkins should be applied.

The best kinds of nuts for garden cultivation are Lambert's Filbert, the Red and the White Filberts, the Cosford, the Norwich Prolific, and Pearson's Prolific.

128. The *Orange*, Citrus Aurantium, has been usually cultivated in England for the beauty of the plant and the fragrance of its blossoms, rather than for the purpose of affording a supply of edible fruit. The latter can, however, be easily grown in a hot-house, some of the fruits thus grown, especially those of the pretty little Tangierine variety, being superior in quality to the imported fruit. The best form of orange house is the span-roofed, with glass on both sides, the height and other conditions being similar to those recommended for stove plants. The trees may be planted out, a row on each side a central path, in a house of moderate width. The borders must be carefully made, with a drainage bottom of from 9 to 12 inches of broken bricks or rubbly stones, and a drain leading to the exterior. Rough turf with the grassy side downwards should be laid over the drainage material, and then 18 inches of good turfy loam mixed with gritty sand or fine burnt ballast, to keep it permeable to water. The trees, if intended to be permanent, should be placed 10 to 12 feet apart. Bottom heat (about 80°) is beneficial; but it is questionable if its advantages beneath a bed of soil are not more than counterbalanced by the risk of over-dryness, and the inconvenience of getting access to the heating pipes in case of repairs becoming necessary. It will generally be found more convenient to grow the plants in pots or tubs, and then bottom heat can be secured by placing them on or over a series of hot-water pipes kept near to or above the ground level. The pots or tubs should be thoroughly well drained. The temperature may be kept at about 50° or 55° in winter, under which treatment the trees will come into bloom in February; the heat must then be increased to 60° or 65° in the day time, and later on to 80° or 85°. Throughout the growing season the trees should be liberally watered, and thoroughly washed every day with the garden engine, care being taken not to injure the young leaves; this will materially assist in keeping down insects. The fruit may be expected to ripen from about the middle of October to January, and if the sorts are good will be of excellent quality. When the trees are at rest the soil must not be kept too wet, since this will produce a sickly condition, through the loss of the small feeding roots. The trees require little pruning or training. When a branch appears to be robbing the rest, or growing ahead of them, it should be shortened back or tied down.

When grown for the production of flowers, which are always in great request, the plants must be treated in a similar manner to that already described, but may do without bottom heat.

The favourite sorts of oranges are the Tangierine, a delicious small-fruited early variety; the Mandarin, which is larger than Tangierine; the St Michael's, which is the most commonly grown; the Maltese Blood, which is a very distinct sort with red flesh; and the Plata or silver orange.

129. The *Peach*, Amygdalus Persica, or Persica vulgaris, is one of the most delicious of exotic garden fruits. There are two principal races, the *Peach* proper, which has fruits covered with a downy skin, and the *Nectarine*, which has fruits covered with a smooth skin. The peach and the nectarine would therefore appear to be distinct kinds of fruit, and indeed have an appreciable difference of flavour; but as both peaches and nectarines have been known to grow on the same branch, and individuals half-peach half-nectarine have been produced, they must be regarded as merely varieties of one kind of fruit. Their treatment, moreover, is the same in every respect.

To perpetuate and multiply the choicer varieties, peaches and nectarines are budded upon plum or almond stocks. For dry situations almond stocks are preferable, but they are not long-lived, while for damp or clayey loams it is better to use plums. Double-working is sometimes beneficial ; thus an almond budded on a plum stock may be rebudded with a tender peach, greatly to the advantage of the latter. The peach border should be composed of turfy mellow loam, such as is suitable for the vine and the fig ; this should be used in as rough a state as possible, or not broken small and fine. The bottom should slope towards the outer edge, where a drain should be cut, with an outlet, and on this sloping bottom should be laid a thickness of from 9 inches to 12 inches of rough materials, such as broken bricks or mortar rubbish, over which should be placed a layer of rough turf with the grassy side downwards, and then the good loamy soil to form the border, which need not be of greater depth than 18 inches, for the peach tree is most productive when the roots are kept near the surface. The borders should not be cropped heavily with culinary vegetables, as deep trenching is very injurious. Sickly and unfruitful trees may often be revived by bringing up their roots within 5 or 6 inches of the surface. The experience of the last few seasons has, however, been so disastrous that it has been questioned whether it may not be better, in cold soils and bleak situations, to abandon outdoor peach culture, and to cover the walls with a casing of glass, so that the trees may be under shelter during the uncongenial spring weather.

The fruit of the peach is produced on the ripened shoots of the preceding year. If these be too luxuriant, they yield nothing but leaves ; and if too weak, they are incapable of developing flower buds. To furnish young shoots in sufficient abundance, and of requisite strength, is the great object of peach training and pruning. Trees of slender-growing, twiggy habit naturally fall most readily into the fan form of training, and accordingly this has generally been adopted in the culture of peaches and nectarines. The old fan form is very nearly that of fig. 82 (p. 245). The young tree is, in many cases, procured when it has been trained for two or three years in the nursery ; but it is generally better to commence with a maiden plant, that is, a plant of the first year after it has been budded. It is then in ordinary practice headed down to five or six buds, and in the following summer from two to four shoots, according to the vigour of the plant, are trained in, the laterals from which, if any, are thinned out and nailed to the wall. If there are four branches, the two central ones are shortened back at the subsequent winter pruning so as to produce others, the two lower ones being laid in nearly at full length. In the following season additional shoots are sent forth ; and the process is repeated till eight or ten principal limbs or mother branches are obtained, forming, as it were, the frame-work of the future tree. The branches may be depressed or elevated, so as to check or encourage them, as occasion may arise ; and it is highly advantageous to keep them thin, without their becoming in any part deficient of young shoots. Sometimes a more rapid mode of formation is now adopted, the main shoots being from the first laid in nearly at full length, instead of being shortened. The pruning for fruit consists in shortening back the laterals which had been nailed in at the disbudding, or summer pruning, their length depending on their individual vigour and the luxuriance of the tree. In well-developed shoots the buds are generally double, or rather triple, a wood bud growing between two fruit buds ; the shoot must be cut back to one of these, or else to a wood bud alone, so that a young shoot may be produced to draw up the sap beyond the fruit, which is generally desirable to secure its proper swelling. The point of this leading shoot is subsequently pinched off, that it may not draw away too much of the sap. If the fruit sets too abundantly, it must be thinned, first when as large as peas, reducing the clusters, and then when as large as nuts to distribute the crop equally ; the extent of the thinning must depend on the vigour of the tree, but one or two fruits ultimately left to each square foot of wall is a full average crop. The final thinning should take place after stoning.

The best-placed healthy young shoot produced from the wood buds at the base of the bearing branch is to be carefully preserved and in due time nailed to the wall. In the following winter this will take the place of the branch which has just borne, and is to be cut out. If there be no young shoot below, and the bearing branch is short, the shoot at the point of the latter may sometimes be preserved as a fruit bearer, though if the bearing branch be long it is better to cut it back for young wood. It is the neglect of this which constitutes the principal fault in carrying out the English fan system, as it is usually practised. Several times during summer the trees ought to be regularly examined, and the young shoots respectively topped or thinned out ; those that remain are to be nailed to the wall, or braced in with pieces of slender twigs, and the trees ought occasionally to be washed with the garden engine.

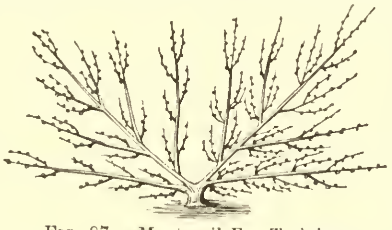

Fig. 87.—Montreuil Fan Training.

The Montreuil form of training is represented by fig. 87. The principal feature is the suppression of the direct channel of the sap, and the substitution of four or more commonly two mother branches, so laid to the wall that the central angle contains about 90°. The other branches are all treated as subordinate members. This form is open to the objection that, if the under branch should die, the upper one cannot be brought down into its place.

The form à la Dumoutier (fig. 88), so called from its inventor, is merely a refinement on the Montreuil method. The formation of

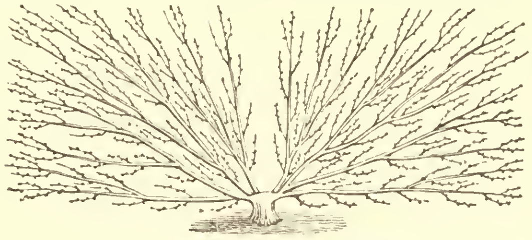

Fig. 88.—Dumoutier's Fan Training.

the tree commences with the inferior limbs and proceeds towards the centre, the branches being lowered from time to time as the tree acquires strength. What is most worthy of notice in this method is the management of the subordinates in the pruning for fruit. When a shoot promises blossom, it is generally at some distance from the point of insertion into the old wood, and the intermediate space is covered with wood buds. All the latter, therefore, which are between the old wood *a* and the blossom *c* in fig. 89, except the lowest *b*, are carefully removed by *ebourgeonnement*. This never fails to produce a shoot *d*, the growth of which is favoured by destroying the useless spray *e* above the blossoms, and pinching off the points of those which are necessary to perfect the fruit. A replacing shoot is thus obtained, to which the whole is invariably shortened at the end of the year.

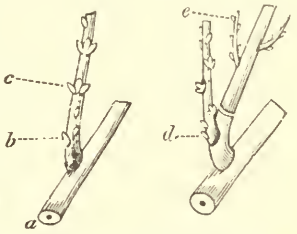

Fig. 89.—Pruning à la Dumoutier.

Mr Seymour's form (fig. 90) approaches more nearly to the French method than any other practised in England, but the direct channel of the sap is not suppressed. It will be seen that the bearing shoots are all on the upper side of the mother branches, and that these bearing shoots are wholly reproduced once a year. The one side of the annexed figure represents the tree after the winter pruning, the other (left hand) side before it has undergone that operation. On the latter side the young shoots will be seen to be in pairs, and at the winter pruning the lower one, or that which has borne fruit, is cut out, and the other is brought down into its place, and shortened to about 8 or 9 inches, care being taken to cut at a wood bud. At

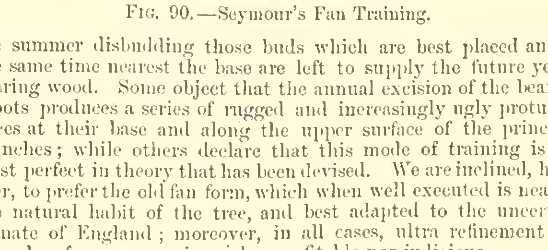

Fig. 90.—Seymour's Fan Training.

the summer disbudding those buds which are best placed and at the same time nearest the base are left to supply the future year's bearing wood. Some object that the annual excision of the bearing shoots produces a series of rugged and increasingly ugly protuberances at their base and along the upper surface of the principal branches; while others declare that this mode of training is the most perfect in theory that has been devised. We are inclined, however, to prefer the old fan form, which when well executed is nearest the natural habit of the tree, and best adapted to the uncertain climate of England ; moreover, in all cases, ultra refinement for the sake of appearance is neither profitable nor judicious.

For cold and late situations, the late Thomas Andrew Knight recommended the encouragement of spurs on the young wood, as such spurs, when close to the wall, generate the best organized and most vigorous blossoms, and generally insure a crop of fruit. They may be produced, by taking care, during the summer pruning or disbudding, to preserve a number of the little shoots emitted by the yearly wood, only pinching off the minute succulent points. On the spurs thus formed blossom buds will be developed early in the following season. This practice is well adapted to cold situations.

Peach trees require protection, especially at the period of blossoming, particularly in the north of England and in Scotland. Canvas or bunting screens are most effectual. By applying these early in the season, great benefit may be derived from retarding the blossom till the frosty nights of spring have passed. Wooden and glass copings are also very useful in warding off frosts.

Forcing.—The pruning and training of the trees in the peach house do not differ materially from the methods practised out of doors. It may also be stated here that when occasion arises peach trees well furnished with buds may be transplanted and forced immediately without risking the crop of fruit, a matter of some importance when, as sometimes happens, a tree may accidentally fail. In the forcing of peaches fire heat is commonly applied about December or January; but it may, where there is a demand, begin a month sooner. At first the house should be merely kept closed at about 45°, but the heat should gradually increase to 55° by the time the trees are in flower, and to 60° when the fruit is set, after which the house should be kept moist by sprinkling the walls and paths, or by placing water troughs on the return pipes, and the temperature should range from 65° by day to 70° or more with sun heat. After the fruit has set, the foliage should be refreshed and cleansed by the daily use of the syringe or garden engine. When the fruit has stoned, that is, as soon as the kernels have been formed, the temperature should be raised to about 60° as a minimum, and to 70°, with 75° by sun heat, as a maximum. Water must now be copiously supplied to the border, and air admitted in abundance. After the end of April little fire heat is required. When the fruit begins to ripen, syringing must be discontinued till the crop is gathered, after which the syringe must be again occasionally used. If the leaves should happen to shade the fruit, not only during the ripening process, but at any time after the stoning period, they should be gently turned aside, for, in order that the fruit may acquire good colour and flavour, it should be freely exposed to light and air when ripening; it will bear the direct rays of the sun, even if they should rise to 100°. The trees often suffer from mildew, which is best prevented by keeping the borders of the peach house clear and sufficiently moist, and the house well ventilated.

The following are some of the best peaches and nectarines, arranged in the order of the times of their ripening:—

Peaches.

Early Beatrice	e. July.	Premier	e. Aug. / b. Sept.
Early Louisa	e. July.		
Frogmore Golden	e. July.	Royal George	e. Aug. / b. Sept.
Hale's Early	b. Aug.		
Rivers's Early York	b.m. Aug.	Bellegarde	b.m. Sept.
A Bec	m. Aug.	Belle Bauce	m. Sept.
Washington Rathripe	m. Aug.	Dymond	m. Sept.
Early Silver	m.e. Aug.	Late Admirable	m.e. Sept.
Crawford's Early	e. Aug. / b. Sept.	Desse Tardive	e. Sept. / b. Oct.
Grosse Mignonne	e. Aug. / b. Sept.	Walburton Admirable	e. Sept. / b. Oct.
Noblesse	e. Aug. / b. Sept.	Salway	e. Oct. / b. Nov.

Nectarines.

Lord Napier	b. Aug.	Violette Hâtive	e. Aug. / b. Sept.
Rivers's White	m. Aug.		
Murrey	e. Aug.	Welbeck Seedling	e. Aug. / b. Sept.
Balgowan	e. Aug. / b. Sept.	Victoria (under glass)	Sept.
Elruge	e. Aug. / b. Sept.	Pine apple	b. Sept.
		Stanwick Elruge	b. Sept.
Pitmaston Orange	e. Aug. / b. Sept.	Albert Victor	m.e. Sept.
		Stanwick (under glass)	m.e. Sept.

Pear. 130. The *Pear* has originated in part from the wild species, Pyrus communis, and in part from other species of the genus, including P. sinensis from China, P. Achras from Southern Russia, P. Sinai from Syria, and P. salicifolia from the Caucasus. It may be readily raised by sowing the pips of ordinary cultivated or of wilding kinds, these forming what are known as free or pear stocks, on which the choicer varieties are grafted for increase. For new varieties the flowers should be fertilized with a view to combine, in the seedlings which result from the union, the desirable qualities of the parents. The dwarf and pyramid trees, more usually planted in gardens, are obtained by grafting on the quince stock, the Portugal quince being the best; but this stock, from its surface-rooting habit, is most suitable for thin shallow soils, or for those of a cold damp nature. Some of the finer pears do not unite readily with the quince, and in this case double working is resorted to; that is to say, a vigorous-growing pear is first grafted on the quince, and then the choicer pear is grafted on the pear introduced as its foster parent.

In selecting young pear trees for walls or espaliers, some persons prefer plants one year old from the graft, but trees two or three years trained are equally good. The trees should be planted immediately before or after the fall of the leaf. The wall trees require to be planted from 25 to 30 feet apart when on free stocks, and from 15 to 20 feet when dwarfed. Where the trees are trained *en pyramide*, or *en quenouille* (see figs. 78, 79), they may stand 8 or 10 feet apart, but standards in orchards should be allowed at least 30 feet, and dwarf bush trees half that distance.

In the formation of the trees the same plan may be adopted as has already been described as suitable for the apple (par. 116). For the pear orchard a warm situation is very desirable, with a soil deep, substantial, and thoroughly drained. Any good free loam is suitable, but a calcareous loam is the best. The late Mr Rivers recommends that pear trees worked on the quince should have the stock covered up to its junction with the graft. This is effected by raising up a small mound of rich compost around it, a contrivance which induces the graft to emit roots into the surface soil, and also keeps the stock from becoming hard or bark-bound. The fruit of the pear is produced on spurs, which appear on shoots more than one year old. The mode most commonly adopted of training wall pear-trees is the horizontal (see figs. 80, 81). For the slender twiggy sorts the fan form is to be preferred, while for strong growers like Gansel's Bergamot, the half-fan or the horizontal is more suitable. In the latter form old trees are apt to acquire an undue projection from the wall, and become scraggy, to avoid which a portion of the old spurs should be cut out annually.

The summer pruning of established wall or espalier-rail trees consists chiefly in the timely displacing or rubbing off of the superfluous shoots, so that the winter pruning, in horizontal training, is little more than adjusting the leading shoots and thinning out the spurs, which should be kept close to the wall, and allowed to retain but two or at most three buds. In fan-training, the subordinate branches must be regulated, the spurs thinned out, and the young laterals finally established in their places. When horizontal trees have fallen into disorder, the branches may be cut back to within 9 inches of the vertical stem and branch, and trained in afresh, or they may be grafted with other sorts, if a variety of kinds is wanted.

Summer and autumn pears should be gathered before they are fully ripe, otherwise they will not in general keep more than a few days. The Jargonelle, as Forsyth rightly advises, should be allowed to remain on the tree, and be pulled daily as wanted, the fruit from standard trees thus succeeding the produce of the wall trees. In reference to the Crassane, Mr G. Lindley recommends gathering the crop at three different times, the first a fortnight or more before it is ripe, the second a week or ten days after that, and the third when fully ripe. The first gathering will come into eating latest, and thus the season of the fruit may be considerably prolonged. It is evident that the same method may be followed with other sorts which continue only a short time in a mature state.

The varieties of pears are very numerous, while comparatively few sorts are required in any ordinary garden. The following is a small selection of good sorts which do well in the climate of Britain, and they are arranged according to the months when they are commonly in use,—a period which, however, varies considerably in different seasons:—

Dessert Pears.

Doyenné d'Été	July.	Maréchal de Cour	Oct., Nov.
Beurré de l'Assomption	Aug.	Pitmaston Duchesse d'Angoulême	Oct., Nov.
Jargonelle	Aug.		
Souvenir du Congrès	Aug., Sept.	Althorp Crassane	Oct.-Dec.
Williams's Bon Chrétien	Aug., Sept.	Thompson's	Nov.
Beurré d'Amanlis	Sept.	Huyshe's Prince Consort	Nov., Dec.
Madame Treyve	Sept.	Passe Colmar	Nov., Dec.
Beurré Superfin	Sept., Oct.	Winter Nelis	Nov.-Feb.
Fondante d'Automne	Sept., Oct.	Chaumontel	Nov.-Mar.
Baronne de Mello	Oct.	Beurré d'Arenberg	Dec., Jan.
Comte de Lamy	Oct.	Glou Morceau	Dec., Jan.
Louise Bonne of Jersey	Oct.	Huyshe's Victoria	Dec., Jan.
Seckel	Oct.	Monarch	Dec., Jan.
Belle Julie	Oct., Nov.	Zéphirin Grégoire	Dec., Jan.
Beurré Bosc	Oct., Nov.	Beurré de Jonghe	Dec.-Feb.
Doyenné du Comice	Oct., Nov.	Joséphine de Malines	Jan., Feb
Duchesse d'Angoulême	Oct., Nov.	Easter Beurré	Jan.-Apr
Gansel's Bergamot	Oct., Nov.	Nec plus Meuris	Jan.-Apr.
Marie Louise	Oct., Nov.	Nouvelle Fulvie	Feb., Mar.

Kitchen Pears.

Besi d'Héry	Oct.-Jan.	Bellissime d'Hiver	Nov.-Apr.
Black Worcester	Nov.-Feb.	Catillac	Dec.-Apr.
Flemish Bon Chrétien	Nov.-Mar.	Winter Franc Réal	Jan.-Mar.
Verulam	Nov.-Mar.	Uvedale's Saint Germain	Jan.-Apr.

131. The *Pine-apple*, Bromelia Ananas, or Ananassa sativa, requires for its cultivation a tropical climate similar to that of the West Indies—a mean temperature of 70° at the coldest and of 83° at the warmest season, with a range of about 10° between the night and day temperature. It also requires a supply of heat, averaging about 90°, to the soil in which the roots are placed, and hence it is grown in a hot-house, where it can be supplied with bottom heat, by being plunged in a bed of fermenting material, such as tanner's bark or decaying leaves, or by hot water applied either in pipes passing through hollow chambers, or shallow hot-water tanks placed beneath the plunging beds. The heat arising from violent fermentation is, however, greater than the tender roots can bear, and if great watchfulness be not employed, the labour of many months may be wasted in a single day. Bottom heat should not exceed 95°, and may be brought down when active growth is not required to about 75°. Pine-apple

It must be regulated in its application by the amount of light and of warmth in the air. During the season when the plants are at rest it should be comparatively low; during their season of active growth it should be considerable; and during their ripening season it should be highest of all.

The top spit of an old loamy pasture, including the turf, and mixed with about one-third the bulk of good well-rotted dung, forms a suitable compost for the pine-apple. The soil used at Meudon, where these fruits have been very successfully grown, is a sandy peat or leaf-mould obtained from a high-lying spot, where hard-wooded trees, chiefly beech, have long been growing. The late Mr Fleming, when at Trentham, used a mixture of three parts turfy maiden loam to one part of peat, these ingredients being mixed together and laid under a wooden platform on which sheep were fed (which was so constructed that the dung and urine of the sheep fell through), and left there long enough to become well enriched. Other noted cultivators have recommended turfy loam and sheep or deer dung in the proportion of six of loam to three of the manure, one of leaf-mould being added. The compost should be prepared a considerable time beforehand, and frequently turned over and aerated; when used, it should be roughly broken with the spade, but not screened. Some cultivators, who do not otherwise enrich the soil, use half-inch bones and soot at the time of potting in the proportion of an 8-inch potful of each to a barrowful of fibrous surface soil. The plants when growing freely are benefited by the use of liquid manure of an ammoniacal character.

The pine-apple is sometimes propagated by planting the crowns which grow on the fruit, but more commonly from the suckers which appear at the base of the stem, these being a less time in arriving at a fruiting state. When removed from the fruit or stem, the crowns or suckers are trimmed and laid aside till the scar has dried, after which they are potted. This usually takes place during August or September, as the offsets should be allowed to obtain considerable size before they are removed, for the reason that large suckers grow with more vigour and come sooner into fruit than those of smaller size. They should be placed in 6-inch or 8-inch pots, the soil being somewhat lighter then than that used afterwards. They may be slightly shaded for a short period, and in about eight or twelve days may receive a little water. The old routine of pine-apple culture embraced a period of three years, but this has been reduced by modern growers to about eighteen months. The more rapid method was first brought into notice by Abercrombie. Its chief features are the employment of more mature suckers at the outset, and the acceleration of the growth of the plants afterwards by the application of a hotter and moister atmosphere than formerly, so as to obtain the growth of two summers in one.

The roots should be preserved in a fresh healthy state during winter, so as not to require being cut away, as was formerly done; and this may be secured by giving very moderate and judicious waterings, and by keeping the bottom heat well under control. About the beginning of March, or earlier, the forwardest young plants from suckers are selected from the stock of succession plants, and the earth and roots examined; they are then put into larger pots in good soil, and plunged in a bed having a genial bottom heat of about 85°. They require to be shaded for a few days, and after they begin to root should receive moderate waterings. As soon as the roots thicken in the balls of soil, which will be about the beginning of August, they are to be transferred into 10-inch or 12-inch pots, in which they will mature their fruit. At each successive shift the ball of earth and roots is to be preserved entire. From March onwards the temperature is gradually increased as follows:—In March, 60° to 70° by night, 70° to 80° by day; April 70° to 75° by night, 80° to 85° by day; May 75° to 80° by night, 90° to 95° by day; June 80° to 85° by night, 95° to 100° by day. After the beginning of August the heat is allowed to decline gradually until it arrives at the winter temperature of 60°. While fire heat is used, the nocturnal temperature should not exceed 80°, and sufficient moisture must be supplied. To prevent the plants from being drawn, they should be allowed ample space—2 feet from plant to plant is not too much—and be placed as near the glass as possible. In August and September abundance of air and more copious supplies of water are given. To prevent the roots from damping off in winter, water must be cautiously applied, and the pits should be heated by means of fire heat rather than by fermenting materials. Some gardeners apply this biennial mode of cultivation only to the varieties of the Queen type, but our best cultivators for the most part adopt it in its main features for all varieties, and the fruit produced is finer than that grown upon the triennial course. Those, however, who wish to cultivate such large and coarse sorts as the Providence may possibly find it necessary to take a longer period for fruiting them.

The period at which pine-apple plants first show their fruit stems is the most critical in their whole culture. The plant must be of a certain age, or at least of a certain magnitude, before it will start freely or to good purpose. In the second year a Queen pine is capable of producing a perfect fruit; and in the third year the large varieties arrive at puberty. The solid part of the stem is then observed to have increased in bulk, and to have ascended considerably above the soil. The start is generally required to be made at a particular period, but the fruit stalks do not appear until the pot is filled with roots. It is therefore necessary that the roots shall have nearly occupied all the new soil by the time the development of the fruit is required, and care should be taken that in winter the tender fibres should suffer neither from drought nor from excessive moisture or heat. After the plants show fruit they are never shifted; but the surface soil may be replaced by some fresh and rich compost. Water is supplied from time to time, but should never be colder than the average temperature of the house. Whilst the fruit is swelling, care must be taken to carry on the growth of the plant with equability and moderation. As the fruit approaches maturity, water is gradually withheld, lest the flavour should be impaired. Pine-apples should be cut a short time before they obtain complete maturity; they do not keep sound long after being cut, and consequently, if they have to be kept over for a short period the plant, pot and all, should be moved to a dryish moderately cool room.

The Hamiltonian system of pine growing was at one time more frequently adopted than now. Instead of the suckers being detached from their parent stems before fruiting, the base of the old stem was bared of leaves and earthed up with rich compost, into which it rooted freely, each sucker thus producing a ripe fruit in from eight to twelve months from the time it was started. When this fruit was cut, the process was repeated till a third succession of fruit and a fourth were obtained, after which the sucker which bore the last fruit was cut off with 6 or 8 inches of the main stem, and potted so as to furnish another similar progeny of suckers.

The Queen, as a quick-fruiting sort, and the larger Smooth-leaved Cayenne, are the chief favourites among cultivators. It may, however, be useful to give the names of a few of the best varieties:—

Spineless-leaved Pine-apple.

Smooth-leaved Cayenne, fruit large, cylindrical: good in win

Spiny-leaved Pine-apples.

Black Jamaica: fruit oval, 4 to 5 lb; one of the best for winter use.
Charlotte Rothschild: fruit cylindrical, 7 to 11 lb; good in winter.
Enville: fruit pyramidal, 6 to 7 lb.
Lady Beatrice Lambton: fruit pyramidal, 11 lb; good in winter; very juicy.
Lord Carington: fruit cylindrical, 5 to 7 lb; good in winter.
Prince Albert: fruit pyramidal, 6 to 8 lb; best in summer and autumn.
Queen: fruit cylindrical, 4 to 8 lb; the best sort for general purposes.
Thoresby Queen: fruit roundish-ovate, 6 to 8 lb.

132. The *Plum*, Prunus domestica, is considered a native of Plum.
England, but many of the best cultivated varieties have been introduced from France. The fruit is not only prized for dessert, but also for culinary purposes.

Plums are propagated chiefly by budding on stocks of the Mussel, Brussels, St Julien, and Pear plums. The damson, wine sour, and other varieties, planted as standards, are generally increased by suckers. For planting against walls, trees which have been trained for two years in the nursery are preferred by some, but maiden trees can be very successfully introduced, and by a course of liberal treatment, with less hard pruning, may be more speedily got to a fruiting state. Any good well-drained loamy soil is suitable for plums, that of medium quality as to lightness being decidedly preferable. Walls with an east or west aspect are generally allowed to them, the distance between the trees being from 20 to 30 feet. The horizontal mode of training is adopted by many, but the fan or half-fan forms are also very commonly followed, and where there is sufficient height probably the fan system is the best. The shoots ought to be laid in nearly or quite at full length. The fruit is produced on small spurs on branches at least two years old, and the same spurs continue fruitful for several years. Standard plum trees should be planted 25 feet apart each way, and dwarfs 15 or 20 feet. Such trees require only to have a portion of their wood thinned out occasionally when they are young. The hardy kinds grown in this way are very productive.

In favourable seasons the crops require thinning, to relieve the branches from the excessive weight. The unripe fruit, if fully grown and beginning to change colour, is quite fit for cooking. For dessert purposes the fruit should be allowed to remain on the tree as long as it will hang, and should be gathered by the stalk without disturbing the bloom. Such kinds as Coe's Golden Drop and Ickworth Impératrice, if gathered dry, wrapped in tissue paper, and laid in a dry cool fruit-room, may be kept for months fit for use.

The following is a selection of good reliable varieties of plums, with their times of ripening:—

Dessert Plums.

Early Green Gage	e. July.	Woolston Black	b. Sept.
Royal Hâtive	e. July. b. Aug.	Jefferson	b.m. Sept.
Rivers's Early Apricot	b. Aug.	Kirke's	b.m. Sept.
Denniston's Superb	m. Aug.	Hulings's Superb	m. Sept.
Oullins Golden	m. Aug.	Reine Claude du Comte Hathem	m. Sept.
Green Gage	m.e. Aug.	Coe's Golden Drop	e. Sept.
M'Laughlin's	e. Aug.	Reine Claude de Bavay	e. Sept. b. Oct.
Washington	Sept.	Ickworth Impératrice	b. Oct.
Angelina Burdett	b. Sept.	Late Rivers	e. Oct. b. Nov.
Purple Gage	b. Sept.		
Transparent Gage	b. Sept.		

Culinary Plums.

Early Rivers	e. July.	White Magnum Bonum	Sept.
Early Orleans	b.m. Aug.	Mitchelson's	b. Sept.
Czar	m. Aug.	Pond's Seedling	b.m. Sept.
Sultan	m. Aug.	Victoria (Alderton)	b.m. Sept.
Pershore	m.e. Aug.	Crittenden's Damson	m. Sept.
Orleans	e. Aug.	Diamond	m. Sept.
Prince Engelbert	e. Aug. / b. Sept.	Wine Sour	m. Sept.
		Autumn Compôte	e. Sept.
Prince of Wales	e. Aug. / b. Sept.	Sandall's	e. Sept.
		Belle de Septembre	b.m. Oct.

Quince. 133. The *Quince*, Cydonia vulgaris, is but little cultivated in Great Britain, two or three trees planted in the slip or orchard being in general found to be sufficient for a supply of the fruit; in Scotland it seldom approaches maturity, unless favoured by a wall. The fruit has a powerful odour, but in the raw state is austere and astringent; it, however, makes an agreeable marmalade, and is often used to give flavour and poignancy to stewed or baked apples.

The quince prefers a rich light and somewhat moist soil. The tree is generally propagated by cuttings or layers, the former making the best plants, but being longer in growing. It is much used as a dwarfing stock for certain kinds of pears, and for this purpose the young plants when bedded out in the quarters should be shortened back to about 18 or 20 inches. Those required to form standard fruit-bearing trees should be trained up to a single stem till a height of 5 or 6 feet is attained.

There are three principal varieties of the quince, the Portugal, the apple-shaped, and the pear-shaped. The Portugal is a taller and more vigorous grower than the others, and has larger and finer fruit; the apple-shaped, which has roundish fruit, is more productive, and ripens under less favourable conditions than either of the others; while the pear-shaped has roundish-pyriform fruit, which ripens later than that of the apple-shaped variety.

Raspberry. 134. The *Raspberry*, Rubus Idæus, which is found wild in Great Britain and in woods throughout Europe and Asiatic Russia, is propagated from suckers, which may be taken off the parent stools in October, and planted in rows 5 or 6 feet apart, and at 3 feet asunder in the rows. It is the habit of the plant to throw up from the root every year a number of shoots or canes, which bear fruit the subsequent year, and then decay. In dressing the plants, which is done immediately after the crop is gathered, all these exhausted stems are cut away, and of the young canes only three or four of the strongest are left, which are shortened about a third. The stems, being too weak to stand by themselves, are sometimes connected together by the points in the form of arches, or a stake is driven in midway between the plants, and half the canes are bent one way and half the other both being tied to the stake. Sometimes they are tied upright to stakes fixed to each stool. The best support is, however, obtained by fastening the points of the shoots to a slight horizontal rail or bar, placed a foot and a half on the south side of the rows, by which means the bearing shoots are deflected from the perpendicular to the sunny side of the row, and are not shaded by the annual wood. When this mode of training is adopted, the plan of planting 1 foot apart in the row and leaving one or two canes only to each shoot is preferable. The ground between the rows should never be disturbed by digging; but an abundant supply of good manure should be given annually in autumn as a dressing, which should be forked in regularly to a depth of 4 or 5 inches. All surplus suckers should be got away early in the summer before they have robbed the roots,—five or six, to be reduced to the four best, being reserved to each root. Fresh plantations of raspberries should be made every six or seven years. The double-bearing varieties, which continue to fruit during autumn, require light soils and warm situations. These should be cut close down in February, as it is the strong young shoots of the current year which bear the late autumnal crops. The other varieties may be made to bear in autumn by cutting the stems half-way down at an early period in spring; but, as with all other fruits, the flavour of the raspberry is best when it is allowed to ripen at its natural season.

The following are some of the finer sorts now in cultivation:—

Baumforth's Seedling—a large summer-bearing red.
Carter's Prolific—a large summer-bearing red.
Fastolf or Filby—a large summer-bearing red.
M'Laren's Prolific—a large double-bearing red.
Northumberland Fillbasket—a large summer red.
October Red—a fine autumn-bearing red.
October Yellow—a fine autumn-bearing yellow.
Prince of Wales—a large summer-bearing red.
Red Antwerp—a large summer-bearing red.
Rogers's Victoria—a large autumn-bearing red.
Round Antwerp—a large summer-bearing red.
Sweet Yellow Antwerp—a large summer-bearing yellow.

Service. 135. The *Service*, Pyrus Sorbus or P. domestica, is a European tree which has been regarded as a native of England on the evidence of a single tree, which has probably been planted, now existing in the forest of Wyre. Though not much cultivated, its fruit is esteemed by some persons, and therefore two or three trees may very well be provided with a place in the orchard, or in a sheltered corner of the lawn. The tree is seldom productive till it has arrived at a goodly size and age. The fruit has a peculiar acid flavour, and, like the medlar, is fit for use only when thoroughly mellowed by being kept till it has become bletted. There is a pear-shaped variety, pyriformis, and also an apple-shaped variety, maliformis, both of which may be propagated by layers, and still better by grafting on seedling plants of their own kind. The fruit is sometimes brought to market in winter.

136. The *Strawberry* of the garden has been obtained by the crossing of several species of Fragaria, the larger-fruited sorts from F. grandiflora, chilensis, and virginiana, and the smaller alpines from F. vesca. The alpine varieties should be raised from seeds; while the other sorts are continued true to their kinds by runners. If new varieties are desired, these are obtained by judicious crossing and seeding. Stra- berr

The seeds of the alpines should be saved from the finest fruit ripened early in the summer. They should at once be sown, either in a sheltered border outdoors or in pots. The soil should be rich and light, and the seeds very slightly covered by sifting over them some leaf-mould or old decomposed cow dung. When the plants appear and have made five or six leaves, they should be transplanted to where they are to remain for bearing. The seeds sown in pots may be helped on by gentle heat, and when the plants are large enough should be pricked out in fine rich soil, and in June transferred to the open ground for bearing; they will produce a partial crop in the autumn, and a full one in the following season. The same treatment may be applied to the choicer seedlings of the larger-fruited sorts from which new varieties are expected.

The runners of established sorts should be allowed to root in the soil adjoining the plants, which should, therefore, be kept light and fine, and as soon as a few leaves are produced on each the secondary runners should be stopped. When the plants have become well-rooted, they should at once be planted out. They do best in a rather strong loam, and should be kept tolerably moist. The scarlet section prefers a rich sandy loam. The ground should be trenched 2 or 3 feet deep, and supplied with plenty of manure, a good proportion of which should lie just below the roots, 10 or 12 inches from the surface. The plants may be put in on an average about 2 feet apart. Mr Myatt, a well-known strawberry-grower for market, plants in rows 18 inches apart, and the same distance from plant to plant in the rows, but leaves a space of 30 inches for an alley separating groups of three rows, and after the first year the middle row is cleared away. Some of the best growers allow 2½ feet between the rows, with the plants 2 feet from each other.

A mulching of strawy manure put between the rows in spring serves to keep the ground moist and the fruit clean, as well as to afford nourishment to the plants. Unless required, the runners are cut off early, in order to promote the swelling of the fruit. The plants should be watered during dry weather after the fruit is set, and occasionally till it begins to colour. As soon as the fruit season is over, the runners are again removed, and the ground hoed and raked. The plantation should be renewed every second or third year, or less frequently if kept free of runners, if the old leaves are cut away after the fruit has been gathered, and if a good top-dressing of rotten dung or leaf-mould is applied. A top-dressing of loam is beneficial if applied before the plants begin to grow in spring, but after that period they should not be disturbed during the summer either at root or at top. If the plants produce a large number of flower-scapes, each should, if fine large fruit is desired, have them reduced to about four of the strongest. The lowest blossoms on the scape will be found to produce the largest, earliest, and best fruits. The fruit should not be gathered till it is quite ripe, and then, if possible, it should be quite dry, but not heated by the sun. Those intended for preserving are best taken without the stalk and the calyx.

Forcing.—The runners propagated for forcing are layered into 3-inch pots, filled with rich soil, and held firm by a peg or stone. If kept duly watered, they will soon form independent plants. The earlier they are secured the better. When firmly rooted they are removed and transferred into well-drained 6-inch pots, of strong well-enriched loam, the soil being rammed very firmly into the pots, which are to be set in an open airy place. In severe frosts they should be covered with dry litter or bracken, but do not necessarily require to be placed under glass. They are moved into the forcing houses as required. The main points to be kept in view in forcing strawberries are, first, to have strong stocky plants, the leaves of which have grown sturdily from being well exposed to light, and secondly, to grow them on slowly till fruit is set. When they are first introduced into heat, the temperature should not exceed 45° or 50° by fire heat, and air must be freely admitted; should the leaves appear to grow up thin and delicate, less fire heat and more air must be given, but an average temperature of 55° by day may be allowed, and continued while the plants are in flower. When the fruit is set the heat may be gradually increased, till at the ripening period it stands at 65°, and occasionally at 75° by sun-heat. While the fruit is swelling the plants should never be allowed to get dry, but when it begins to colour no more water should be given than is absolutely requisite to keep the leaves from flagging. The plants should be removed from the house as soon as the crop is gathered. The forced plants properly hardened make first-rate outdoor plantations, and if put out early in summer, in good ground, will often produce a useful autumnal crop.

The varieties are very numerous. The following are some of the best and most distinct of those now in cultivation, those marked * being specially suitable for forcing:—

Amateur—a brisk-flavoured variety.
British Queen *—one of the best-flavoured sorts; requires good cultivation.
Dr Hogg—a hardier form of British Queen.
Elton—late, and valuable for preserving.
Enchantress—a fine-flavoured late variety.
Filbert Pine *—an excellent high-flavoured sort.
Frogmore Late Pine—a good late sort.
James Veitch *— a large solid showy variety.
Keens' Seedling *—a fine old sort, of great merit for all purposes.
La Constante *—an excellent sort, of sprightly flavour.
La Grosse Sucrée *—large, and of excellent flavour.
Loxford Hall Seedling—one of the best late sorts.
Lucas *—a useful fine-flavoured variety.
Myatt's Eliza—very high-flavoured, perhaps in this respect unequalled.
Oscar *—good for a general crop; travels well.
President *—a useful brisk-flavoured sort.
Sir Charles Napier *—a capital market fruit, rather acid.
Sir Harry—a favourite market fruit.
Sir Joseph Paxton *—an excellent large high-flavoured sort.
Vicomtesse Héricart de Thury *—good for all purposes; one of the best.

137. The *Vine*, Vitis vinifera, a native of the shores of the Caspian, and a deciduous climbing shrub, is hardy in Britain so far as regards its vegetation, but not hardy enough to bring its fruit to satisfactory maturity, so that for all practical purposes the vine must be regarded as a tender fruit. Planted against a wall or a building having a south aspect, or trained over a sunny roof, such sorts as the Black Cluster, Black Prince, Pitmaston White Cluster, Royal Muscadine, Sweetwater, &c., will ripen in the warmest English summers so as to be very pleasant eating, but in cold summers the fruit is not eatable in the raw state, and can only be converted into wine or vinegar. For outdoor culture the long-rod system is generally preferred.

When the plant is grown under glass, the vine border should occupy the interior of the house and extend outwards in the front, but it is best made by instalments of 5 or 6 feet as fast as the previous portions become well filled with roots, which may readily be done by packing up a turf wall at the extremity of the portion to be newly made; an exterior width of 15 feet will be sufficient. Inside borders require frequent and thorough waterings. In well-drained localities the border may be partially below the ground level, but in damp situations it should be made on the surface; in either case the firm solid bottom should slope outwards toward an efficient drain. A good bottom may be formed by chalk rammed down close. On this should be laid at least a foot thick of coarse hard rubbly material, a layer of rough turf, grass side downwards, being spread over it to prevent the compost from working down. The soil itself, which should be 2½ or 3 feet deep, never less than 2 feet, should consist of five parts rich turfy loam, one part old lime rubbish or broken bricks, including a little wood ashes or burnt earth (ballast), one part broken charcoal, and about one part of half-inch bones, the whole being thoroughly mixed, and kept dryish till used.

Young vines raised from eyes are generally preferred for planting. The eyes being selected from well-ripened shoots of the previous year are planted about the end of January, singly, in small pots of light loamy compost, and after standing in a warm place for a few days should be plunged in a propagating bed, having a bottom heat of 75°, which should be increased to 85° when they have produced several leaves, the atmosphere being kept at about the same temperature or higher by sun heat during the day, and at about 75° at night. As soon as roots are freely formed the plants must be shifted into 6-inch pots, and later on into 12-inch ones. The shoots are trained up near the glass, and, with plenty of heat (top and bottom) and of water, with air and light, and manure water occasionally, will form firm strong well-ripened canes in the course of the season. To prepare the vine for planting, it should be cut back to within 2 feet of the pot early in the season, and only 3 or 4 of the eyes at the base should be allowed to grow on. The best time for planting is in spring, when the young shoots have just started. The vines should be planted inside the house, from 1 to 2 feet from the front wall, the roots being placed an inch deeper in the soil than before, carefully disentangled and spread outwards from the stem, and covered carefully and firmly with friable loam, without manure. When the shoots are fairly developed, the two strongest are to be selected and trained in. When forcing is commenced, the vinery is shut up for two or three weeks without fire heat, the mean temperature ranging about 50°. Fire heat must be at first applied very gently, and may range about 55° at night, and from 65° to 70° by day, but a few degrees more may be given them as the buds break and the new shoots appear. When they are in flower, and onwards during the swelling of the berries, 85° may be taken as a maximum, running up to 90° with sun heat, and the temperature may be lowered somewhat when the fruit is ripe. As much ventilation as the state of the weather will permit should be given. A moist growing atmosphere is necessary both for the swelling fruit and for maintaining the health of the foliage. A due amount of moisture may be kept up by the use of evaporating troughs and by syringing the walls and pathways two or three times a day, but the leaves should not be syringed. When the vines are in flower, and when the fruit is colouring, the evaporating troughs should be kept dry, but the aridity must not be excessive, lest the red spider and other hurtful insects should attack the leaves. In the course of the season the borders (inside) will require several thorough soakings of warm water,—the first when the house is shut up, this being repeated when the vines have made young shoots a few inches long, again when the vines are in flower, and still again when the berries are taking the second swelling after stoning. Outside borders require watering in very dry summer weather only.

There are three principal systems of pruning vines, termed the *long-rod*, the *short-rod*, and the *spur* systems, and good crops have been obtained by each of them. It is admitted that larger bunches are generally obtained by the long-rod than by the spur system. The principle of this mode of pruning is to train in at considerable length, according to their strength, shoots of the last year's growth for producing shoots to bear fruit in the present; these rods are afterwards cut away and replaced by young shoots trained up during the preceding summer; and these are in their turn cut out in the following autumn after bearing, and replaced by shoots of that summer's growth. By the short-rod system, short instead of long rods are retained; they are dealt with in a similar manner. The spur system has, however, become the most general. In this case the vines are usually planted so that one can be trained up under each rafter, or up the middle of the sash, the latter method being preferable. The shoots are cut back to buds close to the stem, which should be encouraged to form alternately at equal distances right and left, by removing those buds from the original shoot which are not conveniently placed. The young shoots from these buds are to be gently brought to a horizontal position, by bending them a little at a time, and usually opposite about the fourth leaf the rudiments of a bunch will be developed. The leaf directly opposite the bunch must in all cases be preserved, and the young shoot is to be topped at one or two joints beyond the incipient fruit, the latter distance being preferable if there is plenty of room for the foliage to expand; the lateral shoots, which will push out after the topping, must be again topped above their first or second joints. If the bunches are too numerous they must be thinned before the flowers expand, and the berries also must be properly thinned out and regulated as soon as they are well set, care being taken, in avoiding overcrowding, that the bunches be not made too thin and loose.

The cultivation of vines in pots is very commonly practised with good results, and pot-vines are very useful to force for the earliest crop. The plants should be raised from eyes, and grown as strong as possible in the way already noted, in rich turfy loam mixed with about one-third of horse dung and a little bone dust. The temperature should be gradually increased from 60° to 80°, or 90° by sun heat, and a bottom heat a few degrees higher must be maintained during their growth. As the roots require more room, the plants should be shifted from 3-inch pots into those of 6, 12, or 15 inches in diameter, in any of which larger sizes they may be fruited in the following season, but, to be successful in this, the young rod produced must be thoroughly matured after it has reached its limit of growth.

The vine, both indoors and out, is very subject to the vine-mildew, which appears to the naked eye like a white powder; when this is visible there is no effectual remedy, but if taken at the earliest stage it may be destroyed by dusting the whole plant, stem, leaves, and fruit, with sulphur. An equally destructive enemy is the vine louse, *Phylloxera vastatrix*. No certain easily applied cure has yet been discovered, and practically the only sure remedy is to destroy the vines, clear out the old infested soil, and cleanse the structures thoroughly in every part.

The number of varieties of grapes possessing some merit is considerable, but a very few of them will be found sufficient to supply all the wants of the cultivator. For general purposes nothing approaches the Black Hamburg (including Frankenthal) in merit. Those named below are more or less in requisition:—

Outdoor Grapes.

Black Cluster—small, roundish-oval, black berries.
Black Prince—largish, oval, purplish-black berries.
Early Ascot Frontignan—round, amber-coloured berries; musky flavour.
Early Saumur Frontignan—medium, round, pale-amber berries; musky.
Early White Malvasia (Grove-end Sweetwater)—roundish, whitish-green berries.
July Frontignan—medium, round, blue-black berries; musky flavour.
Miller's Burgundy (The Miller)—small, roundish-oval, black berries.
Royal Muscadine (Chasselas de Fontainebleau)—large, round, greenish-yellow berries; one of the best white grapes, indoors or out.

Indoor Grapes.

Alicante—large, oval, blue-black berries; late, and a good keeper.
Black Hamburg—large, roundish-oval, black berries; A 1 in every respect.
Black Monukka—medium, obovate-oblong, brownish-black, seedless, crackling berries; very pleasant eating; may be grown as a curiosity.
Buckland Sweetwater—large, roundish, pale amber berries.
Canon Hall Muscat—large, roundish, amber berries; high musky flavour.
Chasselas Musqué—medium, round, pale amber berries; rich musky flavour.
Duchess of Buccleuch—small, round, greenish-white berries; musky.

Duke of Buccleuch—very large, roundish, greenish-amber berries.
Foster's White Seedling—largish, roundish-oval, greenish-yellow berries.
Frankenthal (Victoria Hamburg)—large, roundish-oblate, black berries.
Grizzly Frontignan—medium, round, grizzly red berries; musky.
Gros Colman—very large, round, black berries; late, requires to hang long.
Gros Maroc—large, oval, purple-black berries; very fine, late.
Lady Downe's—largish, roundish-oval, black berries; late, a good keeper.
Madresfield Court—large, oval or oblong, black berries; slightly musky.
Mill Hill Hamburg—very large, round or oblate, hammered, blue-black.
Muscat of Alexandria—large, oval, pale-amber berries; musky flavour.
Muscat Hamburg—large, oval, black berries; musky flavour.
Raisin de Calabre—large, round, transparent white berries; late.
Trebbiano—medium, roundish-oval, greenish-white berries; late.
Venn's Black Muscat—medium, oval, brownish-black berries; musky.
West's St Peter's—largish, roundish-oval, blue-black berries; late.
White Frontignan—medium, round, greenish-yellow berries; musky.

For the open wall, the Early Ascot Frontignan, Early White Malvasia, and Royal Muscadine may be preferred of the white sorts; and July Frontignan and Black Cluster of the blacks. For a greenhouse vinery, Black Hamburg and Madresfield Court, black; and Foster's White Seedling, Buckland Sweetwater, and Royal Muscadine, white. For early forcing, Black Hamburg and Muscat Hamburg, black; Foster's White Seedling, Royal Muscadine, White Frontignan, and Duke of Buccleuch, white. For a general midseason crop, Black Hamburg or Frankenthal, and Lady Downe's, black; Grizzly Frontignan, reddish; and Muscat of Alexandria and Raisin de Calabre, white. For hanging late, Alicante, Gros Colman, Gros Maroc, Lady Downe's, and West's St Peter's, black; and Muscat of Alexandria and Trebbiano, white.

Walnut. 138. The *Walnut*, Juglans regia, is a lofty tree, native of Persia and Asia Minor. The fruit, whilst young and tender, is much used for pickling, and when ripe is a favourite article of the dessert. The tree succeeds in deep sandy or calcareous loams, and in stiff loams resting on a gravelly bottom. It requires free exposure to air and light. It is propagated by seeds, and occasionally by budding, grafting, or inarching for the perpetuation of special varieties. The trees form their heads naturally, and therefore little pruning is required, it being merely necessary to cut off straggling growths, and to prevent the branches from interlacing. The best time for performing this is in the autumn, just after the fall of the leaf. Plants raised from the seed seldom become productive till they are twenty years old. The fruit is produced at the extremities of the shoots of the preceding y ar; and therefore, in gathering the crop, care should be taken not to injure the young wood. In some parts of England the trees are thrashed with rods or poles to obtain the nuts, but this is far from being a commendable mode of collecting them.

Besides the common walnut, there are several varieties cultivated, particularly the Thin-shelled and the Thetford or Highflyer, which last is by far the best walnut grown.

Orchard-house trees. 139. *Orchard-house Trees.*—The fruits that may be successfully grown in unheated orchard-houses are peaches, nectarines, apricots, plums, figs, cherries, pears, and apples; and all, except the last two, are more readily obtained in those which are judiciously heated.

The trees are sometimes planted out, and sometimes grown in pots. The potted trees are decidedly to be preferred, for those which are planted out are less at the command of the cultivator, and unless the houses are large are apt to outgrow the space; they do not indeed require so much attention as regards water, while pot trees entail very much labour in this respect from the time the fruit is fairly set until it is near the ripening stage; but on the other hand a much greater variety may be grown in this way, and the trees can be shifted from place to place, as required, with the utmost facility. While at rest in winter they can be set close together without injury, and may be continued in this way until they come into flower. After the setting of the fruit, the hardier sorts, as plums, pears, and apples, can be taken out, and put under temporary awnings till it is safe to plunge them beside the walks in the open quarters of the garden, where they grow and swell, if duly watered, as well as if established in the ground. In dry summer weather they need a good watering two or three times a day, and besides this should have a dose of liquid manure occasionally. This removal of the hardier plants to the open air leaves more space under glass for the tenderer sorts.

The trees are most convenient when trained in the pyramidal form, or as compact bushes; and the summer treatment should consist in pinching back the points of all the growing shoots after they have formed two or three leaves.

The vigour of pot fruit trees is greatly due to judicious surface-dressing during the summer months. It should be applied at intervals of ten or twelve days, and should be made up of equal parts of horse-droppings, turfy loam, and malt dust, the whole being laid up in a heap and frequently turned. The dressing should not, however, be applied within three weeks of the ripening of the fruit.

The trees should be repotted in autumn as soon as the leaves have done their work, in similar compost to that first employed—good turfy loam, with about a sixth of rotted manure, and a sprinkling of bone dust. They are to be turned out of the pot, and a slice of about an inch in thickness pared off with a sharp knife, and are then to be replaced in a pot of the same size as that in which they previously grew, unless in those cases where a larger one may be afforded, and then the roots need not be cut away. This disrooting may sometimes be done before the leaves are quite ready to fall, in which case care is necessary to prevent the tree from flagging; and, if the weather be hot, the tops should be kept moist by frequently dewing the foliage with the syringe, but no water must be given at the root for a day or two after repotting. If the wood has been well ripened, trees treated in this way will bear freely during the following season. Whether placed on the floor of the house, or plunged outdoors, the pots should stand on two bricks placed a little apart, so that worms cannot gain admittance by the draining-hole.

The fruit obtained from trees well cultivated in pots in an orchard-house will compare, as regards size and quality, with the best fruit ripened on an open wall or in a forcing-house; but, when grown without fire heat, it is of course but little in advance of the outdoor crops. To the amateur this mode of culture will be found to present many attractions.

VII. *Vegetables.*

140. Under this head we include those esculents which are largely eaten as "vegetables" or as "salads," while the various "herbs" which are used chiefly for flavouring or garnishing will be referred to in a supplementary paragraph.

141. The *Artichoke*, Cynara Scolymus, is a stout-growing hardy perennial, cultivated for the sake of the immature flower-heads. In France the whole of the leaves of the involucre are eaten when in a young and tender state, *en poivrade*, or with pepper, salt, and vinegar; but the only parts of the flower-head used in England are the base of the leaves of the involucre, and the immature floral receptacle called the *bottom*, freed from the bristly seed-down which is called the *choke*. In old plantations about to be destroyed the central leaves are sometimes blanched and eaten; this edible part, like that of the nearly related cardoon (par. 150), is called the *chard*. Ar-cho[ke.]

The artichoke requires a deep cool dry soil, well enriched, and deeply trenched. It is propagated by parting the roots in April, the sets being planted in rows 4 or 5 feet asunder, and 2 feet apart in the rows. As the young plants afford a crop which succeeds that of old plants, a new plantation is made in some gardens every year. During summer the artichokes require little other attention than to be kept clear of weeds. In November the decayed stems and leaves are removed, the ground cleared, and a cone of a foot deep of sifted coal-ashes, or rotten tan, or littery dung, is placed close round the base to defend the stools from frost. In April this is taken away, the stocks are examined, and two or three only of the strongest shoots are permitted to remain; a dressing of manure is given—well-rotted hotbed dung or seaweed—and the ground between the rows is forked over. The offsets, carefully removed, afford materials for young plantations. The heads are cut when nearly full grown, before the scales of the involucre open out.

The varieties most esteemed in England are the Green or French, which has conical heads, and is considered the highest flavoured; the Globe, which has dull purplish heads, and is well adapted for a general crop; and the Purple, which is the earliest. The Laon is that most widely grown at Paris.

142. The *Asparagus*, Asparagus officinalis, is one of the most delicate of our esculents, possessing well-marked diuretic properties, and is grown extensively in private gardens as well as for market. The asparagus prefers a loose light deep sandy soil; the depth should be 3 feet, the soil being well trenched, and all surplus water got away. A considerable quantity of well-rotted dung or of recent seaweed should be laid in the bottom of the trench, and another top-dressing of manure should be dug in preparatory to planting or sowing. Nitrate of soda appears to be the best artificial manure, and salt applied at the rate of 2 lb to the square yard is a good dressing while the plants are growing. The beds should be 3 feet or 5 feet wide, with intervening alleys of 2 feet, the narrower beds taking two rows of plants, the wider ones three rows. The beds should run east and west, so that the sun's rays may strike against the side of the bed. In some cases the plants are grown in equidistant rows 3 to 4 feet apart. Where the beds are made with plants already prepared, either one-year old or two-year old plants may be used, for which a trench should be cut sufficient to afford room for spreading out the roots, the crowns being all kept at about 2 inches below the surface. Planting is best done in May, after the plants have started into growth. To prevent injury to the roots, it is, however, perhaps the better plan to sow the seeds in the beds where the plants are to remain. As-pa[ragus.]

The seed should be sown in March in slight drills; and it is a good precaution to sow more than is necessary, and to thin out towards the end of the first summer, to the distance of about 6 inches in the rows. The ground must be hoed and kept clear of weeds. Frequently slight crops of lettuce are taken from the surface of the beds, and of cauliflower from the spaces between them. The asparagus heads should not be cut before the third spring, and are not in perfection till the fourth or fifth.

The manuring of asparagus, which can scarcely be overdone, should be performed in the end of autumn, when the dead stems are removed. When the plants are in beds, the surface should be stirred with a fork; a layer of well-rotted hotbed dung should then be laid on, and the whole covered with a sprinkling of earth from the alleys. If the plants are grown in rows, the manure is simply dug in between them by means of a digging fork, care being taken not to injure the roots. These operations are repeated annually, and no other culture is required; but it is necessary to observe a due moderation in reaping the crop, as the shoots, when cut too freely, become gradually smaller. A considerable quantity of ground is consequently required to keep up a supply. It is a general rule never to gather asparagus after peas have come into season. To experience the finest flavour of asparagus, it should be eaten immediately after having been gathered; if kept longer than one day, or set into water, its finer flavour is altogether lost. If properly treated, asparagus beds will continue to bear well for many years.

The asparagus grown at Argenteuil, near Paris, has acquired much notoriety for its large size and excellent quality. The French growers plant in trenches, instead of raised beds.

Forcing.—The most common method of forcing asparagus is to prepare, early in the year, a moderate hotbed of stable litter with a bottom heat of 70°, and to cover it with a common frame. After the heat of fermentation has somewhat subsided, the surface of the bed is covered with a layer of light earth or exhausted tan-bark, and in this the roots of strong mature plants are closely placed. The crowns of the roots are then covered with 3 to 6 inches of soil. A common three-light frame may hold 500 or 600 plants, and will afford a supply for several weeks. After planting, linings are applied when necessary to keep up the heat, but care must be taken not to scorch the roots; air must be occasionally admitted. Where there are pits heated by hot water or by the tank system, they may be advantageously applied to this purpose. A succession of crops must be maintained by annually sowing or planting new beds. Mr Lindegard, of the Royal Gardens at Copenhagen, recommends the plan of forcing asparagus on the ground on which it grows, but the results obtained in this way are not so satisfactory.

The principal varieties are the Red-topped and the Green-topped, of which there are several reputed sub-varieties, as the Battersea, Gravesend, Giant, Colossal, &c., which differ but slightly from each other.

ean. 143. The *Bean*, Faba vulgaris, is an annual plant. The seeds are sown about 4 inches apart, in drills 2½ feet asunder for the smaller and 3 feet for the larger sorts. The soil should be a rather heavy loam, deeply worked and well enriched. For an early crop Marshall's Early Dwarf Prolific and the Dwarf Crimson-seeded may be sown in November, and protected during winter in the same manner as early peas. An early crop may also be obtained by dibbling in the seeds in November, sheltering by a frame, and in February transplanting them to a warm border. Successional crops of Early Seville or Early Longpod should be sown in January and February, and the Longpods or Green Windsor in March, April, and May, for a general crop, while for later crops the Dutch Longpod may be sown in June or early in July. All the culture necessary is that the earth be drawn up about the stems. The plants are usually topped when the pods have set, as this not only removes the black aphides which often settle there, but is also found to promote the filling of the pods.

The following are some of the best sorts:—

Early.—Dwarf Crimson-seeded, Marshall's Early Dwarf Prolific, Early Seville, Early Longpod.

Late.—Windsor, Green Windsor, Dutch Longpod.

See BEAN, vol. iii. p. 460, and AGRICULTURE, vol. i. p. 360.

et. 144. The *Beet*, Beta vulgaris, is a hardy biennial, native of the south of Europe, on the sea-coast. The boiled root is eaten cold, either by itself or as a salad; it is also often used as a pickle. The beet prospers in a rich deep soil, well pulverized by the spade. If manure is required, it should be deposited at the bottom of the trench in preparing the ground. The seeds should be sown in drills 15 inches asunder, in April or early in May, and the plants are afterwards to be thinned to about 8 inches apart in the lines, but not more, as moderate-sized roots are preferable. The plants should grow on till the end of October or later, when a portion should be taken up for use, and the rest laid in in a sheltered corner, and covered up from frost. The roots must not be bruised, and the leaves must be twisted off—not closely cut, as they are then liable to bleed. In the north the crop may be wholly taken up in autumn, and stored in a pit or cellar, beyond reach of frost. If it is desired to have fresh roots early, the seeds should be sown at the end of February or beginning of March; and if a succession is required, a few more may be sown by the end of March.

The Yellow Beets are not appreciated at table, and the White Sugar Beets are not suitable for garden culture. We shall only name a selection of the red-fleshed sorts:—Turnip-rooted or Egyptian (very early), Red Castelnaudary (the type of our best beets), Pine-apple Short-top, Nutting's Selected, Carter's Perfection of Beets, Sutton's Dark Red, Dell's Crimson or Osborn's Select.

The White Beet, Beta Cicla, is cultivated for the leaves, which are used as spinach; but for this they are a very sorry substitute. The midribs and stalks of the leaves are also stewed and eaten as seakale, under the name of Swiss chard. The culture does not differ materially from that of the red beet, but more space is required.

See BEET, vol. iii. p. 504, and AGRICULTURE, vol. i. p. 381.

recole. 145. The *Borecole* or *Kale*, Brassica oleracea acephala, includes several varieties which are amongst the hardiest of our esculents, and seldom fail to yield a good supply of winter greens. They require well-enriched soil, and sufficient space for full exposure to air; and they should also be sown early, so as to be well established and hardened before winter.

The main crops should be sown about the first week of April, or, in the north, in the third week of March, and a succession a month later. The Buda kale is sown in May, and planted out in September, but a sowing for late spring use may be made in the last week of August, and transplanted towards the end of September. To prevent overcrowding, the plants should be transplanted as soon as they are of sufficient size, but if the ground is not ready to receive them a sufficient number should be pricked out in some open spot. In general the more vigorous sorts should be planted in rows 2½ feet or 3 feet and the smaller growers 2 feet apart, and 18 inches from plant to plant. In these the heads should be first used, only so much of the heart as is fresh and tender being cut out for boiling; side shoots or sprouts are afterwards produced for a long time in succession, and may be used so long as they are tender enough to admit of being gathered by snapping their stalks asunder.

The best of the borecoles or kales are—Dwarf Green Curled or Scotch Kale, very hardy, and from its dwarf habit often sheltered by snow; Cottager's Kale, very hardy, one of the most prolific and well-flavoured; Purple Borecole, very hardy. The following are less vigorous in growth, but are of excellent quality:—Jerusalem Kale, Egyptian Kale, Buda Kale,—the last two very hardy.

146. The *Broccoli*, Brassica oleracea botrytis asparagoides, is supposed to have sprung from the cauliflower, being, like it, of Italian origin, and differing chiefly in possessing greater hardiness of constitution. Miller indeed states (*Gardeners' Dictionary*) that the broccolis known in his time were imported from the island of Cyprus. Broccoli

The broccoli succeeds best in a fresh, loamy soil, somewhat firm in texture. For the autumn broccolis the ground can scarcely be too rich, but the winter and spring sorts, on ground of this character, are apt to become so succulent and tender that the plants suffer from frost even in sheltered situations, while plants less stimulated by manure and growing in the open field may be nearly all saved, even in severe winters. The main crops of the early sorts, for use in autumn, such as the Capes and Grange's, should be sown early in May, and planted out while young, to prevent them coming too early into flower; in the north they may be sown a fortnight earlier. The later sorts, for use during winter and spring, should be sown about the middle or end of May, or about ten days earlier in the north. The seed beds should be made in fresh light unexhausted soil; and if the season be dry, the ground should be well watered before sowing. If the young plants are crowding each other, they should be thinned. The ground should not be dug before planting them out, as the firmer it is the better; but a shallow drill may be drawn to mark the lines. The larger growing sorts may be put in rows 3 feet apart, and the plants about 2½ feet apart in the rows, and the smaller-growing ones at from 2 to 2½ feet between, and 1½ to 2 feet in the rows. If the ground is not prepared when young plants are ready for removal, they should be transferred to nursery beds and planted at 3 to 4 inches apart, but the earlier they can be got into their permanent places the better.

It is of course the young flower-heads of the plant which are eaten. When these form, they should be shielded from the light, by bending or breaking down an inner leaf or two. In some of the sorts the leaves naturally curve over the heads. To prevent injury to the heads by frost in severe winters, the plants should be laid in with their heads sloping towards the north, the soil being thrown back so as to cover their stems; or they may be taken up and laid in closely in deep trenches, so that none of the lower bare portion of the stem may be exposed. Some dry fern may also be laid over the tops.

The spring varieties are extremely valuable, as they come at a season when the finer vegetables are scarce. They afford a supply from March to May inclusive. In all cases great care should be taken to procure the seed true, as it is very liable to become deteriorated through crossing by insect agency.

The following are good types of broccoli, but the varieties are frequently changing, in name at least, the supposed novelties being often merely good and pure stocks of older kinds:—

For autumn and winter use: Early Purple Cape, Early White Cape, Grange's, Veitch's Self-protecting Autumn, Snow's Superb Winter White, Osborn's Winter White, Backhouse's Winter.

For late winter and spring use: Knight's Protecting, Cooling's Matchless, Leamington, Chappel's Cream, Ellotson's Mammoth, Sutton's Perfection, Penzance, Purple Sprouting.

For the latest supply: Cattell's Eclipse, Carter's Champion, Lauder's Goshen, Late White Protecting, Miller's Dwarf Late White.

147. The *Brussels Sprouts*, Brassica oleracea bullata gemmifera, have long been cultivated near Brussels. There appears to be no information as to the plant's origin, but, according to the late Dr Van Mons, it is mentioned in the year 1213, in the regulations for holding the markets of Belgium, under the name of *spruyten* (sprouts). It is very hardy and productive, and is much esteemed for the table on account of its flavour and its sightly appearance. Brussels sprouts.

The seed should be sown about the middle of March, and again in the first or second week in April for succession. Any good garden soil is suitable. For an early crop it may be sown in a warm pit in February, pricked out and hardened in frames, and planted out in a warm situation in April. The main crop may be planted in rows 2 feet asunder, the plants 18 inches apart. They should be got out early, so as to be well established and come into use before winter. The head may be cut and used after the best of the little rosettes which feather the stem have been gathered; but, if cut too early, it exposes these rosettes, which are the most delicate portion of the produce, to injury, if the weather be severe.

The earliest sprouts become fit for use in November, and they continue good, or even improve in quality, till the month of March following. Van Mons mentions that by successive sowings the sprouts are obtained in Brussels for the greater part of the year.

The most reliable crop is perhaps obtained from seed of the ordinary variety imported from Holland; but good English-raised seed, represented by Carter's Perfection, may also be obtained. Scrymger's Giant is a vigorous dwarf kind. We doubt, however, the policy of planting dwarf kinds, as the taller ones with longer stems, if sufficiently vigorous, must yield a larger produce.

In this place may be noted two hybrid sprouts, both raised by Mr Melville, at Dalmeny Park, near Edinburgh. They are the Albert Sprouts, a hardy green, long in running to seed, the result of a cross between the savoy and Brussels sprouts; and the Dalmeny Sprouts, which grow 6 inches or 8 inches high, with a compactly cabbaged head of moderate size, and a stem thickly set with cabbage-like sprouts, a cross obtained between the cabbage and Brussels sprouts. Both may be grown in the same way as the borecoles.

Cabbage. 148. The *Cabbage*, Brassica oleracea capitata, has sprung from the biennial B. oleracea of the British sea-coasts. The cabbage requires a well-manured and well-wrought loamy soil. It should have abundant water in summer, liquid manure being specially beneficial. Round London, where it is grown in perfection, the ground for it is dug to the depth of two spades or spits, the lower portion being brought up to the action of the weather, and rendered available as food for the plants; while, the top-soil, containing the eggs and larvæ of many insects, being deeply buried, the plants are less liable to be attacked by the club. Farm-yard manure is that most suitable for the cabbage, but artificial manures such as guano, superphosphate of lime or gypsum, together with lime-rubbish, wood-ashes, and marl, may, if required, be applied with advantage.

The first sowing of cabbage should be made about the beginning of March, and should consist of Nonpareil or Enfield Market (also known as the Early Battersea); these will be ready for use in July and August, following the autumn-sown crops. Another sowing of the same sorts, or of the St John's Day, should be made in the last week of March or first week of April, and will afford a supply from August till November; and a further crop of such sorts as Early York, Little Pixie, Atkins's Matchless, or other kinds that heart quickly, may be made in May to supply young-hearted cabbages in the early part of winter. The autumn sowing, which is the most important, and affords the supply for spring and early summer use, should be made about the last week in August, in warm localities in the south, and about a fortnight earlier in the north; or, to meet fluctuations of climate, it is as well in both cases to anticipate this sowing by another two or three weeks earlier, planting out a portion from each, but the larger number from that sowing which promises best to stand without running to seed. The sorts should be Enfield Market, Nonpareil, or Winnigstadt. These later sown plants will be ready for transplanting by the end of September or early in October, and may be placed in the ground previously occupied by the pea or bean crop.

The cabbages grown late in autumn and in the beginning of winter are denominated Coleworts (vulg. Collards), from a kindred vegetable no longer cultivated. Two sowings are made, in the middle of June and in July, and the seedlings are planted a foot or 15 inches asunder, the rows being 8 or 10 inches apart. The sorts employed are the Rosette and the Hardy Green.

About London the large sorts, as Enfield Market, are planted for spring cabbages 2 feet apart each way; but a plant from an earlier sowing is dibbled in between every two in the rows, and an intermediate row a foot apart is put in between the permanent rows, these extra plants being drawn as coleworts in the course of the winter. The smaller sorts of cabbage may be planted 12 inches apart, with 12 or 15 inches between the rows. The large sorts should be planted 2 feet apart, with 2½ feet between the rows. The only culture required is to stir the surface with the hoe to destroy the weeds, and to draw up the soil round the stems.

The *Red Cabbage*, Brassica oleracea capitata rubra, of which the Red Dutch is the most commonly grown, is much used for pickling. It is sown about the end of July, and again in March or April. The Dwarf Red and Utrecht Red are smaller sorts. The culture is in every respect the same as in the other sorts, but the plants have to stand until they form hard close hearts.

The *Couve Tronchuda* or *Portugal Cabbage*, Brassica oleracea acephala costata, is of a distinct type and of excellent quality. The fleshy ribs of the leaves, cooked like sea-kale, are the only parts eaten. It is somewhat tender, and requires to be sown early in spring for use during the autumn.

The names of the varieties of cabbage are very numerous, but, on comparing them at Chiswick, Mr Barron reduces the garden varieties to about seventeen types, the best of which are:—*Early sorts*: Atkins's Matchless, Early York, Little Pixie, Nonpareil, St John's Day. *Mid-season*: Enfield Market (Battersea or Fulham), Rosette Colewort, Winnigstadt. *Late sorts*: Bacalan, Hardy Green Colewort, Pomeranian. See CABBAGE, vol. iv. p. 617.

Capsicum. 149. The *Capsicum* is the produce of several species of the genus Capsicum cultivated for the sake of their pods, which in a green state are used in salads and in pickles, and when ripe are powdered to form cayenne pepper. The pods, either green or ripe, are also used to make Chili vinegar.

The *Annual Capsicum, Spanish Pepper*, or *Guinea Pepper*, Capsicum annuum, is the sort most commonly grown. The seeds should be sown in a hotbed in February, the young plants being transferred successively into 3-inch, 5-inch, and 8-inch pots. They require a warm genial atmosphere, and a light rich soil, and should be assisted with liquid manure or such artificial fertilizers as Clay's or Jackman's. In the south of England they may be grown in the open air, on a warm sunny border, if planted out towards the end of June. The fruit ripens in September, and may be kept two or three years in a dry room. The *Bird Pepper*, C. baccatum, and the *Chili*, C. frutescens, are both sub-shrubby plants, requiring stove heat. They should be grown in peaty soil, should not be overpotted, and should be kept dryish at the root in winter. The best cayenne pepper is prepared from C. frutescens, and C. baccatum is much relished by some persons. The *Bell Pepper*, C. grossum, and the *Large Sweet Spanish*, are milder in flavour than the other sorts, and are much eaten in salads and also with cold meats. See CAYENNE PEPPER, vol. v. p. 280.

Cardoon. 150. The *Cardoon*, Cynara Cardunculus, a perennial from the south of Europe and Barbary, is a near relation of the artichoke (par. 141). The edible part, called the *chard*, is composed of the blanched and crisp stalks of the inner leaves. Cardoons are found to prosper on light deep soils. The seed is sown annually about the middle of May, in shallow trenches, like those for celery, and the plants are thinned out to 10 or 12 inches from each other in the lines. In Scotland it is preferable to sow the seed singly in small pots, placing them in a mild temperature, and transplanting them into the trenches after they have attained a height of 8 or 10 inches. Water must be copiously supplied in dry weather, both to prevent the formation of flower stalks and to increase the succulence of the leaves. In autumn the leaf-stalks are applied close to each other, and wrapped round with bands of hay or straw, only the points being left free. Earth is then drawn up around them to the height of 15 or 18 inches. Sometimes cardoons are blanched by a more thorough earthing up, in the manner of celery, but in this case the operation must be carried on from the end of summer. During severe frost the tops of the leaves should be defended with straw or litter. Besides the common and Spanish cardoons, there are the prickly-leaved Tours cardoon, the red-stemmed cardoon, and the Paris cardoon, all of superior quality, the Paris being the largest and most tender. The common artichoke is also used for the production of chard.

Carrot. 151. The *Carrot*, Daucus Carota, has been much improved and transformed from the wild state; it is probably a native of the sea-coasts of southern Europe, but is now abundant throughout Europe and Asiatic Russia. The carrot delights in a deep sandy soil, which should be well drained and deeply trenched. In regard to the preparation of the ground, one of our best northern gardeners has said—"Trench in autumn; trench deep and lay the manure at the bottom of the trench; in spring rake down, lay on an inch of wood ashes, and dig them lightly in." For the long-rooted sorts the soil should be at least 3 feet deep, but the Short Horn varieties may be grown in about 6 inches of good compost laid on the top of a less suitable soil. Peat earth may be usefully employed in lightening the soil. Good carrots of the larger sorts may be grown in unfavourable soils by making large holes 18 inches deep with a crowbar, and filling them up with sandy compost in which the seeds are to be sown. The main crop is sown at the end of March or beginning of April. After sowing, it is only necessary to thin the plants, and keep them clear of weeds. The roots are taken up in autumn and stored during winter in a cool shed or cellar.

Forcing.—For a supply of young carrots in winter, a hotbed composed of 3 or 4 feet thick of leaves, or of 18 inches of dung, or of 2 feet of dung and leaves mixed, should be prepared about the end of November or beginning of December, and covered with a frame and lights. The bed should be surfaced with 8 or 9 inches of light soil, of which leaf-mould may form a considerable proportion, and the seed of Early Short Horn, Early Nantes, or French Forcing should be sown in drills 3 inches apart, and covered to the depth of ½ inch. The young plants should be thinned to 1½ inches apart. The temperature should range from 60° to 65°, as much light and air being given as possible, but the sashes should be covered at night, especially in frosty weather. For succession sow again on a gentle hotbed under glass early in February, and follow this by another sowing on a warm sheltered south border early in March. The seed bed should be made up of light rich compost, in a situation well exposed to the sun. If these quick-growing sorts are preferred, small successional sowings should be made in May and again in July, James's Intermediate being substituted at the last sowing. Where a little protection can be given by a frame in winter, some of the Early Short Horn may be sown in August for spring use.

The following are good garden carrots:—*Early*: French Forcing, Early Nantes, Early Short Horn. *Mid-season*: James's Intermediate, Long Blunt Red. *Main Crop*: Long Surrey, Altrincham. See AGRICULTURE, vol. i. p. 369.

Cauliflower. 152. The *Cauliflower*, Brassica oleracea botrytis cauliflora, is said by our old authors to have been introduced from Cyprus, where, as well as on the Mediterranean coasts, it appears to have been cultivated for ages. It is one of the most delicately flavoured of vegetables, the dense cluster formed by its incipient succulent flower-buds being the edible portion.

The sowing for the first or spring crop, to be in use in May and June, should be made from the 15th to the 25th of August for England, and from the 1st to the 15th of August for Scotland. In the neighbourhood of London the growers adhere as nearly as possible to the 21st day. A sowing to produce heads in July and August takes place in February on a slight hotbed. A late spring sowing to produce cauliflowers in September or October or later, should be made early in April, and another about the 20th of May.

The cauliflower succeeds best in a rich soil and sheltered position; but, to protect the young plants in winter, they are sometimes pricked out in a warm situation at the foot of a south wall, and in severe weather covered with hoops and mats. A better method is to plant them thickly under a garden frame, securing them from cold by coverings, and giving air in mild weather. For a very early supply, a few scores of plants may be potted and kept under glass during winter, and planted out in spring, defended with a hand-glass. Sometimes patches of three or four plants on a south border are sheltered by hand-glasses throughout the winter. It is advantageous to prick out the spring-sown plants into some sheltered place, before they are finally transplanted in May. The later crop, the transplanting of which may take place at various times, is treated like early cabbages. After planting, all that is necessary is to hoe the ground, and draw up the soil about the stems.

It is found that cauliflowers ready for use in October may be kept in perfection over winter. For this purpose they are lifted carefully with the spade, keeping a ball of earth attached to the roots. Some of the large outside leaves are removed, and any points of leaves that immediately overhang the flower are cut off. They are then placed either in pots or in hotbed frames, the plants being arranged close together, but without touching. In mild dry weather the glass frames are drawn off, but they are kept close during rain storms; and in severe frost they are thickly covered with mats.

The late Mr Barnes of Bicton informs us in the *Gardeners' Magazine* that his cauliflowers for spring are sown the first week of October, in pans, in a little bottom heat; and about the end of the month, or the beginning of November, are potted into 3-inch pots, and plunged close to the glass. The plants are kept shifted on in some old melon-bed mould until the beginning of January, when they are shifted finally into 7-inch pots. In the first week in February the ground is prepared. If wet, a little of the soil is taken out where each hand-glass is to stand, and replaced with dry dusty rubbish, in order to prevent the cauliflowers from getting the disease of "black legs." Four plants are turned out under each hand-glass. If the weather proves dry, a liquid manure, consisting of ¼ lb of nitrate of soda to 1 hogshead of cow-dung water, with the addition of a few gallons of hot water, is applied, which causes the plants to grow in March as in May, and produce fine cauliflowers early in April. Mr Barnes states that by shifting on the plants until they are in 12-inch pots, and then placing them in a vinery or peach-house, he has had cauliflowers early in March.

Some of the best varieties of cauliflower are—the Walcheren, which, if true, is of excellent quality, and the most generally useful for autumn; Dwarf Erfurt, which is very dwarf and early, and good for summer and early autumn use; Early London, rather tall, but with a fine compact curd; Lenormand's, a second early; Snowball, dwarf, compact, and quick-heading; and Veitch's Autumn Giant, which is an excellent hardy sort for autumn.

Celeriac. 153. The *Celeriac*, Apium graveolens rapaceum, the *céleri-navet* of the French, is a variety of celery in which the stem forms an irregular knob, which is the part used, either sliced in salads or cooked. It is a hardy substitute for other kinds of celery. The roots grow to 3 lb or 4 lb weight. The plants should be reared like those of celery; and, some time before winter sets in, they should be taken up and stored amongst sand in a shed or cellar.

Celery. 154. The *Celery*, Apium graveolens, has been so much improved by cultivation as to have lost its acrid deleterious properties, and is now a stout succulent plant, with a mild and agreeable flavour, and in the finer varieties with the stalks solid instead of hollow and pipy. The blanched portions only should, however, be used.

Celery is usually sown at three different times,—on a hotbed in the beginning of March, and in the open ground in March, and again in April. The seedlings, when about 2 inches high, are pricked into rich soil, in which they are allowed to stand till they are 4 or 5 inches high. The first crop is defended by frames or hand-glasses, and is planted wide to admit of being lifted with balls of earth adhering to the roots. Towards the end of May trenches for blanching the celery are prepared 3½ or 4 feet apart, 15 inches wide at the bottom, and about a foot below the natural level of the surface. The soil at the bottom of the trench is to be carefully dug and manured, and a single row of plants placed in each trench. Sometimes, where a large supply is required, the trenches are made 6 feet wide, and rows 15 or 18 inches apart are planted across the trenches. As the plants advance in growth, earth is laid up about the stalks of the leaves, and this is repeated at the end of every ten or fifteen days. Many delay the earthing-up until the plants have nearly attained their full size, when the operation is performed at once; but it is better to commence the earthing-up when the crop is half-grown, and to complete it by adding a little more soil at short intervals. Successional crops should be planted out from the 1st of June till the 1st of August. Celery loves a rich light soil, and will bear to be flooded with water at the root while growing.

The varieties of celery include some with red stalks and some with white. The latter, as they blanch more perfectly than the red, are sometimes preferred, but the red varieties blanch to a very delicate pink, and are generally better flavoured. Some of the best varieties are:—*Whites*: Early Dwarf Solid White (Incomparable White), Williams's Matchless White, Wright's Grove White. *Reds*: Leicester Red (Major Clarke's Solid), Ivery's Nonesuch, Sulham Prize Pink, Williams's Matchless Red. See CELERY, vol. v. p. 290.

155. The *Chicory* or *Succory*, Cichorium Intybus, is much esteemed by the French as a winter salad, and when blanched is known by the name of *Barbe de Capucin*. When intended for winter use, it is sown in May or June, commonly in drills, and the plants are thinned out to 4 inches apart. If at first the leaves grow very strong, they are cut off, perhaps in the middle of August, about an inch from the ground, so as to promote the production of new leaves, and check the formation of flower-stems. About the beginning of October the plants are raised from the border, and all the large leaves cut off; the roots are also shortened, and they are then planted pretty closely together in boxes filled with rich light mould, and watered when needful. When frost comes on, the boxes are protected by any kind of litter or haulm. As the salad is wanted, they are removed into some place having a moderately increased temperature, and where there is no light. Each box affords two crops of blanched leaves, and these are reckoned fit for cutting when about 6 inches long. Chicory.

Another mode of obtaining the young leaves of this plant in winter is to sow seeds in a bed of light rich mould, or in boxes in a heat of from 55° to 60°, giving a gentle watering as required. The leaves will be fit to cut in a fortnight after sowing, and the plants will afford a second crop.

In Belgium a variety of chicory called *Witloef* is much preferred as a salad to the French *Barbe de Capucin*. The seeds are sown and the plants thinned out like those of the ordinary sort. They are eventually planted in light soil, in succession, from the end of October to February, at the bottom of trenches a foot or more in depth, and covered over with from 2 to 3 feet of hot stable manure. In a month or six weeks, according to the heat applied, the heads are fit for use, and should be cut before they reach the manure. The plants might easily be forced in frames on a mild hotbed, or in a mushroom-house, in the same way as sea-kale.

The sorts cultivated are the Common, the Improved, and the Witloef. That grown for mixing with coffee is a variety with larger fleshy roots. See CHICORY, vol. v. p. 614.

156. The *Chives*, Allium Schœnoprasum, is a hardy perennial, found in the North of England and in Cornwall, and growing in rocky pastures throughout temperate and northern Europe and Asiatic Russia, and also in the mountain districts of southern Europe. It is cultivated for the sake of its leaves, which are used in salads and soups as a substitute for young onions. It will grow in any good soil, and is propagated by dividing the roots into small clumps in spring or autumn; these are planted from 8 to 12 inches apart, and soon form large tufts. The leaves should be cut frequently so as to obtain them tender and succulent. Chives.

157. The *Corn-Salad* or *Lamb's Lettuce*, Valerianella olitoria, is a weedy annual, native of southern Europe, but naturalized in corn-fields in central Europe, and not unfrequent in Britain. In France it is used in salads during winter and spring as a substitute for lettuces, but it is less esteemed in England. The plant is raised from seed sown on a bed or border of light rich earth, and should be weeded and watered, as occasion requires, till winter, when it should be protected with long litter during severe frost. The largest plants should be drawn for use in succession. Sowing may be made every two or three weeks from the beginning of August till October, and again in March, if required in the latter part of the spring. The sorts principally grown are the Round-leaved and the Italian, which last is sometimes referred to Valerianella eriocarpa. Corn-salad.

158. The *Cress*, or *Garden Cress*, Lepidium sativum, is an annual plant, native of western Central Asia. It is used in salads, the young plants being cut and eaten while still in the seed-leaf, forming, along with plants of the white mustard in the same stage of growth, what is commonly called "small salad." The seeds should be sown thickly broadcast or in rows in succession every ten or fourteen days, according to the demand. The sowings may be made in the open ground from March till October, the earliest under hand-glasses, and the summer ones in a cool moist situation; but Cress.

during winter they must be raised on a slight hotbed, or in shallow boxes or pans placed in any of the glass-houses where there is a temperature of 60° or 65°.

The *Golden* or *Australian Cress* is a dwarf, yellowish green, mild-flavoured sort, which is cut and eaten when a little more advanced in growth, but while still young and tender. It should be sown at intervals of a month from March onwards, the autumn sowing, for winter and spring use, being made in a sheltered situation.

The *Curled* or *Normandy Cress* is a very hardy sort, of good flavour. In this, which is allowed to grow like parsley, the leaves are picked for use while young; and, being finely cut and curled, they are well adapted for garnishing. It should be sown thinly in drills, in good soil in the open borders, in March, April, and May, and for winter and spring use at the foot of a south wall early in September, and about the middle of October.

Cucumber. 159. The *Cucumber*, Cucumis sativa, a tender annual, is cultivated both for stewing and pickling, but more usually and extensively for salads. Being an annual plant, it is usually increased by seeds, but it may be readily raised from cuttings, which should consist of the tops of the leading branches, and should be planted in deep pots, half-filled with a compost of leaf-mould and sand, the pots being then covered with a pane of glass, and plunged in a brisk heat. To grow these plants successfully through the winter, a tropical heat must be maintained, for the method of doing which see p. 264. If properly heated hot-water pits or houses cannot be had, and hotbeds have to be employed, it is better not to attempt very early forcing, but to defer sowing till about the first week in February.

In hotbed culture, the preparation of materials for the seed-bed, which should consist of stable dung in a full state of fermentation, should be set about towards the middle of January. The dung should be turned over, well shaken, and mixed about three times at intervals of a few days. The bed should be made up in a sheltered situation open to the sun. The frame should then be set on, and the sashes kept closed till the heat rises to 85° or so, when they should be tilted to allow the steam to pass off. In a few days the surface of the bed should be covered with a layer a few inches in thickness of light soil; and as soon as the heat of the bed ranges about 70° the seeds may be sown singly in 3-inch pots of sifted leaf-mould, with a lump of fibrous turf at the bottom for drainage, the seed being moderately pressed into the soil, and covered to the depth of about half an inch. The heat of the bed should range from 75° to 80°. After germination, the plants should be placed within 6 inches of the glass. When the plants have formed two joints, the growing point should be stopped above the second joint, the succeeding young shoots being stopped above the second or third joint. Subsequently three or four of the shoots, as nearly equal in strength as possible, should be selected for principal branches, and the laterals from these should be allowed to fill out the frame and bear fruit; they should be stopped at one or two joints above the fruit, and all weak shoots removed, being pinched off with the finger and thumb rather than cut, to avoid loss of sap by bleeding. The cucumber is a monœcious plant, and at one time, in order to secure the swelling of the fruit, the female flowers were carefully fertilized; but it is found that this is not necessary unless seed is required.

The fruiting-bed is to be made up in the same way as the seed-bed, only, as it is required to be more lasting, it is better to mix up tree leaves with the dung. The bed may be made up in the first week in February, and should be 4 feet high in front, and 4½ feet at back. The frame should be put on at once, and the lights or sashes kept closed till the heat has risen to the surface. If dry the dung may require watering to keep up fermentation; if it is moist and hot it may be found necessary to make holes with a stake in the sides of the bed to moderate the heat; but unless it rises above 85° there is no danger of its injuring the roots. A few days before the plants are introduced some hillocks of soil should be put into the frame, in order that they may become thoroughly warmed. These should be so arranged that the plant is within 6 inches of the glass. The plants themselves should be removed to the frame for a day or two before turning them out, the soil being moist, but not wet. A good medium compost may consist of two parts of turfy loam, one of peat, and one of leaf-mould, with the addition of some clean coarse sand; or of two parts turfy friable loam, two of turfy heath-mould, three of leaf-mould, and one of clean coarse sand. If the loam be of a less fibrous nature, more peat or leaf-mould or some decayed dung should be used. The bottom heat should range from 75° to 80°, and the atmosphere should be kept moist, and at a temperature ranging from 70° to 80°, the latter by sun-heat. An abundance of light is also essential, but in very bright sunshine a thin shading is beneficial. The water used both at the roots and at the tops should always be warmed, and, while ventilation is to be duly attended to, a cold draught should be avoided.

Winter cucumbers are generally grown in small houses set apart for them (see p. 224). The seeds are sown in August, and planted out so as to become well established before the dull weather sets in. In the case of culture in houses or pits, the heat, bottom and top, is maintained by hot-water pipes or tanks, and the branches are trained over trellises placed about a foot from the glass. The plants must in this case be run up with a single stem, till they reach the upper side of the trellis, when the leader should be stopped in order to produce the branches necessary for covering the allotted space, and these must also be stopped when fruit-bearing laterals are required. These last should be stopped at one joint beyond the fruit, till it can be seen whether or not a shoot will push from the same joint as the fruit, in which case the joint above the fruit is also to be pinched off.

The hardier varieties of cucumber, especially the short prickly sorts, known as *gherkins*, and used for pickling, are often grown under hand-glasses, a cavity having been made in a warm situation, and filled with hot dung and a small covering of earth. In the southern counties of England, pickling cucumbers are sown in drills in the open ground. The earth is made fine and level, and at distances of 3½ feet, in rows 6 feet apart, shallow circular hollows are formed with the hand, a foot wide, and half an inch deep in the middle, in each of which, about the beginning of June, eight or ten seeds are deposited. When the plants appear, they are thinned out to three or four, the weakest or least healthy being rejected, and all the further attention they require is occasional cleaning and watering, according to the state of the weather.

Some of the most popular varieties of the cucumber are:—

Spineless: Rollisson's Telegraph, Carter's Champion.
White-spined: Kenyon's Improved, Empress Eugenie, Improved Manchester Prize, Latter's Victory of England.
Black-tipped White-spined: Tender and True, Hamilton's Market Favourite, Blue Gown.
Black-spined: Dr Livingstone, Henderson's A1, Weedon's Black Spine.
See CUCUMBER, vol. vi. p. 687.

160. The *Egg Plant*, Solanum Melongena, the *Aubergine* or *Brinjal* of the French, is a tender annual, native of South America and of the tropical parts of Asia and Africa. In France it is cultivated for the fruits, which are cooked before they are eaten. The seed should be sown early in February in a warm pit, where the plants are grown till shifted into 8-inch or 10-inch pots, in well-manured soil. Manure water should be given occasionally while the fruit is swelling, about four fruits being sufficient for a plant. The French growers sow them in a brisk heat in December, or early in January, and in March plant them out four or eight in a hotbed with a bottom heat of from 60° to 68°, the sashes being gradually more widely opened as the season advances, until they may be taken off by about the end of May. The two main branches which are allowed are pinched to induce laterals, but when the fruits are set all young shoots are taken off in order to increase their size. The best variety is the Large Purple, which produces oblong fruit, sometimes reaching 6 or 7 inches in length, and 10 or 12 inches in circumference. The Chinese is also an oblong-fruited sort, with white fruit and more juicy flesh than some of the other sorts. The fruit of the ordinary form almost exactly resembles the egg of the domestic fowl. Egg plant.

161. The *Endive*, Cichorium Endivia, is a hardy annual, native of the northern provinces of China and other parts of Asia. As in the case of the lettuce, the blanched hearts are used for salads and in soups. The main crop should be sown about the middle of June, on a seed-bed of light rich soil, and the early crop about the middle of May. The seeds should be scattered sparsely, that the plants may not come up in clusters. The seedlings should be transplanted into a rich soil in an open situation, at about a foot apart in rows, which for the curled-leaved sorts should be a foot asunder, and for the broad-leaved sorts 15 inches. When the plants have reached their maturity, the leaves are gathered up and tied together a little below the tips, and a few days later about the middle of the plant, and in two or three weeks they are found sufficiently blanched for use. Endive.

For winter use the seed should be sown about the middle of July, and a little additional in August. They should be planted in the same way as the earlier crops, but it is advisable, as they approach maturity, to draw the earth quite up about the leaves. At that season, too, the plants may be advantageously planted on sloping banks of earth facing south. They may be blanched by inverting a garden pot with the drainage hole closed, or a common garden saucer 10 or 12 inches in diameter, over the centre of the plants as they grow flat on the earth. Later on they may be blanched in boxes in the mushroom-house, or in a cellar, or by using blanching pots, such as are provided for sea-kale. The time occupied in blanching varies from ten days in summer to three weeks in winter. A sufficient quantity to afford a supply for a week may be operated on at one time.

For protection during the winter it is a good plan to plant the endive on November, at 6 or 8 inches apart, on sloping sheltered banks facing the south, covering it with litter in severe weather, but leaving it uncovered at all other times. A more certain method to obtain a supply during that season is, however, either to take up the late-sown plants before frost sets in, and to plant them in dry earth or sand in a frame, or to place a frame over them where they grow. The early winter crops are sometimes planted at the back of a south wall, and when covered up for blanching they will endure a considerable amount of cold.

There are two races of endives, the Curled (*Chicorée frisée* of the French), with crispy much-cut leaves, and the Batavian (*Scarole* of the French), with broad lettuce-like leaves. Some of the favourite sorts are—

Curled: French Small Green Curled, early; Large Green Curled; Staghorn, for late crops; and Curled Picpus.

Batavian: Small Batavian, Round-leaved Batavian; Lettuce-leaved, early; and Fraser's Broad-leaved Batavian, for late crops.

Garlic. 162. The *Garlic*, Allium sativum, a hardy bulbous perennial, is propagated by separating the cloves of which the bulbs are composed, and planting them 2 to 3 inches deep in spring, at a few inches apart, in rows a foot asunder, in a light, rich, and rather dry soil, and in a warm situation. A few short rows will suffice in most cases, and, if required early, a small patch may also be planted about the end of October. After the leaves have ripened, the bulbs may be taken up, sun-dried, tied in bunches by the stalks, and hung up in a dry airy cool store-room till wanted. Garlic is used for flavouring.

Gourds. 163. The *Gourds* cultivated in gardens for their esculent produce are varieties of several species of Cucurbita, the most commonly used being the vegetable marrow and the pumpkin.

The *Vegetable Marrow*, Cucurbita Pepo var., is the most important of the gourds used as an esculent, and furnishes in good seasons a very large supply for the table. The fruits are best when eaten quite young and not over-boiled, the flesh being then tender, and the flavour sweet and nutty.

Vegetable marrows require a warm situation and a rich soil free from stagnant moisture. They do well on a rubbish or old-dung heap, or in a warm border on little hillocks made up with any fermenting material, to give them a slight warmth at starting. The seeds should be sown in a warm pit in April, and forwarded under glass, but in a very mild heat; the plants must be shifted into larger pots, and be gradually hardened previous to being planted out, when the mild weather sets in in May or June. The use of hand-glasses makes it possible to transplant earlier than would otherwise be advisable. The seeds may be sown early in May in pots under a hand-glass, or towards the end of May in the open ground, if heat is not at command. The true vegetable marrow or succade gourd bears fruit of an oblong-elliptical shape, about 9 inches long, pale-greenish while young, with whitish flesh, and scarcely any indication of ribs; when mature it is of a pale yellow colour. There is a variety which is more oblong, grows to 15 or 18 inches, and has the surface slightly marked by irregular longitudinal obtuse ribs. The shoots may be allowed to run along the surface of the ground, or they may be trained against a wall or paling, or on trellises. As the gourds cross readily, care is necessary to keep any particular variety true. One of the best vegetable marrows is called Moore's Vegetable Cream.

The *Custard Marrow*, one of the Patissons or Crown Gourds, bears a peculiar-looking flattened fruit with scolloped edges, which has a sweeter and less nutty flavour than the true marrow.

The *Pumpkin*, Cucurbita maxima, grows to a very large size, some of the varieties, as the large yellow or *Potiron jaune*, sometimes producing fruit over 200 lb in weight. The flesh of this is yellow, the ripe fruit, in which state only it is used, being of a pale salmony buff colour exteriorly. It will keep for some months in a dry airy place, and is used in soups or stews, or mashed like potatoes, or baked in pies. There are several varieties of this type. The cultivation of the pumpkin resembles that of the vegetable marrow, but it requires abundance of space for its spreading vines.

Many of the other gourds (of which some are very ornamental) produce edible fruits, but as some, notably the orange gourd and the bottle gourd, are cathartic and deleterious, they should not be indiscriminately eaten.

Horse-radish. 164. The *Horseradish*, Cochlearia Armoracia, or Armoracia rusticana, a hardy perennial, is cultivated for its long roots, or more properly underground rootstocks, which when scraped into shreds, or grated and made into a delicious sauce, are eaten with roast beef. Its properties are antiscorbutic. The horseradish requires a deep, rich, and rather moist sandy loam or alluvial soil, the object being to obtain long straight roots. One method of producing new plants is to plant the sets, consisting of the crowns of old roots, or of 1 or 2 inch lengths of the root itself, at the bottom of a trench 2½ feet deep, the lower half of the soil being well manured; only a single shoot should be retained, so as to produce one thick vigorous stick. The roots planted in spring are sometimes taken up in the winter following; if left to grow another year they become very much thicker, though less tender. In digging the roots the soil should be thrown back so as to lay them bare. Those that spring from the set are cut off, and it is manured and left to grow up again the following year. Before the ground becomes frost-bound, a supply should be dug up, and stored in damp sand for use during that emergency.

Jerusalem Artichoke. 165. The *Jerusalem Artichoke*, Helianthus tuberosus, a hardy tuberous perennial, a species of sunflower, derives its epithet *Jerusalem* from a corruption of the Italian *Girasole*, a sunflower, and its name of *Artichoke* from the resemblance in flavour which its tubers bear to that of the receptacles or "bottoms" of that plant. It is propagated by means of its tubers planted in the manner of potatoes, in rows 3 or 4 feet asunder, some time in February or March; by the autumn the new tubers will be fit for use. As a matter of convenience, though the tubers themselves are hardy enough to bear the frosts of winter, they may be dug up about November, and stored in dryish sand. They should have a well-manured soil, and the stems should not be allowed to be too crowded, which is in great measure obviated by planting them annually.

166. The *Kidney Bean* includes what is commonly known as the French Bean, Phaseolus vulgaris, and the Scarlet Runner, Phaseolus multiflorus, both very productive vegetables of excellent quality. Kidney bean.

The *Common Kidney Bean* or *French Bean*, Phaseolus vulgaris, is a tender annual, and should be grown in a rich light loamy soil and a warm sheltered situation. The soil should be well enriched with hotbed dung. The earliest crop may be sown by the end of March or beginning of April. If, however, the temperature of the soil is below 45°, the beans make but little progress. The main crops should be got in early in May; and a later sowing may be made early in July. The earlier plantings may be sown in small pots, and put in frames or houses, until they can be safely planted out-of-doors. The earliest out-of-doors crop may be sheltered by means of thatched hurdles, placed sloping on bearers supported by posts. The seeds should be covered 1½ or 2 inches deep, the distance between the rows being about 2 feet, or for the dwarfest sorts 18 inches, and that between plants from 4 to 6 inches. The pods may be used as a green vegetable, in which case they should be gathered whilst they are so crisp as to be readily snapped in two when bent; but when the dry seeds are to be used, the pods should be allowed to ripen. As the green pods are gathered others will continue to be formed in abundance; but if old seed-forming pods are allowed to remain, the formation of young ones will be greatly checked.

Forcing.—The kidney bean may be easily forwarded in pots in a forcing-house, or in prepared soil in a heated pit. The bottom heat should range about 70°, and the atmospheric temperature should show a minimum of 60°, and a maximum of 70°, running up to 80° by sun-heat. The seed should be sown three or four in a 10-inch pot, nearly filled with light turfy soil and leaf-mould, or decomposed cow dung, the stems being earthed up after the true leaves are formed; and they must be well syringed and watered daily. To keep down the red spider, the under side of the leaves should be thoroughly moistened by syringing early in the morning with water at 60°; the house being then kept shut up till the air is raised to 75° or 80°, both surfaces will, in consequence of condensation, become thoroughly wetted. When the plants come into flower, plenty of air must be admitted. Kidney beans may thus be obtained fit for use, in six weeks or two months from the time of sowing. It may therefore be desirable to sow some seed in August to succeed the crops in the open ground, and, for succession, in September and October; for spring use sow in January, February, and March. The early dwarf sorts are the best for forcing, such as Fulmer's Early, Newington Wonder, Osborn's Forcing, Williams's Early Prolific, Syon House, and White Advancer.

The varieties of French beans being numerous, we here add the names of some of the most desirable for general cultivation:—

Early: White Canterbury, Fulmer's Forcing, Minier's First Early, Osborn's Forcing, Sir Joseph Paxton, White Advancer.

Second Early: Canadian Wonder, bears late; Negro Long-podded, bears late; New Mammoth Negro, earlier than Canadian Wonder; Newington Wonder; Pale Dun; Syon House; Williams's Prolific, bears late.

The *Scarlet Runner Bean*, Phaseolus multiflorus, differs from the common French bean in being a perennial, and in having tuberous roots, which, it may be stated, are narcotic and poisonous. These may be preserved through the winter in dryish earth in a frost-proof cellar, for an early crop the following season. The late Mr Cuthill mentions having found from experiment that plants raised from roots come into bearing just one month earlier than those raised from seed. The seeds of the runner beans should be sown in an open plot,—the first sowing in May, another at the beginning of June, and a third about the middle of June. In the London market-gardens they are sown 8 to 12 inches apart, in 4 feet rows if the soil is good. The twining tops are pinched or cut off when the plants are from 2 to 2½ feet high, to save the expense of staking. It is better, however, in private gardens to have the rows standing separately, and to support the plants by stakes 6 or 7 feet high and about a foot apart, the tops of the stakes being crossed about one-third down. If the weather is dry when the pods are forming abundantly, plenty of tepid water should be supplied to the plants. In training the shoots to their supports, they should be twined from right to left, contrary to the course of the sun, or they will not lay hold.

The ordinary Scarlet Runner is most commonly grown, but there is a white-flowered variety which has also white seeds; this is very prolific and of excellent quality, and is now much grown for market. Another variety called Painted Lady, with the flowers red and white, is very ornamental, but not so productive. Carter's Champion is a large-podded productive variety.

167. The *Kohl Rabi*, or *Turnip Cabbage*, Brassica oleracea caulo-

Kohl Rabi. rapa, is a biennial, the upper part of whose stem swells into a round fleshy mass, resembling a turnip, but produced above ground. Kohl Rabi is exceedingly hardy, withstanding both severe frosts and drought. It is not much grown in English gardens, though when used young it forms a good substitute for turnips. The seeds should be sown in May and June, and the seedlings should be planted shallowly in well-manured ground, 8 or 10 inches apart, in rows 15 inches asunder; and they should be well watered, so as to induce quick growth. The bulbs will be fit for use when they are as large as—not larger than—an early turnip. The best sorts are Early White Vienna, and Early Purple Vienna.

Leek. 168. The *Leek*, Allium Porrum, a hardy biennial, is said to be a native of Switzerland, but more probably comes from the East. The leeks, which prefer a light soil, are sown in beds about the middle of March, and later for a succession, and in June or July are planted out 6 inches asunder; and in rows 15 or 18 inches apart. When the weather is moist the plants are dropped upright into the hole made by the dibble, and no more earth than will just cover the fibres is allowed to fall in, the hole being left open to encourage the stem to swell out, and blanching is effected gradually by the earth washing into the hole. They are also planted in trenches like celery, and earthed up when they have made their growth. The leeks will be fit for use in September, and will last till the spring.

The best sorts are—Early Netherlands, for early use; Large Rouen, one of the very best; London Flag, and Musselburgh, the latter being reputedly the hardiest; and Carentan, a very large hardy French sort.

Lettuce. 169. The *Lettuce*, Lactuca sativa, is a hardy annual, highly esteemed as a salad plant, while its milky juice forms the *lactucarium* of the materia medica. The London market-gardeners make preparation for the first main crop of Cos lettuces in the open ground early in August, a frame being set on a shallow hotbed, and, the stimulus of heat not being required, this is allowed to subside till the first week in October, when the soil, consisting of leaf-mould mixed with a little sand, is put on 6 or 7 inches thick, so that the surface is within 4½ inches of the sashes. The best time for sowing is found to be about the 11th of October. When the seeds begin to germinate the sashes are drawn quite off in favourable weather during the day, and put on, but tilted, at night in wet weather. Very little watering is required, and the aim should be to keep the plants gently moving till the days begin to lengthen. In January a more active growth is encouraged, and in mild winters a considerable extent of the planting out is done, but in private gardens the preferable time would be February. The ground should be light and rich, and well manured below, and the plants put out at 1 foot apart each way. In planting at this early season, the dibble, in closing in the soil, should be inserted on the south side of the plant. Frequent stirring of the ground with the hoe greatly encourages the growth of the plants. A second sowing should be made about the 5th of November, and a third in frames about the end of January or beginning of February. In March a sowing may be made in some warm situation; successional sowings may be made in the open border till August, about the middle of which month a crop of Brown Cos and Hardy Hammersmith should be sown, the latter being the most reliable in a severe winter. These plants may be put out early in October on the sides of ridges facing the south or at the front of a south wall, beyond the reach of drops from the copings, the Hardy Hammersmith being planted 6 or 8 inches apart. Young lettuce plants should be thinned before they crowd or draw each other, and transplanted as soon as possible after two or three leaves are formed. Some cultivators prefer that the summer crops should not be transplanted, but sown where they are to stand, the plants being merely thinned out; but transplanting checks the running to seed, and makes the most of the ground.

Forcing.—For a winter supply by gentle forcing, the Hardy Hammersmith and Brown Dutch Cabbage lettuces, and the Brown Cos and Green Paris Cos lettuces, should be sown about the middle of August and in the beginning of September, in rich light soil, the plants being pricked out 3 inches apart in a prepared bed, as soon as the first two leaves are fully formed. About the middle of October the plants should be taken up carefully with balls attached to the roots, and should be placed in a mild hotbed of well-prepared dung (about 55°) covered about 1 foot deep with a compost of sandy peat, leaf-mould, and a little well-decomposed manure. The Cos and Brown Dutch varieties should be planted about 9 inches apart. Give plenty of air when the weather permits, and protect from frost.

There are two races of the lettuce, the Cos lettuce, with erect oblong heads, and the Cabbage lettuce, with round or spreading heads,—the former generally crisp, the latter soft and flabby in texture. Some of the best lettuces for general purposes of the two classes are the following:—

Cos: White Paris Cos, best for summer; Green Paris Cos, hardier than the white; Alphange Cos, stands well; Brown Cos, one of the hardiest and best for winter; Hicks's Hardy White Cos; Sugarloaf Bath Cos.

Cabbage: Hammersmith Hardy Green, very hardy, good for winter; Tom Thumb; Brown Dutch; Neapolitan, best for summer; Grand Admiral, stands the winter well; Stanstead Park.

Mushroom. 170. The *Mushroom*, Agaricus campestris, is a well-known fungus of a specially savoury character; it grows wild in Great Britain on upland pastures, and appears to be indigenous to most regions of the globe. The plant is propagated by spores, the fine black dust seen to be thrown off when a mature specimen is laid on white paper or a white dish; these give rise to what is known as the "spawn" or mycelium, which consists of whitish threads permeating dried dung or similar substances, and which, when planted in a proper medium, runs through the mass, and eventually appears in the form of the mushroom. This spawn may be obtained from old pastures, or decayed mushroom beds, and is purchased from nurserymen in the form of bricks charged with the mycelium, and technically known as mushroom spawn. When once obtained, it may, like leaven, be indefinitely preserved. It may be produced by placing quantities of horse dung saturated with the urine of horses, especially of stud horses, with alternate layers of rich earth, and covering the whole with straw, to exclude rain and air; the spawn commonly appears in the heap in about two months afterwards. The droppings of stall-fed horses, or of such as have been kept on dry food, should be made use of.

The old method of growing mushrooms in ridges out of doors, or on prepared beds either level or sloping from a back wall in sheds or cellars, may generally be adopted with success. The beds are formed of horse droppings which have been slightly fermented and frequently turned, and may be made 2 or 3 feet broad, and of any length. A layer of dung about 8 or 10 inches thick is first deposited, and covered with light dryish earth to the depth of 2 inches; and two similar layers with similar coverings are added, the whole being made narrower as it advances in height. When the bed is finished, it is covered with straw to protect it from rain, and also from parching influences. In about ten days, when the mass is milkwarm, the bed will be ready for spawning, which consists of inserting small pieces of spawn bricks into the sloping sides of the bed, about 6 inches asunder. A layer of fine earth is then placed over the whole, and well beaten down, and the surface is covered with a thick coat of straw. When the weather is temperate, mushrooms will appear in about a month after the bed has been made, but at other times a much longer period may elapse. The principal things to be attended to are to preserve a moderate state of moisture and a proper mild degree of warmth; and the treatment must vary according to the season.

Mr Cuthill describes a very simple mode of culture. The ridge is built up of dung as it is brought fresh from the London stables; in this fermentation soon sets in, and, when the heat of the bed declines to 80°, pieces of spawn bricks are inserted, a foot apart, in the sides of the bed, which is then moulded over, 2 inches thick, pressed with the feet, and beaten with the spade, then watered, and beaten again with the spade, and finally smoothed down. The more the mould is pressed, the finer the crop, and the more solid the texture of the mushroom.

These ordinary ridge beds furnish a good supply towards the end of summer, and in autumn. To command a regular supply, however, at all seasons, the use of a mushroom-house (see par. 13, p. 226) will be found very convenient. The material employed in all cases is the droppings of horses, which should be collected fresh, and spread out in thin layers in a dry place, a portion of the short litter being retained well moistened by horse urine. It should then be thrown together in ridges and frequently turned, so as to be kept in an incipient state of fermentation, a little dryish friable loam being mixed with it to retain the ammonia given off by the dung. With this or a mixture of horse-dung, loam, old mushroom-bed dung, and half-decayed leaves, the beds are built up in successive layers of about 3 inches thick, each layer being beaten firm, until the bed is 9 or 10 inches thick. If the heat exceeds 80°, holes should be made to moderate the fermentation. The beds are to be spawned when the heat moderates, and the surface is then covered with a sprinkling of warmed loam, which after a few days is made up to a thickness of 2 inches, and well beaten down. The beds made partly of old mushroom-bed dung often contain sufficient spawn to yield a crop, without the introduction of brick or cake spawn, but it is advisable to spawn them in the regular way. The spawn should be introduced an inch or two below the surface when the heat has declined to about 75°, indeed the bed ought never to exceed 80°. The surface is to be afterwards covered with hay or litter. The atmospheric temperature should range from 60° to 65° till the mushrooms appear, when it may drop a few degrees, but not lower than 55°. If the beds require watering, water of about 80° should be used, and it is preferable to moisten the covering of litter rather than the surface of the beds themselves. It is also beneficial, especially in the case of partially exhausted beds, to water with a dilute solution of nitre. For a winter supply the beds should be made towards the end of August, and the end of October.

Mustard. 171. The *Mustard*, Sinapis alba, or Brassica alba, is a hardy annual, used as a small salad—generally accompanied by garden cress—while still in the seed-leaf. To keep up a supply, the seed should be sown every week or ten days. The sowings in the open ground may be made from March till October, earlier or later according to the season. The ground should be light and rich, and the situation warm and sheltered. Sow thickly in rows 6 inches apart, and slightly cover the seed, pressing the surface smooth with the back of the spade. When gathering the crop, cut the young plants off even with the ground, or pull them up and cut off the roots, commencing at one end of a row. From October to March the seeds should be sown thickly in shallow boxes and placed in a warm house or frame, with a temperature not below 65°.

Nasturtium. 172. The *Nasturtium*, or *Indian Cress*, Tropæolum majus, is a perennial climber, native of Peru, but in cultivation treated as a hardy annual. The flowers are sometimes eaten in salads, and are used for garnishing, and the leaves and young green fruits are pickled in vinegar as a substitute for capers. The plant should have a warm situation, and the soil should be light and well enriched; sow thinly early in April, either near a fence or wall, which may be utilized for its support, or in an open spot, where it will require stakes 6 to 8 feet high. Its flowers are no less ornamental than useful.

New Zealand Spinach. 173. The *New Zealand Spinach*, Tetragonia expansa, is a half-hardy annual, native of New Zealand, sometimes used as a substitute for spinach during the summer months, but in every way inferior to it. The seeds should be sown in March, on a gentle hotbed, having been previously steeped in water for several hours. The seedlings should be potted, and placed under a frame till the end of May, and should then be planted out, in light rich soil. The young leaves are those which are gathered for use, a succession being produced during summer and autumn.

Onion. 174. The *Onion*, Allium Cepa, is a hardy bulbous biennial, which has been cultivated in Britain from time immemorial, but the native country of which is unknown. The onion should be grown in an open situation, and on a light, rich, well-worked soil, which has not been recently manured. The principal crop may be sown at any time from the middle of February to the middle of March, if the weather is fine and the ground sufficiently dry. The seed should be sown in shallow drills, 10 inches apart, the ground being made as level and firm as possible, and the plants should be regularly thinned, hoed, and kept free from weeds. At the final thinning they should be set from 3 to 6 inches apart, the latter distance in very rich soil. About the beginning of September the crop is ripe, which is known by the withering of the leaves; the bulbs are then to be pulled, and exposed on the ground till well dried, and they are then to be put away in a store-room or loft, where they may be perfectly secured from frost and damp.

About the end of August a crop is sown to afford a supply of young onions in the spring months. Those which are not required for the kitchen, if allowed to stand, and if the flower-bud is picked out on its first appearance, and the earth stirred about them, frequently produce bulbs equal in size and quality to the large ones that are imported from the Continent. A crop of very large bulbs may also be secured by sowing about the beginning of September, and transplanting early in spring to very rich soil. Another plan is to sow in May on dry poor soil, when a crop of small bulbs will be produced; these are to be stored in the usual way, and planted in rich soil about February, on ground made firm by treading, in rows about a foot apart, the bulbs being set near the surface, and about 6 inches asunder. The White Spanish and Tripoli are good sorts for this purpose.

To obtain a crop of bulbs for pickling, seed should be sown thickly in March, in rather poor soil, the seeds being very thinly covered, and the surface well rolled; these are not to be thinned, but should be pulled and harvested when ripe. The best sorts for this crop are the Silver-skinned, Early Silver-skinned, Nocera, and Queen.

Forcing.—Onions may be forced like mustard and cress if required for winter salads, the seeds being sown thickly in boxes which are to be placed in a warm house or frame. The young onions are of course pulled while quite small.

The *Potato Onion*, Allium Cepa aggregatum, is propagated by the lateral bulbs, which it throws out, under ground, in considerable numbers. This variety is very prolific, and is useful when other sorts do not keep well. It is sometimes planted about midwinter, and then ripens in summer, but for use during the spring and early summer it is best planted in spring. It is also known as the underground onion, from its habit of producing its bulbs beneath the surface.

The *Tree Onion* or *Egyptian Onion*, Allium Cepaproliferum, produces small bulbs instead of flowers, and a few offsets also underground. These small stem bulbs are excellent for pickling.

The *Welsh Onion* or *Ciboule*, Allium fistulosum, is a hardy perennial, native of Siberia. It forms no bulbs, but, on account of its extreme hardiness, is sown in July or early in August, to furnish a reliable supply of young onions for use in salads during the early spring. These bulbless onions are sometimes called Scallions, a name which is also applied to old onions which have stem and leaves but no bulbs.

The following are among the best varieties of onions for various purposes:—

For summer and autumn.—Queen; Early White Naples: these two sorts are also excellent for sowing in autumn for spring salading. Silver-skinned; Tripoli, including Giant Rocca.

For winter.—Brown Globe, including Magnum Bonum; White Globe; Yellow Danvers; White Spanish, in its several forms; Trébons, the finest variety for autumn sowing, attaining a large size early, ripening well, and keeping good till after Christmas; Strasburg (Deptford); Weathersfield Red; Blood Red, strong-flavoured.

For pickling.—Queen, Early Silver-skinned, White Nocera, Egyptian.

175. The *Orach* or *Mountain Spinach*, Atriplex hortensis, native of Tartary, is a tall-growing hardy annual, whose leaves, though coarsely flavoured, are used as a substitute for spinach, and to correct the acidity of sorrel. The White and the Green are the most desirable varieties. The plant should be grown quickly in rich soil. It may be sown in rows 2 feet apart, and about the same distance in the row, about March, and for succession again in June. If needful, water must be freely given, so as to maintain a rapid growth. Orach.

176. The *Oxalis crenata*, Oca of the South Americans, is a tuberous-rooted half-hardy perennial, native of Peru. Its tubers are comparatively small, and somewhat acid; but if they be exposed to the sun from six to ten days, they become sweet and floury. In the climate of England they can only be grown by starting them in heat in March, and planting out in June in a light soil and warm situation. They grow freely enough, but few tubers are formed, and these of small size. The fleshy stalks, which have the acid flavour of the family, may, however, be used in the same way as rhubarb for tarts. The leaves may be eaten in salads. It is easily propagated by cuttings of the stems, or by means of sets like the potato. Oxalis crenata.

177. The *Oxalis Deppei*, a bulbous perennial, native of Mexico, has scaly bulbs, from which are produced fleshy, tapering, white, semi-transparent roots, about 4 inches in length, and 3 to 4 inches in diameter. They strike down into the soil, which should therefore be made light and rich with abundance of decayed vegetable matter. The bulbs should be planted about the end of April, 6 inches apart, in rows 1 foot asunder, being only just covered with soil, and having a situation with a southern aspect. The roots should be dug up before they become affected by frost, but if protected they will continue to increase in size till November. When taken up, the bulbs should be stored in a cool dry place for replanting, and the roots for use. The roots are gently boiled with salt and water, peeled and eaten like asparagus with melted butter and the yolks of eggs, or served up like salsafy and scorzonera with white sauce. Oxalis Deppei.

178. The *Parsnip*, Pastinaca sativa, is a hardy biennial, found in temperate regions. Its long tapering fleshy whitish nutritious roots have a peculiar but agreeable flavour. It succeeds best on a free sandy loam, which should be trenched and manured in the previous autumn, the manure being well buried. The seed should be sown thinly in March, in rows, 18 inches apart, and finally thinned out to 1 foot apart. The leaves will decay in October or November, when a portion of the roots may be taken up and stored in dryish sand for immediate use, the rest being left in the ground, to be taken up as required, but the whole should be removed by February to a dry cool place, or they will begin to grow. The best sorts are the Hollow-crowned, the Maltese, and the Student. Parsnip.

179. The *Pea*, Pisum sativum, is a hardy annual, climbing by means of the tendrils of its leaves, and has been cultivated from time immemorial. The seeds or pulse are very nutritious, whether eaten green or ripe, and those of the early crops are esteemed as luxuries. Pea.

The pea prefers a friable calcareous loam, deeply worked, and well enriched with good hotbed or farm-yard manure. The early crops require a warm sheltered situation, but the later are better grown 6 or 8 feet apart, or more, in the open quarters, dwarf crops being introduced between the rows. The dwarf or early sorts may be sown 3 or 4 feet apart. The deep working of the soil is of importance, lest the plants should suffer in hot dry weather from mildew or arrest of growth. The first sowing should be made about the beginning or middle of November, in front of a south wall, the plants being defended by spruce fir branches or other spray throughout the winter. In February sowings are sometimes made in flower-pots or boxes, and the young plants afterwards planted out. The main crop should be sown towards the end of February, and moderate sowings should be made twice a month afterwards, up to the beginning of July for the north, and about the third week in July for warmer districts. During dry hot weather late peas derive great benefit from mulching and watering. The latest sowings, at the middle or end of August, should consist of the best early sorts, as they are not so long in producing pods as the larger and finer sorts, and by this means the supply may be prolonged till October or November. As they grow up the earth is drawn to the stems, which are also supported by stakes, a practice which in a well-kept garden is always advisable, although it is said that the early varieties arrive sooner at maturity when recumbent. Where space permits, all the taller sorts are best sown in single rows at wide intervals of 20 or 30 feet.

Peas grown late in autumn are subject to mildew, to obviate which Mr Knight proposed to dig over the ground in the usual way, and to soak the spaces to be occupied by the rows of peas thoroughly with water,—the earth on each side to be then collected so as to form ridges 7 or 8 inches high, these ridges being well watered, and the seed sown on them in single rows. If dry weather at any time set in, water should be supplied profusely once a week.

To produce very early crops the French market-gardeners sow early in November, in frames, on a border having a good aspect, the seeds being covered very slightly. The young plants are transplanted into other frames in December, the ground inside being dug out so as to be 18 or 20 inches below the sashes, and the earth thus removed placed against the outside of the frames. The young plants, when 3 or 4 inches high, are planted in patches of three or four, 8 inches asunder, in four longitudinal rows. The sashes are covered at night with straw mats, and opened whenever the weather is sufficiently mild. When 8 or 10 inches high, the stems are inclined towards the back of the frame, a little earth being drawn to their base, and when the plants come into blossom the tops are pinched out, above the third or fourth flower, to force them into bearing. As soon as they begin to pod, the soil may have a gentle watering, whenever sufficiently warmed by the sun, but a too vigorous growth at an earlier period would be detrimental. Thus treated the plants bear pods fit for gathering in the first fortnight in April.

A very convenient means of obtaining an early crop is to sow in 5-inch pots, a few seeds in each, the plants to be ultimately planted out on a warm border. Peas may also be obtained early if gently forced in frames, in the same way as kidney beans, the dwarfest varieties being preferable.

For the very early peas the rows should range east and west, but for the main crops north and south. The average depth of the drills should be about 2 inches for small sorts, and a trifle more for the larger kinds. The drills should be made wide and flat at bottom, so that the seeds may be better separated in sowing. The large sorts are the better for being sown 3 inches apart. Chopped furze may be advantageously scattered in the drill before covering in, to check the depredations of mice, and before levelling the surface the soil should be gently trodden down over the seeds.

A good selection of sorts may be made from the following:—

Early: Dillistone's Early (Sutton's Ringleader, Carter's First Crop), the earliest sort; Sangster's No. 1, a good form of Early Frame; William I., fine; Laxton's Alpha, the earliest wrinkled pea; Dickson's First and Best; Maclean's Little Gem, a very dwarf wrinkled pea; Tom Thumb (Beck's Gem), a very dwarf round pea. The last two are useful for forcing and for pots.

Second Early: Maclean's Advancer, Standish's Criterion, Laxton's Marvel, Carter's Telephone, Dr Maclean, Premier, Carter's Stratagem.

Late: James's Prolific, Carter's G. F. Wilson, Veitch's Perfection; Ne Plus Ultra, the finest of all late peas, but a little delicate in cold wet soils and seasons; General Wyndham, continues to produce very late; British Queen, Champion of England, Laxton's Omega.

otato. 180. The *Potato*, Solanum tuberosum, is a half-hardy perennial, producing underground tubers, largely used as an esculent. It thrives best in a rather light friable loam; and in thin sandy soils the produce, if not heavy, is generally of very good quality. Soils which are naturally wet and heavy, as well as those which are heavily manured, such as old garden ground, are not suitable. Indeed it is best, except when there is ample space, to grow only the earlier kinds in gardens. If the soil is of fair quality, the less manure used upon it the better, unless it be soot or lime. Gypsum, bone-dust, superphosphate of lime, and nitrate of soda may also be used, and wood ashes are advantageous if the soil contains much vegetable matter.

Potatoes are commonly propagated by dividing the tubers, leaving to each segment or "set" one or two eyes or buds. The "sets" are then planted by the aid of the dibble or spade, in rows at a distance varying from 15 inches to 3 feet, the distance being regulated by the height of the stems, and that between the sets varying from 6 to 12 inches, 8 inches being a good average space for garden crops, with 2 feet between the rows. The sets may be put in 6 inches deep. The late T. A. Knight suggested the planting of whole tubers or sets, at greater distances apart, by which means, he argued, a larger produce would be obtained; he proposed to leave 4 feet between the rows, but that distance, except with the larger varieties, has been found to be too great. Though the planting of whole tubers instead of the cut sets has been thus highly recommended, yet according to some experiments made in the garden of the Horticultural Society at Chiswick the cut sets yield a much better return than whole ones. The full-sized tubers are, however, preferable to smaller ones, as their larger buds tend to produce stronger shoots. It has also been found that the best returns are obtained from sets taken from the points of the tubers—not from their base. Mr Thomas Dickson of Edinburgh long ago observed that the most healthy and productive crop was to be obtained by planting unripe tubers, and proposed this as a preventive of the disease called the "curl," which sometimes attacks the young stems, causing them and also the leaves to become crumpled, and few or no tubers to be produced. It has also been noted that the sprouting of the eyes of the potato may be accelerated if, while still unripe, it is taken up and exposed for some weeks to the influence of a scorching sun. The best sets are those obtained from plants grown in elevated and open situations, and it is also beneficial to use sets grown on a different soil.

The earliest crops should, if possible, be planted in a light soil and in a warm situation, towards the end of February, or as early as possible in March. In some cases the tubers for early crops are sprouted on a hotbed, the plants being put out as soon as the leaves can bear exposure. If the young sprouts are about 2 inches long, they may be planted out towards the end of March; if they are protected young potatoes will be procured in seven or eight weeks. It will improve the crop if, when the stems have grown a few inches above ground, the earth is drawn up to them, but the operation will delay its maturity for two or three weeks. Mr Knight recommends removing the flowers as they appear, in order to increase the produce. The fine early varieties, however, scarcely produce any flowers.

The main crop should be planted by the middle of March, late planting being very undesirable. Those intended for storing should be dug up as soon as they are fairly ripe, unless they are attacked by the dire disease, in which case they must be taken up as soon as the murrain is observed; or if they are then sufficiently developed to be worth preserving, but not fully ripe, the haulms or shaws should be pulled out, to prevent the virus passing down them into the tubers; this may be done without disturbing the tubers, which can be dug afterwards. See AGRICULTURE, vol. i. p. 364.

Forcing.—The best forcing sorts are the Ash-leaf as a kidney, and the Early Market or Rector of Woodstock for a round. The earliest crop may be planted in December, and successional ones in January and February. The mode of cultivation adopted by the London market gardeners is thus in substance explained by Mr Cuthill. A long trench, 5 feet wide and 2 feet deep, is filled with hot dung, on which soil to the depth of 6 inches is put. The sets employed are middle-sized whole potatoes, which are placed close together over the bed, covered with 2 inches of mould, and then hooped and protected with mats and straw, under which conditions they will sprout in about a month. A bed of the requisite length (sometimes 100 yards) is then prepared of about 2 feet thickness of hot dung, soil is put on to the depth of 8 inches, and the frames set over all. The potatoes are then carefully taken up from the striking bed, all the shoots being removed except the main one, and they are planted 4 inches deep, radishes being sown thinly over them and covered lightly with mould. When the haulm of the potato has grown to about 6 inches in height, the points are nipped off, in order to give the radishes fair play; and, although this may stop growth for a few days, still the potato crop is always excellent. After planting nothing more is required but to keep up the temperature to about 70°, admitting air when practicable, and giving water as required. The crop is not dug up until it has come to maturity.

Potatoes are also grown largely in hooped beds on a warm border in the open ground. The sets after having been sprouted, as above, are planted out in January in trenches 2 feet deep filled with hot dung, the sets being planted 5 inches deep, and over all radishes are sown. The ridges are then hooped over, allowing about 2 feet of space in the middle, between the mould and the hoop, and are covered with mats and straw, but as soon as the radishes come up they are uncovered daily, and covered again every night as a protection against possible frosts. This is continued till the potatoes are ready for digging in May.

Potatoes are sometimes grown in pots in heat, sprouted sets being planted in 11-inch pots about two-thirds full of soil, and placed near the glass in any of the forcing-houses, where a temperature of from 65° to 70° is to be maintained. The plants are duly watered and earthed up as they advance in growth.

Small supplies of young waxy tubers are produced during winter, in boxes placed in a mushroom-house or in a common cellar. If in October old seed tubers are placed in layers, alternately with a mixture of tree leaves and light mould, the young tubers before mid-winter will often attain the size and appearance of early potatoes; they are, however, watery, and possess little flavour.

The varieties of the potato are very numerous, and much attention has been paid during the last few years to the production of new and improved kinds. The following are named as a limited selection of a few of the standard sorts in the several groups, those marked * having coloured skins, the rest being white:—

Early.—Round: Early Market, Rector of Woodstock, Porter's Excelsior, *Triumph, *Radstock Beauty, Bedfont Prolific, Breesee's Climax. *Kidney*: Old Ash-leaf, Myatt's Ash-leaf, Avalanche, Snowflake, International Kidney, *Bountiful, *Beauty of Hebron.

Main Crop and Late.—Round: Schoolmaster, Regent, *Vicar of Laleham, Victoria, *Grampian, *Vermont Beauty, Champion. *Kidney*: Covent Garden Perfection, Lapstone, Woodstock Kidney, *Trophy, Magnum Bonum, *Late American Rose, Cattell's Eclipse.

181. The *Radish*, Raphanus sativus, is a fleshy-rooted annual, unknown in the wild state. Some varieties of our wild radish, R. Raphanistrum, however, met with on the Mediterranean coasts, come so near to it as to suggest that it may possibly be a cultivated race of the same species. It is very popular as a raw salad. There are two principal forms, the spindle-rooted and the turnip-rooted. Radish.

The radish succeeds in any well-worked not too heavy garden soil, but requires a warm sheltered situation. The seed is generally sown broadcast, in beds 4 to 5 feet wide, with alleys between, the beds requiring to be netted over to protect them from birds. The earliest crop may be sown about the middle of December, the seed-beds being at once covered with litter, which should not be removed till the plants come up, and then only in the daytime, and when there is no frost. If the crop succeeds, which depends on the state of the weather, it will be in use about the beginning of March. Another sowing may be made in January, a third early in February, if the season is a favourable one, and still another towards the end of February, from which time till October a small sowing should be made every fortnight or three weeks in spring, and rather more frequently during summer. About the end of October, and again in November, a late sowing may be made on a south border or bank, the plants being protected in severe weather with litter or mats. The winter radishes, which grow to a large size, should be sown in the beginning of July and in August, in drills from 6 to 9 inches apart, the plants being thinned out to 5 or 6 inches in the row. The roots become fit for use during the autumn. For winter use they should be taken up before severe frost sets in, and stored in dry sand.

Forcing.—To obtain early radishes a sowing should be made about the beginning of November, and continued fortnightly till the middle or end of February; the crop will generally be fit for use about six weeks after sowing. The seed should be sown in light rich soil, 8 or 9 inches thick, on a moderate hotbed, or in a pit with a temperature of from 55° to 65°. Gentle waterings must be given, and air admitted at every favourable opportunity; but the sashes must be protected at night and in frosty weather with straw mats or other materials. Some of these crops are often grown with forced potatoes. The best forcing sorts are Wood's Early Frame, and the Early Rose Globe, Early Dwarf-top Scarlet Turnip, and Early Dwarf-top White Turnip.

Those best suited for general cultivation are the following:—

Spindle-rooted: Long Scarlet, including the sub-varieties Scarlet Short-top, Early Frame Scarlet, and Wood's Early Frame; Long Scarlet Short-top, best for general crop.

Turnip-rooted: Early Rose Globe-shaped, the earliest of all; Early Dwarf-top Scarlet Turnip, and Early Dwarf-top White Turnip; Earliest Erfurt Scarlet, and Early White Short-leaved, both very early sorts; French Breakfast, olive-shaped; Red Turnip, and White Turnip, for summer crops.

Winter sorts: Black Spanish, White Chinese, Californian Mammoth.

Rampion. 182. The *Rampion*, Campanula Rapunculus, is a tap-rooted biennial, native or naturalized in the south of England, and found on banks and in pastures in central and southern Europe, extending to the Caucasus. The white fleshy roots, known as "ramps," are used raw as a salad, or boiled like asparagus. It is but little cultivated in England. The seed, which is very minute, and should be mixed with sand before sowing to secure even distribution, is sown in drills 6 to 8 inches apart, about the end of May or beginning of June, in deeply worked ground, and in a cool situation, and the young plants are merely to be thinned and kept clear of weeds. The roots, which somewhat resemble small radishes, will be fit for use about November, and on the approach of frost, if taken up and stored in sand, they will keep fresh and firm till spring.

Rhubarb. 183. The *Rhubarb* of gardens is derived from different species of Rheum, especially R. Rhaponticum and R. undulatum. The parts chiefly utilized are the fleshy foot-stalks of the leaves, which are much used for preserves, puddings, and tarts, as well as for stewing.

Rhubarb requires an open situation and a rich deep soil, which should be well manured, and prepared by deep trenching. To form a plantation, divisions of the old roots, each provided with a bud or crown, should be put in early in spring, the crown being set about 2 inches below the surface. They should stand 3 to 4 feet apart each way, according to the habit of the variety. The plants will afford a supply in the following spring. It is desirable to renew the plantation in the course of four or five years, shifting to new ground. When gathering the crop, the leaf-stalks should be bent downwards, and pulled off sideways, not cut. The flower-stems should be cut off as soon as they make their appearance, in order to strengthen the root. Established sorts must be increased by division, as seedlings do not reproduce the variety. Rhubarb may, however, be grown from seeds—a flower stem or two being allowed to grow up for the purpose of producing them. The seeds should be sown on a slight hotbed in spring, and transplanted out in rows in the month of May, no stalks being gathered from them for the first two years.

Forcing.—Rhubarb may be forced in a variety of ways for early or winter use; it may have a pot or box set over the crown and covered up by warm litter, dung, or leaves like sea-kale; or the roots may be taken up, potted, and set into any forcing-house at work, the crowns being kept in the dark so as to blanch the stalks; or they may be planted closely in long narrow boxes of moderate depth, and set in a mushroom-house or cellar, where there is a considerable temperature. The rhubarb will soon throw up its stalks, and these, being partially etiolated, possess a delicacy and flavour superior to those grown in the open air. It is easy, by varying the time of subjecting the boxes to the increased temperature, to keep up a succession of rhubarb stalks, from the period at which kitchen apples become scarce or begin to lose their flavour, till green gooseberries come into season.

The favourite old sorts of rhubarb were the Tobolsk and the Elford or Buck's; the latter comes from R. undulatum, and is one of the best in flavour, as well as of a fine red colour. Other good sorts of more modern date are Mitchell's Royal Albert, Dancer's Early Scarlet, Myatt's Linnæus, and Myatt's Victoria, the last a large-growing thick-stalked kind, the others being all earlier sorts. Johnson's St Martin's and Salt's Crimson Perfection are also favourite kinds; and Stott's Monarch grows to a very large size.

184. The *Rocambole*, Allium Scorodoprasum, is a hardy bulbous perennial, occurring in a wild state in sandy pastures and waste places throughout Europe, but not common in the south; in Britain it is found chiefly in the north of England and the south of Scotland. The plant is grown for the sake of its bulbs, which are smaller and milder than those of garlic, and consist of several cloves chiefly produced at the roots. The cloves should be planted about the end of February or in March, and treated like the garlic or shallot. When mature, the bulbs should be taken up, dried, and stored for use. Rocambole.

185. The *Salsafy* (or *Salsify*), Tragopogon porrifolius, is a hardy biennial, with long cylindrical fleshy esculent roots, which, when properly cooked, are extremely delicate and wholesome; it occurs in meadows and pastures in the Mediterranean region, and, in Britain, is confined to the south of England. The salsafy requires a free rich deep soil, which should be trenched in autumn, the manure used being placed at two spades' depth from the surface. The first crop should be sown in March, and the main crop in April, in rows a foot from each other, the plants being afterwards thinned to 8 inches apart. In November the whitish roots should be taken up and stored in sand for immediate use, others being secured in a similar way during intervals of mild weather. Salsafy.

186. The *Savoy*, Brassica oleracea bullata major, is a near ally of the cabbage, but has bullate or blistered leaves; it is more hardy, and, except in very severe seasons, instead of suffering is rather improved in flavour by frost. The savoys come into use in autumn, and continue until the spring. The early crop should be sown in February, the main crop about the middle of March, and a month afterwards the latest crop. The rows of the smaller sorts should be 15 inches, and those of the larger ones 2 feet, apart. Savoy.

The best sorts of savoys for garden culture are:—

Tours, early and hardy; Ulm, early, but not so hardy; Little Pixie, small, early, and good; Dwarf Green Curled, best for a general crop; Golden, handsome and excellent. The large Drumhead savoy is more suitable for field culture, unless bulk of produce is required.

187. The *Scorzonera*, Scorzonera hispanica, is a hardy perennial, a native of Spain, but cultivated in gardens for its fleshy cylindrical roots, which resemble those of salsafy except in being black outside, and which are used in the same manner. They should be treated in every respect like salsafy (par. 185). Scorzonera.

188. The *Sea-kale*, Crambe maritima, is a hardy perennial, growing spontaneously along the coasts of England, of Ireland, and of the Scotch lowlands, along the western coasts of Europe, and on the Baltic, reappearing on the Black Sea. Sea-kale.

Sea-kale prefers a light dry soil, and when manure is necessary it should consist of sea-weed or well-rotted dung; or a dressing of salt or of nitrate of soda may be given. When it is raised from seeds, they should be sown in March or April in rows a foot asunder, the plants being thinned to 6 inches apart. In the following March these should be planted out in trenched well-prepared ground, 2 feet asunder, in rows 2½ to 3 feet apart. The top with the crown buds should be cut off before planting to prevent them from running up to seed. In the spring of the second year the young shoots if blanched will be fit for use, and therefore the summer growth should in every way be promoted by the use of water and liquid manure. Tolerably blanched stalks may be produced by plants only nine months old from the seed, and after two summers seedling plants will have acquired sufficient strength for general cropping. The seeds, instead of being sown in rows and transplanted, may be deposited in patches of three or four together, where they are to remain. In the autumn, after the leaves have been cleared off, the ground should be forked up, and 6 or 8 inches' depth of leaves or of light sandy soil laid over the plants, by either of which means they will be blanched, though not forced. The blanched sprouts should be cut for use whilst they are crisp, compact, and from 3 to 6 inches in length, the stem being cut quite down to the base.

Sea-kale beds may be made equally well from cuttings of the roots, the extremities of the roots, technically called "thongs," being the parts best adapted for this purpose. They should be taken up in autumn, cut into lengths of about 4 inches, and laid aside in a heap of sand or earth till spring, when they should be planted out like the seedlings. Cuttings should not be taken from any but very healthy plants.

Forcing.—Sea-kale may be forced in the open beds by the aid of sea-kale pots or covers, which are large enough to cover a plant, contracted a little at top, with a movable lid or cover. In the autumn the stalks are cut over, the decayed leaves removed, the ground loosened about the eyes, and a thin stratum of coal-ashes mixed with salt laid on the surface to keep down earth-worms. One of the earthenware pots or covers, or failing these a large inverted flower-pot, is placed over each plant or each patch of plants, and leaves of trees are closely packed round the pots, and raised to about a foot above them. When fermentation commences, a thermometer should be occasionally introduced into a few of the pots, to ascertain that the temperature within does not exceed 60° Fahr., and the thickness of the leaves is to be regulated accordingly. In a month or six weeks the shoots will be ready for cutting, and by means of the movable lids they can be examined and the shoots gathered without materially disturbing the covering. If the crowns are thus covered up by about the end of October, the crop may be cut by about the third week of December, and by starting a batch at various times a supply may be kept up till the middle of May.

Strong plants may also be taken up and planted on hotbeds, the sashes being kept covered close; or they may be set thickly in boxes as recommended for rhubarb (par. 183), and placed in any heated structure, or in the mushroom house; but, to have the shoots crisp and tender as well as blanched, light must be completely excluded. Besides the common purple-leaved, there is a green-leaved sort, which is said to blanch better.

Shallot. 189. The *Shallot*, Allium ascalonicum, is a native of Palestine, and is much used in cookery for high-flavoured soups and gravies, besides which it is excellent when pickled. It is a hardy bulbous perennial, and is propagated by offsets, which are often planted in September or October, but the principal crop should not be got in earlier than February or the beginning of March. The mixing of soot with the manure has been recommended as a protection against maggots. In planting, the tops of the bulbs should be kept a little above ground, and it is a commendable plan to draw away the soil surrounding the bulbs when they have got root-hold. They should not be planted on ground recently manured. They require the same general treatment as garlic and rocambole, and should be stored in a similar manner. They come to maturity about July or August. There are two sorts—the Common, and the Jersey or Russian, the latter being much larger and less pungent.

Skirret. 190. The *Skirret*, Sium Sisarum, is a fleshy-rooted perennial, native of China and Japan, the roots of which are boiled, and afterwards served up like salsafy. It requires a free, deep, and much enriched soil, and is generally raised from seeds, which should be sown in drills a foot apart about the end of March, the bed being well-watered in dry weather. The roots will be in use about November, and will continue fresh through the winter if carefully stored.

Sorrel. 191. The *Sorrel*, Rumex Acetosa, is a hardy perennial, found throughout Europe, in Asiatic Russia, and in North America. The leaves are used, more so on the Continent than in Britain, in soups, salads, and sauces. Sorrel grows freely in any good garden soil, and is increased by dividing the roots during the early part of spring. They should be planted in rows 15 to 18 inches apart. The leaves, when fully grown, are gathered singly.

The common garden sorrel is much superior to the wild plant; but the Belleville, which is the kind generally cultivated near Paris, is still better, its leaves being larger and not so acid. The Blistered-leaved, which has large leaves with a blistered surface, has the advantage of being slow in running to seed.

The *French Sorrel*, Rumex scutatus, is a hardy perennial, native of France and Switzerland, with densely-branched trailing stems. The leaves are roundish heart-shaped and glaucous; they are more acid than those of the common sorrel.

Spinach. 192. The *Spinach*, Spinacia oleracea, is an annual plant, which has been long cultivated for the sake of its succulent leaves. It should be grown on good ground, well worked and well manured; and for the summer crops abundant watering will be necessary.

The first sowing of winter spinach should be made early in August, and another towards the end of that month, in some sheltered but not shaded situation, in rows 18 inches apart,—the plants, as they advance, being thinned, and the ground hoed. By the beginning of winter the outer leaves will have become fit for use, and if the weather is mild successive gatherings may be obtained up to the beginning of May. The Prickly-seeded and the Flanders are the best for winter; and these should be thinned out early in the autumn to about 2 inches apart, and later on to 6 inches. The Lettuce-leaved is a good succulent winter sort, but not quite so hardy.

To afford a succession of summer spinach, the seeds should be sown about the middle of February, and again in March; after this period small quantities should be sown once a fortnight, as summer spinach lasts but a very short time. They are generally sown in shallow drills between the lines of peas. If a plot of ground has to be wholly occupied, the rows should be about a foot apart. The Round-leaved is the best sort for summer use.

Tomato. 193. The *Tomato* or *Love Apple*, Lycopersicum esculentum or Solanum Lycopersicum, is a tender annual from South America, much esteemed in England as an esculent, either raw or cooked.

Tomatoes were formerly raised from seed sown in gentle heat in February or early in March, potted singly into small pots, shifted on into larger pots, and gradually exposed to the air till about the end of May, when, if the season was favourable, they were planted out against a wall with a south aspect, or in the warmest situation at command. As they grew, they were nailed to the wall, or otherwise supported. Only the earlier of the fruit ripened out of doors in an average season; and when a fair quantity had set, the plants were stopped, the secondary branches being also stopped above the fruit, and laterals removed gradually. Under these circumstances the fruit began to ripen in August, successively coming to maturity, at which stage, and when perfectly dry, it had to be gathered and hung up or laid on shelves. The partially ripened fruit had to be got in before it was injured by frost, its maturation being completed in a vinery or other heated house, and, though not acquiring the full flavour, the forwardest of these late fruits thus became usable.

Forcing.—The outdoor treatment remains as above sketched out, but, owing to the precarious nature of the crop in bad seasons, large quantities are now grown under glass. Mr G. T. Miles, of Wycombe Abbey Gardens, has explained in the *Gardeners' Chronicle* his mode of culture, of which the following is an abstract:—

"To grow it properly, it requires considerable heat and every possible ray of sunshine, as well as a free circulation of dry warm air. The compost should consist of about one-half rough turfy loam, one-fourth of roadside scrapings, and one-fourth of decomposed manure or horse-droppings, moderately fresh. For planting out, a ridge of soil 2 feet wide and 15 inches deep should be placed on a warm bed of tan or leaves. For pot cultivation those from 12 to 15 inches in diameter are most appropriate, and these should not be quite filled, in order that surface dressings of the same material or of pure manure may be applied afterwards. For early work a sowing should be made in January, and the plants moved onwards until they have moderately filled 5-inch pots with roots, when they are transferred to the beds or fruiting-pots; in each case the plants are kept about 2 feet apart. Other sowings may be made at intervals till about the end of August. From the last sowing a supply is obtained for a considerable period onwards through the winter months. The plants are restricted to one main stem, which is allowed a run of 6 feet or more, as the position may admit, and from this all laterals are removed in an early stage of growth. Top-dressings of rich materials should be applied when the surface soil becomes full of roots; copious supplies of stimulating manure-water are also necessary, and the fruits should be kept perfectly free from damp while they are ripening. For this purpose, if close confined pits are used, a chink of air should be kept on continuously."

Tomatoes may also be allowed to run freely over the back wall of a forcing house, and, if sufficiently fed, will bear fruit abundantly.

Mr Miles observes that these plants, when grown out of doors, are generally placed in an excellent position, but the main point—the enrichment of the soil—is overlooked or not sufficiently attended to. A portion of good soil should be provided for each plant, and heavy mulchings of manure should be placed upon the surface as soon as practicable after planting, in order to prevent the soil becoming dry and parched. In these cases three or more main shoots are allowed to each plant, because it often happens that the space will not allow a good run, and a certain amount of growth with foliage is essential to the well-doing of the plants.

The following varieties afford considerable choice:—

Red-fruited: Early Gem, small, but a good cropper, and the quickest to ripen; Vick's Criterion, small and free-bearing, particularly adapted for growing in small pots; Vilmorin's Dwarf Early, dwarf and free-bearing; Hathaway's Excelsior, one of the finest, a great cropper; Trophy, large and very fine; Conqueror, large and prolific.

Yellow-fruited: Carter's Green Gage, of a distinct yellow colour, and of fine flavour.

Smaller-fruited: Cherry Red and Burghley Pet, round, prolific, and agreeably flavoured; Dickson's Queen of Tomatoes, with pear-shaped, and Nesbit's Victoria, with plum-shaped fruits, both being prolific sorts.

194. The *Turnip*, Brassica campestris Rapa, is a hardy biennial, found in corn-fields in various parts of England. The cultivated varieties have bulbiform roots, much esteemed as an esculent. Turnip.

Turnips should be grown in a rich friable sandy loam, such as will produce medium-sized roots without much aid from the manure heap, and are better flavoured if grown in fresh soil. In light dry soils well decomposed hotbed or farmyard manure is the best that can be used, but in soils containing an excess of organic matter, bone dust, superphosphate of lime, wood-ashes, or guano, mixed with light soil, and laid in the drills before sowing the seed, are beneficial by stimulating the young plants to get quickly into rough leaf, and thus to grow out of reach of the so-called turnip fly. To get rid of this pest, it has been found beneficial to dust the plants with quicklime, and also to draw over the young plants nets smeared with some sticky substance like treacle, by which large numbers will be caught and destroyed. It has been also recommended as a palliative to sow thick in order to allow for a percentage of loss from this and other causes, and, as a preventive, to scatter gas-lime over the surface after the seed has been sown. Mr Thompson (*Gardeners' Assistant*) also recommends the following remedy:—"In the first place, let a supply of water be brought close to hand, or say to each end of the quarter; then let one person move steadily along one side of the piece of ground from one end to the other, delivering the water through a rose as he proceeds. The fleas will jump forward as the water approaches them, and a second person, following the first, will keep them on the hop forward, whilst a third will drive them still further, and so on till the whole are driven off the ground."

The first sowing should be made on a warm border with the protection of a frame or matted hoops, in January or February, the second on a well-sheltered border in March, after which a sowing once a month will generally suffice. In May and June the plot should be in a cool moderately shaded position, lest the plants should suffer from drought. The principal autumn and winter sowings, which are the most important, should be made about the end of June in the northern districts, and in the beginning of July in warmer districts; a small sowing may be made at the end of August to come in before the spring-sown crops are ready. If the weather is showery at the time of sowing, the seed speedily germinates, and the young plants should be kept growing quickly by watering with rain or pond water and by surface stirrings. The drills for the earliest sorts need not be more than 15 inches apart, and the plants may be left moderately thick in the row; the late crops should have at least 2 feet between the rows, and be thinned to 12 inches in the row, a free circulation of air about them being very important in winter. As a provision against prolonged periods of severe weather, it has been recommended to lay the finest roots in rows, covering them well with soil, and leaving intact the whole of the foliage. The very latest sown crops of half-grown roots will prolong the supply until the earliest spring-sown crops are fit for use.

The following are the best sorts of turnips for garden crops:—

Early Purple-top Munich, the earliest and best of all; Early White Strap-leaf, very quick growing, and good; Early Snowball, for summer use; Early White Stone, for summer sowing; Orange Jelly, for summer sowing; Yellow Finland, for winter use; Chirk Castle, for winter use. In addition to these, which have round roots, there are the Jersey Navet, an excellent oblong variety, and very hardy, and the Teltow, a small tapering-rooted sort, employed, on account of its piquant flavour, in ragouts, and for seasoning. The latter should be sown in April and July in sandy soil.

ater ess. 195. The *Water Cress*, Nasturtium officinale, is a hardy perennial, occurring wild in Britain, and also throughout Europe and Asiatic Russia, except the extreme north. It is highly prized as a salad, and accredited with powerful antiscorbutic properties. It may be propagated from seed, but in forming plantations rooted divisions are usually employed. They should occupy positions where they can be supplied with water from a spring, as this will be rarely frozen. The plant will not grow freely on a muddy bottom; hence this has to be replaced by gravel or chalk. A constant current of water is absolutely necessary; and the plants should be disposed in rows parallel with the course of the stream. They thrive best in water about $1\frac{1}{2}$ inch in depth; this increases to about 3 inches when the plants begin to grow, and thereby check the current. In summer the tops of the plants must be kept closely cut, and under proper conditions of water and soil they will yield a gathering once a week. In winter the water should be 4 to 5 inches deep, to obtain which the plants are left with more head. The time for the renewal of the beds is in May and June, and from September to November, the planting being done in succession; those planted in May are fit to cut by August, and those planted in November are ready to gather in the spring. When collected for sale, the shoots are cut, not broken off, the latter plan being injurious. The water cress may also be grown in a shady border of rich light soil, kept constantly moist; but the surface should be covered with a thin layer of sand to keep the leaves clean. It may be also grown in tubs partially filled with soil which is covered with water, in which case the water should be frequently changed, or in shallow pans set in stands of water. If protected from frost in a brick pit with a slight service of hot-water piping, it may be had in use through the winter. To secure this, pans are filled with loamy soil in October or November, and planted with the tops of outdoor cresses; in about six weeks they will be fit to cut, and will furnish successional gatherings.

m. 196. The *Chinese Yam*, Dioscorea Batatas, is a fleshy-rooted perennial climber, native of China. It has annual stems, and deeply penetrating thick club-shaped fleshy roots, or rhizomes, full of starch, which when cooked acquire a mild taste like that of a potato, but have besides somewhat of a medicinal flavour. The roots grow 3 feet or upwards in length, and sometimes acquire a weight of more than $1\frac{1}{2}$ lb. The plant grows freely enough in deep sandy soil, moderately enriched. The sets, consisting of pieces of the roots, may be planted in March or April, and require no other culture than the staking of the climbing stems. They should not be dug up before November, the chief increase in their size taking place in autumn. They sometimes strike downwards 2 or 3 feet into the soil, and must be carefully dug out, the upper slender part being reserved for propagation, and the lower fleshy portion eaten after having been allowed a few days to dry.

197. CULINARY HERBS.—Besides the foregoing esculent and salad plants, there are several minor herbs used for flavouring and garnishing. For the most part they are dwarf perennial plants requiring to be grown on a dry warm soil in an open sunny aspect, or annuals for which a warm sheltered border is the most suitable place; and they may therefore be conveniently grown together in the same compartment—an herb garden. The perennials should be transplanted either every year or every second year.

For winter use the tops of the most useful kinds of herbs should be cut when in flower or full leaf and quite dry, and spread out in an airy but shady place so as to part slowly with the moisture they contain, and at the same time retain their aromatic properties. When quite dry they should be put into dry wide-mouthed bottles and kept closely corked. In this way such herbs as basil, marjoram, mint, sage, savory, and thyme of the aromatic class, balm, chamomile, horehound, hyssop, and rue of the medicinal class, as well as parsley, may be had throughout the season with almost the full flavour of the fresh herb.

Angelica, Archangelica officinalis.—A stout biennial umbellifer; sow in April, in deep rich soil. The stems and leaf-stalks are candied.

Anise, Pimpinella Anisum.—A slender umbelliferous annual; sow in May in light warm soil; English summers are scarcely warm enough to bring it to perfection.

Balm, Melissa officinalis.—A hardy labiate perennial; divide the roots in October; dry for winter use.

Basil, Ocymum Basilicum.—A fragrant labiate annual; sow in a gentle heat in March, and plant out on a warm border; or sow in a warm sheltered place in April or May; or in winter sow in heat (65°-70°) in pots or boxes in rich light soil, once a month from November onwards; that sown in April or May should be cut when in blossom, and dried slowly for winter use.

Borage, Borago officinalis.—A stout native British annual, used for garnishing; sow in March and May in an open place, in good soil.

Burnet, Poterium Sanguisorba.—A hardy native perennial; divide the roots in October or February. It tastes like cucumber.

Caraway, Carum Carui.—A hardy umbelliferous biennial; sow in April or May to flower the following summer.

Chamomile, Anthemis nobilis.—A hardy native British composite perennial of prostrate habit; divide the plants in autumn or spring, planting in rather poor dry soil; the flower-heads should be gathered successively as they open, and carefully dried and stored.

Chervil, Anthriscus Cerefolium.—A hardy annual umbellifer; sow in March, and again in October if required for spring use.

Coriander, Coriandrum sativum.—A hardy annual umbellifer; sow in March in light loamy soil.

Dill, Anethum graveolens.—A hardy annual umbellifer; sow in March on a warm border, in rich light soil.

Fennel, Fœniculum vulgare.—A hardy perennial umbellifer; sow in March, or divide the roots at the same season.

Finochio, Fœniculum dulce.—A somewhat tender kind of fennel, with two-ranked leaves, fleshy at the base, which part is blanched by earthing up like celery; sow in March and successionally if required, in light very rich soil.

Horehound, Marrubium vulgare.—A hardy native labiate perennial, best raised annually from seeds sown early in March, or by selecting self-sown autumn seedlings.

Hyssop, Hyssopus officinalis.—A hardy evergreen suffruticose labiate plant; sow in March or April, young plants being more vigorous than older ones; it may also be divided in spring.

Lavender, Lavandula vera.—An aromatic undershrub of the labiate order, requiring a light warm dry soil, and increased by cuttings, or by slips taken off with roots about March or April.

Marigold, Calendula officinalis.—A hardy composite annual; sow in March, in any garden soil.

Marjoram, Origanum Majorana.—A tender labiate, usually treated as an annual, and known as Knotted Marjoram; sow in March in a slight heat, and plant out on a warm sunny border. The *Pot Marjoram*, Origanum Onites, and *Winter Sweet Marjoram*, Origanum heracleoticum, are hardy perennials, growing best in dry warm soils; divide and transplant in autumn or spring; a winter supply is provided by cutting the stems, when the plant is in flower, and drying in an airy shady place.

Mint, Mentha viridis.—A hardy native labiate perennial, often called Spear-Mint. The running underground roots should be taken up in February or March, and replanted in fresh good soil. The young tops may be obtained early by forcing; the leafy stems may also be cut when at their full growth in summer, and dried for winter use. The *Peppermint*, Mentha piperita, is cultivated like the spear-mint, only its runners grow above instead of beneath the ground, and require planting accordingly.

Parsley, Petroselinum sativum.—A hardy umbelliferous biennial; sow in February, again in May, and again in July to have a good supply, a portion of the last-sown crop being protected by frames or hand-lights, so as to be accessible in frosty weather; it likes a free soil of good quality, but not too richly manured.

Pennyroyal, Mentha Pulegium.—A hardy native labiate perennial, growing in moist situations, and best cultivated on a north border, is propagated freely enough by its running rooting stems, which should be well established early in autumn.

Rosemary, Rosmarinus officinalis.—An evergreen undershrub of the labiate order, just tender enough to be killed in all but the most sheltered situations by the most severe British winters, but surviving uninjured through those of ordinary severity. It requires a light dry soil and a sheltered situation, and is increased by cuttings or rooted slips taken off in spring.

Rue, Ruta graveolens.—A hardy evergreen rutaceous undershrub, which will grow freely in ordinary garden soil, and is propagated by cuttings or slips, or very freely by seeds, which ripen abundantly.

Sage, Salvia officinalis.—A hardy evergreen undershrub, belonging to the labiates, of which there are two varieties, the green-leaved and the red-leaved, the latter being somewhat the hardiest; it is increased by earthing up the outside stems, which after the lapse of a year may be taken off as rooted plants in the following April or May.

Savory, Satureja hortensis.—A hardy labiate annual; sow on a warm border in April; when the plants reach the flowering stage, dry a portion for winter use. The *Winter Savory*, Satureja montana, a hardy evergreen undershrub, is propagated by cuttings taken off in April and May, or by dividing the plant about April.

Tansy, Tanacetum vulgare.—A hardy composite native perennial, which soon grows thick and exhausts the soil, and should therefore be divided and transplanted every second year. If required earlier than the natural season, a root or two may be potted and set in a mild forcing-house or hotbed.

Tarragon, Artemisia Dracunculus.—A hardy perennial composite plant, which grows freely in light dryish soil, and is increased by division in October or March; it should be transplanted every year or two. Tarragon may be had during the winter by potting a root or two early in December, and placing them in heat.

Thyme, Thymus vulgaris.—A hardy evergreen undershrub, requiring a light dry warm soil, and an open but sheltered situation; it may be raised from seeds sown in April, and thinned out; or the old roots may be divided also in April. The tops should be cut in summer, and preserved for winter use in the same way as savory and marjoram. The *Lemon Thyme*, Thymus citriodorus, is of a more decumbent habit, and may be parted and transplanted in spring in genial weather during the month of April.

Wormwood, Artemisia Absinthium.—A hardy native composite perennial, which will grow in any soil, but is most aromatic on those which are dry and poor. The plants should be replaced annually in autumn, when self-sown plants are generally to be found round about the old ones; if not so produced, they can be provided by sowing the seeds during the summer.

VIII.—*CALENDAR OF GARDEN OPERATIONS FOR GREAT BRITAIN.*[1]

JANUARY.

Kitchen Garden.—Wheel out manure and composts during frosty weather; trench vacant ground not turned up roughly in autumn. Sow early peas in a cold frame for transplanting. Sow also Dillistone's Early, Alpha, or other first-crop peas, early in the month, and William I. and Advancer towards the end; Early Seville and Early Longpod beans; and short-topped radish in two or three sowings, at a week's interval, all on a warm border; also Hardy Green and Brown Dutch lettuce in a frame or on south border. Plant shallots and Ashleaf potatoes on a warm border. Protect broccoli as it becomes fit for use, or remove to a dry shed or cellar; lettuces and endive, which are best planted in frames; and parsley in frames so as to be accessible.

Fruit Garden.—Plant fruit trees in open weather, if not done in autumn, which is the proper season, mulching over the roots to protect them from frost, and from drought which may occur in spring. Prune fruit trees in mild weather or in moderate frosts, nailing only in fine weather. Wash trees infested with insects, with a mixture of soap-suds, black sulphur, and tobacco water, or with Gishurst Compound. Take off grafts, and lay them aside in moist earth in a shady place.

Forcing.—Prepare manure for making up hotbeds for early cucumbers and melons, where pits heated with hot water are not in use; also for Ashleaf potatoes. Sow also in heat mustard and cress for salads, onions for salads; celery to be pricked out for an early crop; and Early Horn carrot and kidney-beans on slight hotbeds. Force asparagus, sea-kale, and rhubarb, in hotbeds, in pits, in the mushroom-house, or in the open garden by the use of covers surrounded with warm litter. For pines keep up a bottom heat of 80°, and water sparingly; for cucumbers a top heat of 75°; for vines in leaf and flower a temperature ranging from 65° to 75°. Keep forced strawberries with swelling fruit well watered. Plant vine eyes for propagation in a brisk heat.

Plant Houses.—Give abundance of air to the greenhouse, conservatory, and alpine frame in mild weather, but use little water. A supply of roses, kalmias, rhododendrons, &c., and of hardy flowers and bulbs, as lily of the valley, hyacinths, &c., should be kept up by forcing.

Flower Garden.—Plant out tubers and bulbs of border flowers, where neglected in autumn, deferring the finer florists' flowers till next month. Transplant herbaceous plants in light soils, if not done in autumn; also deciduous trees, shrubs, and hedges. Lay edgings in fine weather. Sow mignonette, stocks, &c., in pots; sow sweet peas, and a few hardy annuals, on a warm border. Give auriculas and carnations abundance of air, but keep the roots rather dry, to prevent damping off.

FEBRUARY.

Kitchen Garden.—Sow successional crops of Early Seville beans, and William I., Advancer, Criterion, and other peas in the beginning and end of the month; early cabbages, to follow the last sowing in August; red cabbages and savoys towards the end. Sow also Early Horn carrot; Early Purple-top Munich turnip; onions for a full crop in light soils, with a few leeks and some parsley. Sow lettuce for succession, with radishes and Round-leaved spinach, twice in the course of the month; and small salads every fortnight. Plant Jerusalem artichokes, shallots, garlic, horse-radish, and early potatoes. Transplant for seed, if not done before, all the brassica tribe, including cabbage, cauliflower, turnip, &c.; also carrots, onions, beet, celery, endive, leeks, and parsnips. Transplant to the bottom of a south wall a portion of the peas sown in pots in frames in November and January for the first crop. Sow Brussels sprouts in gentle heat for an early crop.

Fruit Garden.—Prune apricots, peaches, nectarines, and plums, before the buds are much swelled; finish pruning apples, pears, cherries, gooseberries, currants, and raspberries, before the end of the month; also the dressing of vines. Keep the fruit-room free from spoiled fruit, and shut it close. Cut down the double-bearing raspberries to secure strong autumn-fruiting shoots. Head back stocks preparatory to grafting.

Forcing.—Sow melons and cucumbers on hotbeds and in pits. Sow carrots, turnips, early celery, also aubergines or egg-plants, capsicums, tomatoes, and successional crops of kidney-beans; cauliflower and Brussels sprouts, in gentle heat, to be afterwards planted out. Plant early potatoes on slight hotbeds. Continue the forcing of asparagus, rhubarb, and sea-kale. Pine-apple plants require little water; plants in dung-frames especially should be kept free from damp; shift the fruiting plants by the middle of the month, if not done in August. Commence or continue the forcing of the various choice fruits, as vines, peaches, figs, cherries, strawberries, &c. Pot roots of mint and place in heat to produce sprigs for mint sauce. Be careful to protect the stems of vines that are outside the forcing-houses.

Plant Houses.—Let the greenhouse and conservatory have plenty of air in mild weather. Pot and start tuberous-rooted begonias. Pot young plants of amaryllis, and start the established ones. Put plants of fuchsias, petunias, verbenas, heliotropes, salvias, and other soft-wooded subjects, into a propagating house to obtain cuttings, &c., for the flower garden. Sow stocks, dahlias, and a few tender and half-hardy annuals, on a slight hotbed, or in pots. Propagate old roots of dahlias by cuttings of the young shoots in a hotbed. Sow petunias in heat, and prick out and harden for bedding out; also gloxinias to be grown on in heat till the flowering season.

Flower Garden.—In dry open weather plant dried roots, including most of the finer florists' flowers; continue the transplanting of hardy biennial flowers and herbaceous plants. Sow in the last week mignonette, and hardy annuals, in a warm border, for subsequent transplanting.

MARCH.

Kitchen Garden.—Sow main crops of wrinkled marrow peas; Longpod and Windsor beans; Nonpareil or St John's day cabbages; onions, leeks, Early Horn carrots, parsnips, salsafy, scorzonera, Brussels sprouts, borecoles, lettuces, and spinach. In the beginning and also at the end of the month sow Early Strap-leaf and Early Snowball turnips, and savoys. In the last fortnight sow asparagus, cauliflower, chervil, coriander, dill, fennel, finochio, hyssop, marigold, savory; also sea-kale, radishes, celery, celeriac, and most of the culinary aromatics, as parsley. Small salads should be sown

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[1] *CALENDAR FOR THE UNITED STATES (chiefly for the Latitude of New York).*

JANUARY.

Flower Garden and Greenhouse.—Little is to be done in either. In the greenhouse care must be used to protect against frost. Ventilate but little, and with care; raise the ventilating sash only high enough to let the heated air from the greenhouse drive back the outer air so as not to chill the plants. To destroy the red spider, syringe the plants copiously at night, and splash the paths with water. The aphis, or "green fly," must also be destroyed; tobacco may be used. At this season roses, grape vines, and other plants are often affected by mildew; an effectual remedy is to paint the hot-water pipes with a mixture of sulphur and lime, put on as thick as ordinary whitewash, once each week until it is checked; but care must be taken not to apply it on any surface at a higher temperature than 212°. Hyacinths and other bulbs that have been kept in a cellar or other dark cool place may now be brought into the light of the greenhouse or sitting room, provided they have filled the pots with roots. If they are not well rooted, leave them until they are, or select such of them as are best, leaving the others. In the outside flower garden little can be done except that shrubs may be pruned, or new work, such as making walks or grading, performed, if weather permits.

Fruit Garden.—Pruning, staking up, or mulching can be done if the weather is such that the workmen can stand out. No plant is injured by being pruned in cold weather.

Grapery.—Graperies used for the forcing of foreign grapes may be started, beginning at a temperature of 50° at night, with 10° or 15° higher during the day. The borders must be covered sufficiently deep with leaves or manure to prevent the soil from freezing, as it would be destruction to the vines to start the shoots if the roots were frozen; hence, when forcing is begun in January, the covering should be put on in November, before severe frosts begin.

Vegetable Garden.—But little can be done in the Northern States except to prepare manure, and get sashes, tools, &c., in working order; but in sections of the country where there is little or no frost the hardier kinds of seeds and plants may be sown and planted, such as asparagus, cabbage, cauliflower, carrot, leek, lettuce, onion, parsnip, peas, spinach, turnip, &c. In any section where these seeds can be sown in open ground, it is an indication that hotbeds may be started for the sowing of such tender vegetables as tomatoes, egg and pepper plants, &c.; though, unless in the extreme Southern States, hotbeds should not be started before the beginning or middle of February.

FEBRUARY.

Flower Garden and Greenhouse.—The directions for January will in the main apply to this month, except that now some of the hardier annuals may be sown in hotbed or greenhouse, and also the propagation of plants by cuttings may be done rather better now than in January, as the greater amount of light gives more vitality to the cutting.

Fruit Garden.—But little can be done in most of the Northern States as yet, and in sections where there is no frost in the ground, it is likely to be too wet to work; but in many Southern States this will be the best month for planting fruit trees and plants of all kinds, particularly strawberries, raspberries, blackberries, pear and apple trees, while grape vines will do, though they will also do well quite a month later.

Grapery.—The graperies started last month at 50° at night may now be increased to 60°, with a correspondingly higher day temperature. Great care must be taken to syringe the leaves thoroughly at least once a day, and to deluge the paths with water, so as to produce a moist atmosphere. Paint the hot-water pipes with sulphur mixture, as recommended in January.

Vegetable Garden.—Leaves from the woods, house manure, or refuse hops from breweries may be got together towards the latter part of this month, and mixed and turned to get "sweetened" preparatory to forming hotbeds. Cabbage, lettuce, and cauliflower seeds, if sown early this month in hotbed or greenhouse, will make fine plants if transplanted into hotbed in March. This is preferable to the use of fall-sown plants. Manure that is to be used for the crop should be broken up as fine as possible, for the more completely manure of any kind can be mixed with the soil the better the crop will be, and, of course, if it is dug or ploughed in in large unbroken lumps it cannot be properly commingled.

MARCH.

Flower Garden and Greenhouse.—The long days and bright sunshine will now begin to tell on the plants under glass. Examine all plants that are vigorous and healthy; if the roots have matted the "ball" of earth they must be shifted into a larger-sized pot. Plants from cuttings struck last every ten days. Make up beds for mushrooms with well-prepared dung towards the end of the month. Plant early potatoes in the first week, and a main crop during the last fortnight. Jerusalem artichokes, sea-kale, asparagus, and peas raised in frames, may now be planted; also garlic and shallots. Full crops of cabbages should be planted out; also cauliflowers under hand-glasses. Propagate by slips, or by earthing up the old stems, the various pot-herbs, as sage, savory, thyme, &c., and increase mint by dividing the roots.

Fruit Garden.—Finish the pruning of fruit trees before the middle of the month. Protect those coming into blossom. Begin grafting in the third week; dig and dress between the rows of gooseberries, currants, and other fruit trees, if not already done. Kill wasps assiduously, as soon as they appear.

Forcing.—Continue the forcing of melons and cucumbers, and the various fruits. Pot pine-suckers and crowns that have been kept in tan during winter, repotting those that require large pots, and about the middle of the month shifting them to the succession pit; give a top-dressing to the fruiting plants, turning the tan, and adding new bark to the pits, to keep up bottom-heat, where that is used. In the vinery and peach-house, attend to the keeping down of insects by syringing; and promote the growth of the young shoots, by damping the walls and paths morning and evening. Sow capsicum, egg-plant, and tomato; also in slight heat such tender herbs as basil and marjoram.

Plant Houses.—More water may be given than formerly. Sow seeds of greenhouse and hothouse plants; also the different sorts of tender annuals; pot off those sown last month; sow cineraria for the earliest bloom; also Chinese primulas. Shift heaths and other hard-wooded subjects and stove-plants; plant tuberoses in pots for forcing. Begin to propagate greenhouse plants by cuttings; also coleuses by cuttings in heat, and chrysanthemums in moderate heat, potting them off as soon as rooted.

Flower Garden and Shrubbery.—In the last week, sow hardy annuals in the borders, with biennials that flower the first season, as also perennials. Plant anemone and ranunculus roots; plant the corms of gladiolus. Transplant from the nursery to their final sites annuals sown in autumn, with biennials and herbaceous plants. Propagate perennials from root-slips and offsets. Protect tulips, hyacinths, and choice flowers from severe weather. Continue to propagate the finer sorts of dahlias, both by cuttings and by division of the roots. Finish the pruning of all deciduous trees and hedges as soon as possible. Attend to the dressing of shrubberies; lay turf-edgings, and regulate the surface of gravel walks.

April.

Kitchen Garden.—Sow asparagus, sea-kale, Turnip-rooted beet, salsafy, scorzonera, skirret, carrots, and onions on heavy soils; also marrow peas, Longpod and Windsor beans, turnips, spinach, celery, Enfield Market cabbage, savoys, Brussels sprouts, and German greens, for succession. Sow broccoli and kidney beans both in the second and in the last week, and lettuces and small salads twice or thrice during the month; sow angelica, caraway, also all sweet herbs, if not done last month. Sow vegetable marrow. Plant cauliflower, cabbages, sea-kale, lettuce; and finish the planting of the main crops of potatoes; divide and replant artichokes. Propagate all sorts of pot-herbs, and attend to the hoeing and thinning of spinach, onions, turnips, &c. Earth up cabbages, cauliflower, peas, beans, and early potatoes. Stake up peas; blanch sea-kale and rhubarb in the open air, by covering with straw or leaves.

Fruit Garden.—If vines have been neglected to be pruned, rub off the buds that are not wanted; this is safer than pruning now. Protect the finer sorts of fruit trees on the walls. The hardier orchard-house fruits should now be moved outdoors under temporary awnings, to give the choicer fruits more space,—the roots being protected by plunging the pots. Mulch all newly-planted fruit trees, watering abundantly in dry weather.

Forcing.—Continue the preparation of succession beds and pits for cucumbers and melons. Sow basil in slight heat; pot and push on tomatoes and capsicums. Attend to the routine culture of the pinery, giving water and air when necessary. In the forcing-houses, from the variable state of the weather, considerable vigilance is required in giving air. Keep down red spider (*Acarus*) in the more advanced houses by frequent syringings and a well-moistened atmosphere. Continue the usual operations of disbudding and thinning of fruit, and take care to keep up the proper temperatures.

Plant Houses.—Still sow tender annuals if required; sow cinerarias and primulas. Proceed with all necessary shiftings. Propagate rare and fine plants by cuttings or grafting; increase bouvardias by cuttings, and grow on for winter flowering. Pot off tender annuals, and cuttings of half-hardy greenhouse plants put in during February to get them well established for use in the flower garden.

Flower Garden and Shrubbery.—Sow main or successional crops of annuals of all sorts—half-hardy annuals in warm borders, or on slight hotbeds. Biennials and perennials should be sown before the middle of the month. Plant out gladioli, if not done, tigridias, and fine stocks. Finish the transplanting of herbaceous plants by the end of the first week. Protect stage auriculas and hyacinths from extremes of every description of weather; and tulips from hoar-frosts and heavy rains. Plant out tender deciduous trees and shrubs raised in pots; plant out tea-roses, mulching the roots. Remove part of the coverings of all tender shrubs and plants in the first week, and the remainder at the end of the month. Form and repair lawns and grass walks, by laying turf and sowing perennial grass-seeds; mow the lawns frequently; plant evergreens.

May.

Kitchen Garden.—Sow Pine-apple or Nutting's beet in the first week, small salads every week, radishes and lettuces thrice, spinach once a fortnight, carrots and onions for late drawing, kidney beans in the first week and together with scarlet runners in the last fortnight; endive for an early crop; also peas and Longpod and Windsor beans, cauliflowers, Early York or Little Pixie cabbages, Brussels sprouts, borecole, broccoli, savoys, Buda kale, and German greens, for late crops. Sow anise and basil on a warm border; and borage and parsley on open spots. Sow vegetable marrows and hardy cucumbers on a warm border in the last week; sow cardoons in trenches, or (in the north) in pots under glass shelter; sow chicory for salading. Plant asparagus. Continue hoeing and earthing up the several crops.

Fruit Garden.—Disbud peaches, nectarines, and other early trees against the walls; also attend to the thinning of fruit. Give occa-

CALENDAR FOR THE UNITED STATES—Continued.

month may now be shifted, and the propagation of all plants that are likely to be wanted should be continued. Hardier kinds of annuals may be sown; it is best done in shallow boxes, say 2 inches deep. Lawns can be raked off and mulched with short manure, or rich garden earth where manure cannot be obtained. Flower beds on light soils may be dug up so as to forward the work of the coming busy spring season.

Fruit Garden.—In many sections, planting may now be done with safety, provided the soil is light and dry, but not otherwise. Again at this season, although a tree or plant will receive no injury when its roots are undisturbed in the soil should a frost come after planting, the same amount of freezing will and very often does greatly injure the plant if the roots are exposed.

Grapery.—The grapery started in January will have set its fruit, which should be thinned by one-third. The temperature may now be farther advanced to 70° at night, with 15° higher in the daytime. The same precautions must be used against mildew and insects as given in January. Graperies wanted for succession may be started in February or this month.

Vegetable Garden.—This is a busy month. In localities where the frost is out of the ground, if it is not wet, seeds of the hardier vegetables can be sown. The list of seeds given for the Southern States in January may now be used at the North, while for most of the Southern States tender vegetables, such as egg plant, okra, sweet potatoes, melon, squash, potatoes, tomatoes, &c., may be sown and planted. Hotbeds must now be all started.

April.

Flower Garden and Greenhouse.—Window and greenhouse plants require more water and ventilation. Due attention must be paid to shifting well-rooted plants into larger pots; and, if space is desired, many kinds of hardier plants can be safely put out in cold frames. Towards the end of the month it may be necessary to slightly shade the glass of the greenhouse. All herbaceous plants and hardy shrubs may be planted in the garden. The covering of leaves or litter should be taken off bulbs and tender plants that were covered up for winter, so that the beds can be lightly forked and raked. Sow tender annual flower seeds in boxes inside.

Fruit Garden.—Strawberries that have been covered up with straw or leaves should be relieved around the plants, leaving the covering between them. Raspberries, grape vines, &c., that have been laid down, may now be uncovered and tied up to stakes or trellises, and all new plantations of these and other fruits may now be made.

Vegetable Garden.—Asparagus, rhubarb, spinach, &c., should be uncovered, and the beds hoed or dug lightly. Hardier sorts of vegetable seeds and plants, such as beets, cabbage, cauliflower, celery, lettuce, onions, parsley, parsnip, peas, potatoes, radishes, spinach, turnip, &c., should all be sown or planted by the middle of the month if the soil is dry and warm, and in all cases, where practicable, before the end of the month. It is essential, in sowing seeds now, that they be well firmed in the soil. Any who expect to get early cabbage, cauliflower, lettuce, or radishes, while planting or sowing is delayed until the time of sowing tomato and egg plant in May, are sure to be disappointed of a full crop.

May.

Flower Garden and Greenhouse.—Window and gree house plants should be in their finest bloom. Firing may be entirely dispensed with, though care must still be exercised in ventilating. Every precaution must be used to keep the air moist. "Moss culture" may be tried, the common sphagnum or moss of the swamps, mixed with one-twentieth of its bulk of bone-dust, being laid as a mulch on the top of the earth of the flower-pots; its effect is to shield the pots from the sun, and at the same time stimulate the roots to come to the surface. By the end of the month all of the plants that are wanted for the summer decoration of the flower border may be planted out, first loosening a little the ball of earth at the roots. If the weather is dry, water freely after planting. When the greenhouse is not to be used during the summer months, camellias, azaleas, and plants of that character should be set out of doors under partial shade; but most of the other plants usually grown in the conservatory or window garden in winter may be set in the open border. Flower beds should be kept well hoed and raked, to prevent the growth of weeds next month. Lawns should be mown, and the edgings trimmed. Pelargoniums, pinks, monthly roses, and all the half hardy-kinds of flowering plants should be planted early; but coleus, heliotrope, and the more tender plants should be delayed until the end of the month. Annuals that have been sown in the greenhouse or hotbed may be planted out, and seeds of such sorts as mignonette, sweet alyssum, phlox Drummondii, portulaca, &c., may be sown in the beds or borders.

sional washings with the engine to keep down insects. Pick caterpillars from gooseberries and wall trees on their first appearance. Remove from raspberries and strawberries all suckers and runners that are not wanted.

Forcing.—Plant melons and cucumbers, and some basil, on the hotbeds prepared for vegetables in February, and now free. Plant out vegetable marrows and pumpkins on dung-ridges, under hand-glasses. Sow late crops of cucumbers and melons. Continue the routine culture of the pinery, shifting those intended for autumn and winter fruiting; give abundance of heat and water, keeping down insects.

Plant Houses.—Turn out hardy plants about the middle, and the more tender at the latter end of the month. Sow tender annuals for succession, potting and shifting those sown at an earlier period; sow cinerarias for succession; and a few hardy annuals and ten-week stock, &c., for late crops. Pot off all rooted cuttings. Put in cuttings of the different desirable species which are now fit for that purpose. Plant out in rich soil Richardias, to be potted up in autumn for flowering.

Flower Garden.—Sow annuals for succession in the last week, also biennials and perennials in the nursery compartment, for planting out next year. Propagate plants of which more stock is required, either by cuttings or by dividing the roots. Plant out, during the last week, dahlias, hardy pelargoniums, stocks, and calceolarias, protecting the dahlias from slight frosts. By the end of the month, masses of the following plants may be formed with safety in warm localities:—pelargonium, heliotropium, fuchsia, petunia, nierembergia, salvia, verbena, bouvardia, and lobelia. Protect tulips, ranunculuses, and anemones from the mid-day sun, and from rains and winds. Remove the coverings from all tender plants in the open air.

Shrubbery.—Transplant all kinds of evergreens, this month and September being the proper seasons. The rarer conifers should be planted now and in June, after they have commenced to grow. Proceed with the laying down of lawns and gravel-walks; and keep the former regularly mown.

JUNE.

Kitchen Garden.—Sow kidney beans for succession; also the wrinkled marrow peas, and Seville Longpod, and Windsor beans for late crops. Sow salading every ten days; also carrots, onions, and radishes for drawing young; and chicory for salads; sow endive for a full crop. In the first week sow Early Munich and Yellow Finland turnips for succession, and in the third week for a full autumn crop. Sow scarlet and white runner beans for a late crop, and cabbages for coleworts. Make up successional mushroom beds early in the month. Plant full crops of broccoli, Brussels sprouts, savoys, German greens, leeks, and early celery, with successional crops of cabbage and cauliflower. In the first fortnight of the month, plant hardy cucumbers for pickling, in a warm border, placing hand-glasses over them towards the end of the month. Plant out capsicums on a warm border (south of England), also tomatoes along the bottom of a south wall. Pull and store winter onions, if ripe.

Fruit Garden.—Train and prune the summer shoots of wall and trellis and other trained trees. Mulch and water fruit trees and strawberries in dry weather,—desisting when the fruit begins to ripen. Net over cherry-trees. Destroy aphides and other insects by syringing with tobacco water, or by fumigating, or by dusting with tobacco powder.

Forcing.—Proceed with planting melons and cucumbers raised from seeds and cuttings, for late crops. Keep up the necessary temperatures for the ripening of the various fruits. Continue the routine operations in the pinery; but, if very large-sized fruit is desired, remove the suckers from the stem, and apply heat and water in abundance. Shift suckers and succession plants in the beginning and middle of the month, as the state of the plants may require. The other forcing-houses must still have the necessary heat, but little water and abundance of air must be given to those wherein the fruit is beginning to ripen, and those in which the fruit is past ought to be constantly under a system of thorough ventilation.

Plant Houses.—These will now be occupied with tender greenhouse plants and annuals, and the more hardy plants from the stove. Shift, repot, and propagate all plants that are desirable. Sow fragrant or showy annuals, to flower in pots during winter; and grow on a set of decorative plants for the same object.

Flower Garden.—Plant out dahlias and other tender subjects if risk of frost is past. Take up bulbs and tuberous roots, and dry them in the shade before removing them to the store-room. Fill up with annuals and greenhouse plants those beds from which the bulbs and roots have been raised. After this season, keep always a reserve of annuals in pots, or planted on beds of thin layers of fibrous matter, so as to be readily transplanted. Layer carnations and pipe pinks in the end of the month. Keep the lawns closely mown.

JULY.

Kitchen Garden.—Watering will be necessary in each department, if the weather is hot and dry. In the first week, sow peas for the last crop of the season; also Dutch Longpod beans, and French beans. In the last week, sow Yellow Finland turnip for a full winter crop, spinach for an early winter supply, and Enfield Market or Winnigstadt cabbage for early summer use. Sow endive, for autumn and winter use, in the beginning and end of the month; also successional crops of lettuce and small salads. Make up successional mushroom beds. Plant full crops of celery, celeriac, endive, about the middle and end of the month; late crops of broccoli, cauliflower, and coleworts in the last week. Gather and dry medicinal and pot herbs; also propagate these by slips and cuttings.

Fruit Garden.—Continue the pruning and training of wall and espalier trees, and the destruction of noxious insects. Plant strawberries in pots for forcing next winter, and make new beds out of doors as soon as well-rooted runners can be obtained. Propagate the different sorts of stone fruit trees, by budding on other trees, or on prepared stocks. Gather fruits of all kinds as they ripen.

Forcing.—Prune melons and cucumbers, giving air and water, and maintaining heat, &c. Continue the routine treatment in the pinery, but withhold water when the fruit begins to ripen; push on the growth of the suckers on old plants, which will materially advance the fruiting period. The forcing-houses ought to have abundance of fresh air and moisture, along with the necessary heat.

Plant Houses.—Ventilation will be necessary to keep down excessive heat; and attention must be paid to potting, shifting, and putting in cuttings, and giving abundance of water to the potted plants, both indoors and out. Sow calceolarias; shift heaths, if

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CALENDAR FOR THE UNITED STATES—Continued.

Fruit Garden.—The hay or leaf mulching on the strawberry beds should be removed and the ground deeply hoed, after which it may be placed on again to keep the fruit clean and the ground from drying. Where it has not been convenient before, most of the smaller fruits may yet be planted during the first part of the month. Tobacco dust will dislodge most of the numerous kinds of slugs, caterpillars, or worms that make their appearance on the young shoots of vines or trees.

Vegetable Garden.—Attention should be given to new sowings and plantings for succession. Crops sown last month will have to be thinned out if large enough. Hoe deeply all transplanted crops, such as cabbage, cauliflower, lettuce, &c. Tender vegetables, such as tomatoes, egg and pepper plants, sweet potatoes, &c., can be planted out. Seeds of Lima beans, sweet corn, melon, okra, cucumbers, &c., should be sown; and sow for succession peas, spinach, lettuce, beans, radishes, &c., every ten days.

JUNE.

Flower Garden and Greenhouse.—Tropical plants can now be used to fill up the greenhouse during the summer months. It should be well shaded, and fine specimens of fancy caladiums, dracænas, coleus, crotons, palms, ferns, and such plants as are grown for the beauty of their foliage, will make a very attractive show. The "moss culture" will be found particularly valuable for these plants. Hyacinths, tulips, and other spring bulbs may be dug up, dried, and placed away for next fall's planting, and their places filled with bedding plants, such as coleus, achyranthes, pelargoniums, and the various white and coloured leaf plants. It will be necessary to mow the lawn once a week.

Fruit Garden.—The small fruits should be mulched about the roots, if this has not yet been done. Grape vines outside as well as in should be disbudded.

Vegetable Garden.—Beets, beans, carrots, corn, cucumbers, lettuce, peas, and radishes may be sown for succession. This is usually a busy month, as many crops have to be gathered, and, if hoeing is not promptly seen to, weeds are certain to give great trouble. Tomatoes should be tied up to trellises or stakes if fine-flavoured and handsome fruit is desired, for if left to ripen on the ground they are apt to have a gross earthy flavour.

JULY.

Flower Garden and Greenhouse.—Watering, ventilating, and fumigating (or the use of tobacco in other forms for destruction of aphides) must be attended to. The atmosphere of the greenhouse must be kept moist. Watch the plants that have been plunged out of doors, and see if any require repotting. All plants that require staking, such as dahlias, roses, gladioli, and many herbaceous plants, should now be looked to. Carnations and other plants that are throwing up flower stems, if wanted to flower in winter, should be cut back, that is, the flower stems should be cut off to say 5 inches from the ground.

Fruit Garden.—If grape vines show any signs of mildew, dust them over with dry sulphur, selecting a still warm day. The fruit having now been gathered from strawberry plants, if new beds are to be formed, the system of layering the plants in small pots is the best. Where apples, pears, peaches, grapes, &c., have set fruit thickly, thin out at least one-half to two-thirds of the young fruit.

Vegetable Garden.—The first ten days of this month will yet be time enough to sow sweet corn, beets, lettuce, beans, cucumbers, and ruta-baga turnips. Such vegetables as cabbage, cauliflower, celery, &c., wanted for fall or winter use, are best planted this month, though in some sections they will do later. Keep sweet potatoes hoed to prevent the vines rooting at the joints.

AUGUST.

Flower Garden and Greenhouse.—But little deviation is required in these departments from the instructions for July.

Fruit Garden.—Strawberries that have fruited will now be making "runners" or young plants. These should be kept cut off close to the old plant, so that the full force of the root is expended in making the "crowns" or fruit buds for next season's crop. If plants are required for new beds, only the required number should be allowed to grow, and these should be layered in pots as recommended in July. The old stems of raspberries and blackberries that have borne fruit should be cut away, and the young shoots thinned to three or four canes to each hill or plant. If tied to stakes and topped when 4 or 5 feet high, they will form three or four branches on a cane, and will make stronger fruiting plants for next year.

they require it; cut down pelargoniums past flowering, and plant the cuttings.

Flower Garden and Shrubbery.—Take up the remaining tuberous roots, such as anemones, ranunculuses, &c., by the end of the first week; fill up their places, and any vacancies that may have occurred, with annuals or bedding plants from the reserve ground. Repot auriculas, and sow auricula seed in boxes under glass. Propagate herbaceous and other plants that have gone out of flower, by means of cuttings and slips, especially those required for spring bedding; propagate also the various summer bedding plants increased by cuttings. Increase roses and American shrubs, by layering, budding, or cuttings, and go on with the layering of carnations and picotees. Stake and tie up dahlias and strong herbaceous plants.

August.

Kitchen Garden.—Sow winter and spring spinach in the beginning and about the end of the month; parsley and winter onions, for a full crop, in the first week; cabbages about the middle of the month, for planting out in spring; cauliflower in the first half (Scotland) and in the second half (England) of the month; Hardy Hammersmith and Brown Cos lettuce in the first and last week; small salads occasionally; and Black Spanish radish, for winter crops. Plant out kales and broccoli for late crops; plant celery (earthing up the advancing crops as required), endive for succession, and a few coleworts. Take up shallots, garlic, &c.

Fruit Garden.—Proceed in training and regulating the summer shoots of all fruit trees as directed for the last three months. Net up, in dry weather, gooseberry and currant bushes, to preserve the fruit till late in the autumn. Make new strawberry beds if required. Preserve the ripening fruits on the wall and other trees from insects, and destroy wasp nests. Gather fruits as they ripen.

Forcing.—The routine of cultivation in hotbeds and pits may be continued. Sow, and propagate by cuttings, in the beginning of the month, cucumbers, to be afterwards grown in hot-water pits, or in boxes in the front of the pine-stove, for a winter crop. Make up mushroom beds for winter crop. In the pinery most of the summer fruit will be cut by the middle of the month, when a general shifting of succession plants will take place; as also a potting of suckers; but these will be strengthened by being allowed to remain on the old plants until the end of the month. In the forcing-houses, where the crops are past, part of the sashes may be removed, so as to permit thorough ventilation.

Plant Houses.—Attend to the propagation of all sorts of greenhouse plants by cuttings, and to the replacing in the greenhouse and stoves the more tender species, by the end of the month in ordinary seasons, but in wet weather in the second week. Sow half-hardy annuals, as Nemophila, Collinsia, Schizanthus, Rhodanthe, &c., to flower during winter.

Flower Garden and Shrubbery.—Sow in the second and the last week, on a warm border of a light sandy soil, with an east aspect, any free-flowering hardy annuals as Silene pendula, Nemophila, &c., for planting in spring; and auricula and primula seeds in pots and boxes. Propagate all sorts of herbaceous plants by rooted slips; layer chrysanthemums; take off layers of carnations, picotees, and pansies. Plant cuttings of bedding plants, and of bedding pelargoniums in boxes for convenience of removal. Layer the tops of chrysanthemums, to obtain dwarf flowering plants. Transplant evergreens in moist weather, about the end of the month; and propagate them by layers and cuttings. Pot Neapolitan violets for forcing; or plant out on a mild hotbed. Clip box edgings.

September.

Kitchen Garden.—Sow small salading for late crops; and lettuce and spinach, if not done last month, for spring crops. Plant endive and lettuce at the foot of a south wall to stand the winter; plant out cabbages from the chief autumn sowing. Plant cauliflowers on a warm border in spaces such as can be protected by hand-lights. Thin the winter spinach, when large enough, that it may have space to grow. If broccoli be too rank or tall to withstand the winter, lift and lay nearly up to the neck in the earth, the heads sloping towards the north. Lift onions, and lay them out to ripen on a dry border or gravel-walk. Lift potatoes and store them.

Fruit Garden.—Finish the summer pruning and training. Where the walls are heated, assist the maturing of peaches and nectarines, and the ripening of the young wood for next year, by fires during the day. Gather and lay up in the fruit-room with care the autumnal sorts of apples and pears. Prepare borders and stations for fruit trees during dry weather. Plant strawberries for a main crop. Repot orchard-house trees, disrooting if necessary.

Forcing.—Take care that late melons and cucumbers be not injured by getting too much water, and too little air. Sow a few kidney beans for an early forced crop. In the pinery at once take off and pot all strong suckers not done last month; the remainder may be taken off at the end of the month, and planted in old tan in a frame or pit. Expel damp, and assist the ripening of late grapes and peaches, with fires during the day. Prune early vines and peaches.

Plant Houses.—The various pot plants should now be put in their winter quarters. Keep up moderate temperatures in the stove, and merely repel frosts in the greenhouse, guarding against damp, by ventilation and by the cautious use of water. Pot hyacinths, tulips, and other bulbs for forcing; and propagate half-hardy plants by cuttings.

Flower Garden, &c.—Sow in the beginning of this month all half-hardy annuals required for early flowering; also mignonette in pots, thinning the plants at an early stage; the different species of primula; and the seeds of such plants as, if sown in spring, seldom come up the same season, but if sown in September and October, vegetate readily the succeeding spring. Put in cuttings of bedding pelargoniums in boxes, which may stand outdoors exposed to the sun, but should be sheltered from excessive rains. Continue the propagation of herbaceous plants, taking off the layers of carnations, picotees, pansies, and chrysanthemums, by the end of the month; choice carnations and picotees may be potted and wintered in cold frames if the season is wet and ungenial. Plant evergreens; lay and put in cuttings of most of the hard-wooded sorts of shrubby plants.

October.

Kitchen Garden.—Sow small salading and radishes in the first week, and lettuces in frames on a shallow hotbed for planting out in spring. If the winter prove mild they will be somewhat earlier

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CALENDAR FOR THE UNITED STATES—Continued.

Vegetable Garden.—Hoe deeply such crops as cabbage, cauliflower, and celery. The earthing up of celery this month is not to be recommended. Onions in many sections can be harvested. The proper condition is when the tops are turning yellow and falling down. They are dried best by placing them in a dry shed in thin layers. Sow spinach for fall use, but not yet for the winter crop. Red top, white globe, and yellow Aberdeen turnips should now be sown; ruta-baga turnips sown last month will need thinning, and in extreme Southern States they may yet be sown.

September.

Flower Garden and Greenhouse.—The flower beds in the lawn should be at their best. If planted in "ribbon lines" or "massing," strict attention must be given to pinching off the tops, so that the lines or masses will present an even surface. Tender plants will require to be put in the greenhouse or housed in some way towards the end of this month; but be careful to keep them as cool as possible during the day. Cuttings of bedding plants may now be made freely if wanted for next season, as young cuttings rooted in the fall make better plants for next spring's use than old plants, in the case of such soft-wooded plants as pelargoniums, fuchsias, verbenas, heliotropes, &c.; with roses and plants of a woody nature, however, the old plants usually do best. Dutch bulbs, such as hyacinths, tulips, crocus, &c., and most of the varieties of lilies, may be planted. Violets that are wanted for winter flowering will now be growing freely, and the runners should be trimmed off. Sow seeds of sweet alyssum, candytuft, daisies, mignonette, pansies, &c.

Fruit Garden.—Strawberry plants that have been layered in pots may yet be planted, or in southern districts the ordinary ground layers can be planted. The sooner in the month both are planted the better crop they will give next season; and, as these plants soon make runners, it will be necessary to trim them off. Attend to raspberries and blackberries as advised for last month, if they have not already been attended to.

Vegetable Garden.—If cabbage, cauliflower, and lettuce are wanted to plant in cold frames, the seed should be sown from about the tenth to the twentieth of this month; but judgment should be exercised, for, if sown too early, cabbage and cauliflower are apt to run to seed. The best date for latitude of New York is September 15th. The main crop of spinach or sprouts that is wanted for winter or spring use should be sown about the same date. The earth should be drawn up to celery with a hoe preparatory to earthing up with a spade. Onions that were not harvested and dried last mouth must now be attended to. Turnips of the early or flat sorts may yet be sown the first week of this month in the Northern States, and in the South from two to four weeks later.

October.

Flower Garden and Greenhouse.—In northern sections of the United States, tender plants that are still outside should be got under cover as early as possible. Delay using fire heat as long as possible, unless the nights become so cold as to chill the plants inside the house. Roses, carnations, camellias, azaleas, pelargoniums, and the hardier sorts of plants will do better if placed in a cold frame or pit until the middle of November than they would in an ordinary greenhouse. Look out for insects. Fall bulbs of all kinds may be planted. Take up summer-flowering bulbs and tubers, such as dahlias, tuberoses, gladioli, cannas, caladiums, tigridias, and dry them off thoroughly, stowing them away afterwards in some place free from frost and moisture during winter.

Fruit Garden.—Strawberries that have been grown from pot-grown layers may yet be planted in Southern States; keep the runners trimmed off. Fruit trees and shrubs may be set out; but, if planting is deferred to the last of the month, the ground around the roots should be mulched to the thickness of 3 or 4 inches with straw, leaves, or rough manure, as a protection against frost.

Vegetable Garden.—Celery will now be in full growth, and will require close attention to earthing up, and during the last part of the month the first lot may be stored away in trenches for winter. All vegetable roots not designed to be left in the ground during the winter should be dug up, such as beets, carrots, parsnips, sweet potatoes, &c. The cabbage, cauliflower, and lettuce plants grown from seed sown last month should be pricked out in cold frames. If lettuce is wanted for winter use, it may now be planted in the greenhouse or cold frame, and will be ready for use about Christmas. If asparagus or rhubarb is wanted for winter use, it should be taken up and stowed away in pit, frame, shed, or cellar for a month or two. It may then be taken into the greenhouse and packed closely together under the stage, and will be fit for use from January to March, according to the temperature of the house.

than those sown next month or in January. Plant parsley in pots or boxes to protect under glass in case very severe weather occurs. Plant cabbages in beds or close rows till wanted in spring; and cauliflowers in the last week, to receive the protection of frames, or a sheltered situation. Store potatoes, beet, salsafy, scorzonera, skirret, carrots, and parsnips, by the end of the month. Band and earth up cardoons.

Fruit Garden.—Such fruit trees as have dropped their leaves may be transplanted; this is the best season for transplanting (though with care it may be done earlier), whether the leaves have fallen or not. Protect fig-trees, if the weather proves frosty, as soon as they have cast their leaves. Plant out raspberries. The orchard-house trees should be got under glass before the end of the month. Gather and store all sorts of apples and pears, the longest-keeping sorts not before the end of the month, if the weather be mild.

Forcing.—Maintain the heat in hotbeds and pits by means of fresh dung linings. Give abundance of air in mild bright weather. Dress vines and peaches. Clean and repair the forcing-houses, and overhaul the heating apparatus to see it is in good working condition. Plant chicory or witloef in boxes or on hotbeds for blanching. Sow kidney beans. Make up successional winter mushroom beds.

Plant Houses.—Replace all sorts of greenhouse plants. Fill the pits with pots of stocks, mignonette, and hardy annuals for planting out in spring, along with many of the hardy sorts of greenhouse plants; the whole ought to be thoroughly ventilated, except in frosty weather. From this time till spring keep succulent plants almost without water. Sow cyclamens. Begin to force roses, hyacinths, and a few other bulbs, for winter and early spring decoration. Plant hyacinths in glasses for windows.

Flower Garden.—Sow a few pots of hardy annuals in a frame, or on a sheltered border, for successional spring use if required. Plant the greater part of the common border bulbs as hyacinths, narcissi, crocuses, and early tulips, about the end of the month, with a few anemones for early flowering. Transplant strong plants of biennials and perennials to their final situations; also the select plants used for spring bedding. Protect alpine plants, stage auriculas, and carnations and picotees with glass frames; and half-hardy greenhouse plants, such as fuchsias, &c., about the end of the month, with coverings of broom or spruce-fir, preferring the latter. Take up, dry, and store dahlias and all tender tubers in the end of the month; pot lobelias and similar half-hardy plants from the open borders. Transplant all sorts of hardy evergreens and shrubs, especially in dry soils, giving abundance of water. Put in cuttings of all sorts of evergreens, &c. Plant out the hardier sorts of roses.

November.

Kitchen Garden.—Trench up all vacant ground as soon as cleared of its crops, leaving the surface as rough as possible. Sow Dillistone's Early peas and Early Dwarf Prolific beans, in the second week, for an early crop; also in frames for transplanting. Protect endive, celery, artichoke, and sea-kale, with stable-litter or fern, or by planting the former in frames; take up late cauliflower, early broccoli, and lettuces, and place them in sheltered pits or lay them in an open shed; earth up celery; manure and dress up asparagus beds.

Fruit Garden.—Plant all sort of fruit trees in fine weather—the earlier in the month the better. Protect fig-trees. Commence pruning and nailing. Gather and store the latest apples and pears. Examine the fruit room, and remove all decayed fruit.

Forcing.—Keep up the requisite degree of heat in hotbeds and pits. Cucumbers and pines, on hotbeds, will require more than ordinary attention, to prevent them damping off from too much moisture; hence the advantage of hot-water heating. Force asparagus, rhubarb, and sea-kale, in the mushroom-house, in pits, or in the open border under boxes or cases surrounded and covered by well-fermented stable dung and leaves. Sow Early Horn carrot; also kidney beans and radishes, on hotbeds. In the forcing-houses prune and train the trees; fork over and dress the borders of such houses as have not been already done.

Plant-Houses.—The directions for the greenhouse and conservatory in January apply also to this month generally. Continue the forcing of roses, hyacinths, &c.

Flower Garden, &c.—Plant dried tubers of border flowers, but the finer sorts had better be deferred till spring. Plant tulips in the early part of the month. Put in cuttings of bedding calceolarias, choosing the shoots that will not run up to flower. Protect such half-hardy plants as are not already sheltered. Plant deciduous trees and shrubs so long as the weather continues favourable, and before the soil has parted with the solar heat absorbed during summer. Dig and dress such flower borders and shrubberies as may now be cleared of annuals and the stems of herbaceous plants.

December.

Kitchen Garden.—Collect and smother-burn all vegetable refuse, and apply it as a dressing to the ground. Sow a few peas and beans, in case of accident to those sown in November, drawing up the soil towards the stems of those which are above ground as a protection; earth up celery; blanch endive with flower-pots; sow radishes in a very sheltered place. Attend to trenching and digging in dry weather.

Fruit Garden.—Plant all sorts of fruit trees in mild weather. Proceed with pruning and nailing wall-trees. Examine the fruit-room every week, removing promptly all decaying fruit.

Forcing.—The same degree of attention to hotbeds and pits will be necessary as in the last month. Continue the forcing of asparagus, rhubarb, and sea-kale, in pits and in the mushroom-house. Proceed with the usual routine of culture commenced last month. Make the necessary preparations to begin forcing early or succession crops by the last week of this or the first of next month.

Plant-Houses, Frames, &c.—Carnations and picotees in pots must be kept rather dry to prevent damping off. Heaths and Australian plants must be very sparingly watered, and kept with only fire heat enough to repel frost.

Flower Garden, &c.—Plant shrubs in open weather. Prune hardy roses and other hardy shrubs. Sweep and roll the lawns, and put in repair the gravel-walks, keeping the surface frequently rolled. (T. MO.)

CALENDAR FOR THE UNITED STATES—Continued.

November.

Flower Garden and Greenhouse.—Plants intended to be grown inside should now all be indoors. Keep a sharp look out for cold snaps, as they come very unexpectedly in November, and many plants are lost thereby. In cases where it is not convenient to use fire heat, 5° to 10° of cold can be resisted by covering the plants over with paper, and by using this before frost has struck the plants valuable collections may be saved. When fire heat is freely used, be careful to keep up the proper amount of moisture by sprinkling the paths with water. Little can be done in the flower garden, except to clean off all dead stalks, and straw up tender roses, vines, &c., and, wherever there is time, to dig up and rake the borders, as it will greatly facilitate spring work. Cover up all beds in which there are hyacinths, tulips, and other bulbs with a litter of leaves or straw to the depth of 2 or 3 inches. If short thoroughly-decayed manure can be spared, a good sprinkling spread over the lawn will help it to a finer growth next spring.

Fruit Garden.—Strawberry beds should be covered (in cold sections) with hay, straw, or leaf mulching, to a depth not exceeding 2 inches. Fruit trees and grape vines generally should be pruned; and, if the wood of the vine is wanted for cuttings, or scions of fruit trees for grafts, they should be tied in small bundles and buried in the ground until spring.

Vegetable Garden.—Celery that is to be stored for winter use should be put away before the end of the month in all sections north of Virginia; south of that it may be left in most places where grown throughout the winter if well covered up. The stalks of the asparagus bed should be cut off, and burned if there are berries on them, as the seeds scattered in the soil sometimes produce troublesome weeds. Mulch the beds with 2 or 3 inches of rough manure. All vegetable roots that are yet in the ground, and not designed to be left there over winter, must be dug up in this latitude before the middle of the month, or they may be frozen in. Cover up onions, spinach, sprouts, cabbage, or lettuce plants with a covering of 2 or 3 inches of leaves, hay, or straw, to protect them during the winter. Cabbages that have headed may usually be preserved against injury by frost until the middle of next month, by simply pulling them up and packing them closely in a dry spot in the open field with the heads down and roots up. On approach of cold weather in December they should be covered up with leaves as high as the tops of the roots, or, if the soil is light, it may be thrown over them, if leaves are not convenient. Cabbages will keep this way until March if the covering has not been put on too early. Plough all empty ground if practicable, and, whenever time will permit, do trenching and subsoiling. Cabbage, cauliflower, and lettuce plants that are in frames should be regularly ventilated by lifting the sash on warm days, and on the approach of very cold weather they should be covered with straw mats or shutters. In the colder latitudes, and even in the Middle States, it is absolutely necessary to protect cauliflower in this way, as it is much more tender than cabbage and lettuce plants.

December.

Flower Garden and Greenhouse.—Close attention must be paid to protecting all tender plants, for it is not uncommon to have the care of a whole year spoiled by one night's neglect. Vigilance and extra hot fires will have to be kept up when the thermometer falls to 34° or 35° in the parlour or conservatory. It is well to set the plants under the benches or on the walks of the greenhouse; if they are in the parlour, move them away from the cold point and protect them with paper; this will usually save them even if the thermometer falls to 24° or 26°. Another plan in the greenhouse is to dash water on the pipes or flues, which causes steam to rise to the glass and freeze there, stopping up all the crevices. With plants outside that require strawing up or to be mulched, this will have now to be finished.

Fruit Garden.—In sections where it is an advantage to protect grape vines, raspberries, &c., from severe frost, these should be laid down as close to the ground as possible, and covered with leaves, straw, or hay, or with a few inches of soil.

Vegetable Garden.—Celery in trenches should receive the final covering for the winter, which is best done by leaves or light stable litter; in the latitude of New York it should not be less than 12 inches thick. Potatoes, beets, turnips, or other roots in pits, the spinach crop in the ground, or any other article in need of protection, should be attended to before the end of the month; manure and compost heaps should be forwarded as rapidly as possible, and turned and mixed so as to be in proper condition for spring. Remove the snow that accumulates on cold frames or other glass structures, particularly if the soil which the glass covers was not frozen before the snow fell; it may remain on the sashes longer if the plants are frozen in, since they are dormant, and would not be injured if deprived of light for eight or ten days. If roots have been placed in cellars, attention must be given to ventilation, which can be done by making a wooden box, say 6 by 8 inches, to run from the ceiling of the cellar to the eaves of the building above. (P. H.)

Horticulture.—Index of Principal Subjects.

HOSEA, the son of Beerî, the first in order of the minor prophets. The name Hosea (הוֹשֵׁעַ, LXX. 'Ωσηέ, Vulg. *Osee*, and so our English version in Rom. ix. 25) ought rather to be written Hoshea, and is identical with that borne by the last king of Ephraim, and by Joshua in Num. xiii. 16, Deut. xxxii. 44. Of the life of Hosea we know nothing beyond what can be gathered from his prophecies. That he was a citizen of the northern kingdom appears from the whole tenor of the book, but most expressly from i. 2, where "the land," the prophet's land, is the realm of Israel, and vii. 5, where "our king" is the king of Samaria. The date at which Hosea flourished is given in the title, i. 1, by the reigning kings of Judah and Israel. He prophesied (1) in the days of Uzziah, Jotham, Ahaz, and Hezekiah, kings of Judah; (2) in the days of Jeroboam the son of Joash, king of Israel. As Jeroboam II. died in the lifetime of Uzziah, these two determinations of the period of Hosea's prophetic activity are not strictly coincident, and a question arises whether both are from the same hand or of equal authority. There is no doubt that the date of Jeroboam II. applies to chaps. i. and ii., which were written before the downfall of the dynasty of Jehu (i. 4), and while the nation was still enjoying the prosperity that distinguished Jeroboam's reign. On the other hand, it seems equally certain that chaps. iv.-xiv. are in their present form a continuous composition dating from the period of anarchy subsequent to that king's death. Thus it seems natural to suppose, with Ewald and other scholars, that the name of Jeroboam originally stood in a special title to chaps. i., ii. (or to these along with chap. iii.), which was afterwards extended to a general heading for the whole book by the insertion of the words "of Uzziah . . . . and in the days of." As Hosea himself can hardly be supposed to have thus converted a special title into a general one, the scholars who take this view suppose further that the date by Judæan reigns was added by a later hand, the same perhaps which penned the identical date in the title to Isaiah. On this view the Judæan date merely expresses knowledge on the part of some Hebrew scribe that Hosea was a contemporary of Isaiah. The plausibility of this hypothesis is greatly increased by the fact that there does not appear to be anything in the book of Hosea that is clearly as late as the reign of Hezekiah. On the contrary, the latter part of the book seems to have been written before the expedition of Tiglath Pileser against Pekah in the days of Ahaz. In that war Gilead and Galilee were conquered and depopulated (2 Kings xv. 29), but Hosea repeatedly refers to these districts as still forming an integral part of the kingdom of Israel (v. 1, vi. 8, xii. 11; contrast Micah vii. 14). Assyria is never referred to as a hostile power, but as a dangerous ally, from which some of the godless Ephraimites were ready to seek the help which another party expected from Egypt, but which in truth was to be found only in Jehovah (v. 13, vii. 11, viii. 9, xii. 1, xiv. 3). This picture precisely corresponds with what we read in 2 Kings xv. of the internal dissensions which rent the northern kingdom after the fall of the house of Jehu, when Menahem called in the Assyrians to help him against those who challenged his pretensions to the throne. Under Pekah of Israel, and Ahaz his contemporary in Judah, the political situation was altogether changed. Israel was in alliance with Damascus, and Assyria made open war on the allies (2 Kings xvi.). This new situation may be said to mark a crisis in the history of Old Testament prophecy, for to it we owe the magnificent series of Isaiah's Assyrian discourses (Isa. vii. *seq.*). But the events which stirred Judæan prophets so deeply have left no trace in the book in which Hosea sums up the record of his teaching. He foresees that captivity and desolation lie in the future, but even in his last words of pathetic exhortation he speaks to a nation which looks to Assyria for help and victory (xiv. 3). The received chronology of the kings of Judah and Israel is notoriously precarious, and a comparison of the Assyrian monuments and eponym lists with the Biblical data makes it probable that the period from the accession of Zachariah, son of Jeroboam II., to the fall of Samaria must be shortened by as much as twenty years, and that the interregnum which is commonly supposed to have followed Jeroboam's death must also be cancelled. This correction may be held to remove one difficulty in the title of our book, which on the current chronology assigns to Hosea some sixty years of prophetic activity. On the other hand, most Assyriologists agree that the expedition of Sennacherib, which fell in the fourteenth year of Hezekiah (2 Kings xviii. 13), took place in 701 B.C. In that case Hezekiah did not come to the throne till after the fall of Samaria (722–719); which the book of Hosea predicts as a future occurrence (ch. xiii. 16)—another argument against the authority of the title. There is still, however, a large element of uncertainty in the reconstruction of Hebrew chronology by the aid of the monuments. One date bearing on our book may be taken as certain, viz., the war of Tiglath Pileser with Pekah in 734, and, according to our argument, Hosea committed his prophecies to writing before that year.[1] A more exact determination of the date of the book has been sought by comparing viii. 9, 10, with the statement on the monuments that Tiglath Pileser received tribute from King Menahem (Minhimmi) of Samaria in 738 B.C. That Minhimmi of the monuments is the Menahem of the Bible there seems no good reason to doubt, in spite of the objections of Oppert and G. Smith. But it cannot be assumed that tribute was paid by him in 738 for the first time. The narrative in 2 Kings xv. 19 seems to indicate that the relations of Menahem to Assyria began earlier in his reign,[2] perhaps not long after his accession, which may be dated with probability *c.* 750 B.C.

To sum up, the first part of Hosea's prophetic work, corresponding to chaps i.–iii., lay in the years of external prosperity immediately preceding the catastrophe of the house of Jehu in or near the year 750. The second part of the book is a summary of prophetic teaching during the subsequent troublous reign of Menahem, and must have been completed before 734 B.C. Apart from the narrative in chaps i.–iii., to which we shall presently recur, the book throws little or no light on the details of Hosea's life. It appears from ix. 7, 8, that his prophetic work was greatly embarrassed by opposition, "As for the prophet, a fowler's snare is in all his ways, and enmity in the house of his God." The enmity which had its centre in the sanctuary probably proceeded from the priests (comp. Amos vii.), against whose profligacy and profanation of their office our prophet frequently declaims—perhaps also from the degenerate prophetic guilds which had their seats in the holy cities of the northern kingdom, and with whom Hosea's elder contemporary Amos so indignantly refuses to be identified (Amos vii. 14). In chap. iv. 5 Hosea seems to comprise priests and prophets in one condemnation, thus placing himself in direct antagonism to all the leaders of the religious life of his nation. Under such circumstances, and amidst the universal dissolution of social order and morality to which every page of his book bears testimony, the prophet was driven to the verge of despair (ix. 7), and only the sovereign conviction of Jehovah's infinite love and tender compassion to His people, even in their faithlessness and sin, upheld him in the sure hope of the final repentance and restoration of Israel, which finds such exquisitely pathetic expression in the closing sentences of his prophecy. The hypothesis of Ewald, that he was at last compelled by persecution to retire from the northern kingdom, and composed his book in Judea, rests mainly on an improbable exegesis of several passages, and derives no valid support from the fact that the prophet, to whom the ideal unity of all the tribes of Jacob and the legitimate sovereignty of the house of David are cardinal doctrines, follows the house of Judah with constant interest and growing acquaintance with its internal condition.

The most interesting problem of Hosea's history lies in the interpretation of the story of his married life (chaps. i.–iii.). We read in these chapters that God's revelation to Hosea began when in accordance with a divine command he married a profligate wife Gomer, the daughter of Diblaim. Three children were born in this marriage and received symbolical names, illustrative of the divine purpose towards Israel, which are expounded in chap. i. In chap. ii. the faithlessness of Israel to Jehovah, the long-suffering of God, the moral discipline of sorrow and tribulation by which He will yet bring back His erring people and betroth it to Himself for ever in righteousness, love, and truth, are depicted under the figure of the relation of a husband to an erring spouse. The suggestion of this allegory lies in the prophet's marriage with Gomer, but the details are worked out quite independently, and under a rich multiplicity of figures derived from other sources. In the third chapter we return to the personal experience of the prophet. His faithless wife had at length left him and fallen, under circumstances which are not detailed, into a state of misery, from which Hosea, still following her with tender affection, and encouraged by a divine command, brought her back and restored her to his house, where he kept her in seclusion, and patiently watched over her for many days, yet not readmitting her to the privileges of a wife.

In these experiences the prophet again recognizes a parallel to Jehovah's long-suffering love to Israel, and the discipline by which the people shall be brought back to God through a period in which all their political and religious institutions are overthrown. Throughout these chapters personal narrative and prophetic allegory are interwoven with a rapidity of transition very puzzling to the modern reader; but an unbiassed exegesis can hardly fail to acknowledge that chaps. i. and iii. narrate an actual passage in the prophet's life. The names of the three children are symbolical, but Isaiah in like manner gave symbolical names to his sons, embodying prominent points in his prophetic teaching (Shear-jashub, Isa. vii. 3, comp. x. 21; Maher-shalal-hash-baz, viii. 3). And the name of Gomer bath Diblaim is certainly that of an actual person, upon which all the allegorists, from the Targum, Jerome, and Ephrem Syrus downwards, have spent their arts in vain, whereas the true symbolical names in the book are perfectly easy of interpretation.[3] That the ancient interpreters take the whole narrative as a mere parable is no more than an application of their standing rule that everything in the Biblical history is allegorical which in its literal sense appears offensive to propriety (comp. Jerome's proem to the book). But the supposed offence to propriety

[1] Some writers, including Dr Pusey, claim a later date for the book, identifying Shalman in x. 14 with Shalmaneser IV., the successor of Tiglath Pileser. This identification is altogether arbitrary. If Beth-Arbel is Arbela beyond Jordan (*Onom.*, ed. Lagarde, p. 88), the reference, as Schrader has shown (*Keilinschr. und A. T.*, p. 283), may be equally well to Shalmaneser III., or to a king Shalamanu of Moab, who appears on the monuments as a tributary of Tiglath Pileser.

[2] See on the whole chronology of the period, Schrader, *Keilinschriften und A. T.*, Giessen, 1872; Id., *Keilinschriften und Geschichtsforschung*, *ibid.*, 1878; G. Smith, *Assyrian Eponym Canon*, London, 1875; Wellhausen's article in *Jbb. f. Deutsche Theol.*, 1875, pp. 607 *sq.*; Oppert, *Salomon et ses Successeurs*, Paris, 1877.

[3] Theodorus Mops. remarks very justly, *καὶ τὸ ὄνομα καὶ τὸν πατέρα λέγει, ὡς μὴ πλάσμα ψιλόν τι δοκοίη τὸ λεγόμενον, ἱστορία δὲ ἀληθὴς τῶν πραγμάτων.*

seems to rest on mistaken exegesis and too narrow a conception of the way in which the Divine word was communicated to the prophets. There is no reason to suppose that Hosea knowingly married a woman of profligate character. The point of the allegory in i. 2 is plainly infidelity after marriage as a parallel to Israel's departure from the covenant God, and a profligate wife (אשת זנונים) is not the same thing with an open prostitute (זונה). The marriage was marred by Gomer's infidelity; and the struggle of Hosea's affection for his wife with this great unhappiness—a struggle inconceivable unless his first love had been pure and full of trust in the purity of its object—furnished him with a new insight into Jehovah's dealings with Israel. Then he recognized that the great calamity of his life was God's own ordinance and appointed means to communicate to him a deep prophetic lesson. The recognition of a divine command after the fact has its parallel, as Wellhausen observes, in Jeremiah xxxii. 8.

This explanation of the narrative, which is essentially Ewald's, has commended itself to not a few recent expositors, as Valeton, Wellhausen, and Nowack. It has the great advantage of supplying a psychological key to the conception of Israel or the land of Israel (i. 2) as the spouse of Jehovah, which dominates these chapters, but in the later part of the book gives way to the personification of the nation as God's son. This conception has, indeed, formal points of contact with notions previously current, and even with the ideas of Semitic heathenism. On the one hand, it is a standing Hebrew usage to represent the land as mother of its people, while the representation of worshippers as children of their god is found in Num. xxi. 29, where the Moabites are called children of Chemosh, and is early and widespread throughout the Semitic field (*cf. Trans. Bib. Arch.*, vi. p. 438; *Jour. of Phil.*, ix. p. 82). The combination of these two notions gives at once the conception of the national deity as husband of the land. On the other hand, the designation of Jehovah as Baal, which, in accordance with the antique view of marriage, means husband as well as lord and owner, was current among the Israelites in early times (see BAAL), perhaps, indeed, down to Hosea's age (ii. 16). Now it is highly probable that among the idolatrous Israelites the idea of a marriage between the deity and individual worshippers was actually current and connected with the immorality which Hosea often condemns in the worship of the local Baalim, whom the ignorant people identified with Jehovah. For we have a Punic woman's name, ארישתבעל, "the betrothed of Baal" (Euting, *Punische Steine*, pp. 9, 15), and a similar conception existed among the Babylonians (Herod., i. 181, 182). But Hosea takes the idea of Jehovah as husband, and gives it an altogether different turn, filling it with a new and profound meaning, based on the psychical experiences of a deep human affection in contest with outraged honour and the wilful self-degradation of a spouse. It can hardly be supposed that all that lies in these chapters is an abstract study in the psychology of the emotions. It is actual human experience that gives Hosea the key to divine truth. Among those who do not recognize this view of the passage, the controversy between allegory and literalism is carried on chiefly upon abstract assumptions. The extreme literalists, of whom Dr Pusey may be taken as the modern representative in England, will have it that the divine command justified a marriage otherwise highly improper, and that the offensive circumstances magnify the obedience of the prophet. This is to substitute the Scotist and Neo-Platonic notion of God for that of Scripture. On the other hand, the allegorists, who argue that God could not have enjoined on His prophet a marriage plainly improper and fitted to destroy his influence among the people, are unable to show that what is repulsive in fact is fit subject for a divine allegory. A third school of recent writers, led by Hengstenberg, and resting on a thesis of John Smith, the Cambridge Platonist, will have it that the symbolical action was transacted in what they allow themselves by a *contradictio in adjecto* to call an objective vision. This view has been adopted by Fairbairn (*Prophecy*, ch. v. sec. ii.). The recent Continental literature of the controversy is catalogued by Nowack in his *Commentary*, p. xxxvi.

It was in the experiences of his married life, and in the spiritual lessons opened to him through these, that Hosea first heard the revealing voice of Jehovah (i. 2). Like Amos (Amos iii. 8), he was called to speak for God by an inward constraining voice, and there is no reason to think that he had any connexion with the recognized prophetic societies, or ever received such outward adoption to office as was given to Elisha. His position in Israel was one of tragic isolation. Amos, when he had discharged his mission at Bethel, could return to his home and to his friends; Hosea was a stranger among his own people, and his home was full of sorrow and shame. Isaiah in the gloomiest days of Judah's declension had faithful disciples about him, and knew that there was a believing remnant in the land. Hosea knows no such remnant, and there is not a line in his prophecy from which we can conclude that his words ever found an obedient ear. For him the present condition of the people contained no germ or pledge of future amendment, and he describes the impending judgment, not as a sifting process (Amos ix. 9, 10) in which the wicked perish and the righteous remain, but as the total wreck of the nation which has wholly turned aside from its God. In truth, while the idolatrous feasts of Ephraim still ran their joyous round, while the careless people crowded to the high places, and there in unbridled and licentious mirth flattered themselves that their many sacrifices ensured the help of their God against all calamity, the nation was already in the last stage of internal dissolution. To the prophet's eye there was "no truth, nor mercy, nor knowledge of God in the land—nought but swearing, and lying, and killing, and stealing, and adultery; they break out, and blood toucheth blood" (iv. 1, 2). The root of this corruption lay in total ignorance of Jehovah, whose precepts were no longer taught by the priests, while in the national calf-worship, and in the local high places, this worship was confounded with the service of the Canaanite Baalim. Thus the whole religious constitution of Israel was undermined. And the political state of the realm was in Hosea's eyes not more hopeful. The dynasty of Jehu, still great and powerful when the prophet's labours began, is itself an incorporation of national sin. Founded on the bloodshed of Jezreel, it must fall by God's vengeance, and the state shall fall with it (i. 4, iii. 4). This sentence stands at the head of Hosea's predictions, and throughout the book the civil constitution of Ephraim is represented as equally lawless and godless with the corrupt religious establishment. The anarchy that followed on the murder of Zachariah appears to the prophet as the natural decadence of a realm not founded on divine ordinance. The nation had rejected Jehovah, the only helper. And now the avenging Assyrian is at hand. Samaria's king shall pass away as foam on the water. Fortress and city shall fall before the ruthless invader, who spares neither age nor sex, and thistles shall cover the desolate altars of Ephraim. But the ultimate theme of all prophecy is not judgment but redeeming love, and the deepest thought of every Hebrew seer is the sovereignty of Jehovah's grace in Israel's sin. Hosea could discern no faithful remnant in Ephraim, yet Ephraim in all his corruption is the son of Jehovah, a child nurtured with tender love, a chosen people, whose past history declares in every episode the watchful and patient affection of his father. And that father is God and not man, the Holy One who will not and cannot sacrifice His love even to the justest indignation (chap. xi.). To the prophet who knows this love of Jehovah, who has learned to understand it in the like experience of his own life, the very ruin of the state of Israel is a step in the loving guidance which makes the valley of trouble a door of hope (ii. 15), and the wilderness of tribulation as full of promise as the desert road from Egypt to Canaan was to Israel of old. Of the manner of Israel's repentance and conversion Hosea presents no clear image, nay, it is plain that on this point he had nothing to tell. The certainty that the people will at length return and seek Jehovah their God and David their king rests, not on any germ of better things in Israel, but on the invincible supremacy of Jehovah's love And so the two sides of his prophetic declaration, the passionate denunciation of Israel's sin and folly, and the not less passionate tenderness with which he describes the final victory of divine love, are united by no logical bond. The unity is one of feeling only, and the sob of anguish in which many of his appeals to a heedless people seem to end, turns once and again with sudden revulsion into the clear accents of evangelical promise, which in the closing chapter swell forth in pure and strong cadence out of a heart that has found its rest with God from all the troubles of a stormy life.

Traditions about Hosea.—Beêrî, the prophet's father, is identified by the Rabbins with Beêrah (1 Chron. v. 6), a Reubenite prince carried captive by Tiglath Pileser. This view is already expressed by Jerome, *Quæst. in Paralip.*, and doubtless underlies the statement of the Targum to Chronicles that Beêrah was a prophet. For it is a Jewish maxim that when a prophet's father is named, he too was a prophet, and accordingly a tradition of R. Simon makes Isa. viii. 19, 20 a prophecy of Beêrî (Kimchi *in loc.*; *Leviticus Rabba*, par. 15). According to the usual Christian tradition, however, Hosea was of the tribe of Issachar, and from an unknown town, Belemoth or Belemon (pseudo-Epiphanius, pseudo-Dorotheus, Ephrem Syr., ii. 234; *Chron. Pasch.*, Bonn ed., i. 276). As the tradition adds that he died there, and was buried in peace, the source of the story lies probably in some holy place shown as his grave. There are other traditions as to the burial-place of Hosea. A Jewish legend in the *Shalsheleth haqqabala* (Carpzov, *Introd.*, pt. iii. ch. vii. § 3) tells that he died in captivity at Babylon, and was carried to Upper Galilee, and buried at צפת, that is, Safed (Neubauer, *Géog. du Talmud*, p. 227); and the Arabs show the grave of Neby 'Osha, east of the Jordan, near Es-Salt (Bädeker's *Palestine*, p. 337; Burckhardt's *Syria*, p. 353).

Literature.—Of the older commentaries on Hosea which have been fully catalogued by Rosenmüller in his *Scholia*, it is sufficient to name, as books still practically useful, Le Mercier's Latin annotations, embodying a translation of the chief rabbinical expositions, and the English commentary of E. Pococke, Oxford, 1685, which is not surpassed in learning and judgment by any subsequent work. Among recent expositions the most important are those in Ewald's *Propheten*, Bd. i. (2d ed., Göttingen, 1867; Eng. trans., London, 1876); Hitzig's *Kleine Propheten* (3d ed., Leipsic, 1863); Keil's *Kleine Propheten* (Leipsic, 1866; Eng. trans., Edinburgh, 1868); Pusey's *Minor Prophets*, London, 1860; Reuss's *Bible*, part ii. (Paris, 1876); the *Speaker's Commentary*, vol. vi. (by Huxtable, London, 1876); Heilprin's *Historical Poetry*, vol. ii. (New York, 1880); and the separate publications of Simson (Hamburg and Gotha, 1851), Wünsche (Leipsic, 1868), and Nowack (Berlin, 1880). The last gives a list of recent Continental commentaries and monographs, to which may be added Houtsma's "Bijdrage" (*Theol. Tijdsch.*, 1875, p. 55 *sq.*). The English commentary of Williams (London, 1866) is of little importance; Schmoller's commentary in Lange's *Bibelwerk* (1872; Eng. trans., 1874) is adapted for homiletical purposes. The theology of Hosea is ably discussed by Duhm, *Theol. der Propheten* (Bonn, 1875), with which an essay by Smend (*Stud. u. Krit.*, 1876) may be advantageously compared.

Texts and Versions.—The best edition of the Massoretic text is that with notes by S. Baer (Leipsic, 1878). From the great facsimile of the *Codex Babylonicus Petropolitanus* Hosea and Joel have been separately published (St Petersburg, 1875). The most recent helps to the use of the VSS. are Nestle's appendix to the 6th edition of Tischendorf's Septuagint (Leipsic, 1880), Lagarde's edition of the Targum from the *Cod. Reuch.* (Leipsic, 1872), Ceriani's facsimile editions of the great Ambrosian MSS. of the Syro-Hexaplar (Milan, 1874) and Peshito (Pars iii., Milan, 1879), and Field's *Hexapla* (vol. ii. 1870). An Arabic version directly translated from the Hebrew was published by Schroeter from a Bodleian codex in Merx's *Archiv*, 1869. A convenient and accessible edition of the Hebrew text of Hosea, with Targum and Rabbinical commentaries, is H. v. d. Hardt's reprint (Göttingen, 1775) of R. Stephen's Paris text of 1566. (W. R. S.)

HOSHANGÁBÁD, a British district in the chief commissionership of the Central Provinces of India, lying between 21° 40′ and 22° 59′ N. lat. and between 76° 38′ 30″ and 78° 45′ 30″ E. long. It is bounded N. by the Narbadá (Nerbudda), which separates it from the territories of Bhopál, Sindhia, and Holkar; E. by the Dudhi river, dividing it from Narsinghpur district; S. by the districts of Western Berar, Betúl, and Chhindwára; and W. by Nimár. Hoshangábád may be described as a valley of varying breadth, extending for 150 miles between the Nerbudda and the Sátpura mountains. The soil consists chiefly of black basaltic alluvium, often more than 20 feet deep; but along the banks of the Nerbudda the fertility of the land compensates for the tameness of the scenery. Towards the west, low stony hills and broken ridges cut up the level ground, while the Vindhyás and the Sátpuras throw out jutting spurs and ranges. In this wilder country considerable regions are covered with jungle. On the south the lofty range which shuts in the valley is remarkable in mountain scenery, surpassing in its picturesque irregularity the Vindhyán chain in the north. Many streams take their rise amid its precipices, then, winding through deep glens, flow across the plain between sandy banks covered with low jungle, till they swell the waters of the mighty Nerbudda. None of the streams are of any importance except the Tawá, which is interesting to the geologist on account of the many minerals to be found along its course. The boundary rivers, the Nerbudda and Tapti, are the only considerable waters in Hoshangábád. At Chárwá a dense low jungle extends over a large region, but by far the finest timber is found at Borí and Denwa.

The census of 1877 showed a population of 463,625 (Europeans, 86; Eurasians, 10; aboriginal tribes, 89,029; Hindus, 364,679; Mahometans, 21,765; Buddhists and Jains, 1132). There are only four towns with a population exceeding 5000, viz., Hoshangábád, 11,613; Harda, 9170; Seoni, 7579; and Sohágpur, 7552. The total revenue in 1876–77 was £69,842; the total cost of officials and police, £14,733. There were 11 civil and revenue judges, and 22 magistrates. The number of police was 582. There were 94 Government schools, attended by 4024 pupils.

Of the total area of 4376 square miles only 1442 are cultivated, and of the portion lying waste 825 are returned as cultivable; 2455 acres are irrigated entirely by private enterprise. Wheat forms the staple crop of the district; the other products are inferior grains, cotton, and sugar-cane. Hoshangábád does a considerable export trade in agricultural produce, receiving in return English piece-goods, spices, cocoa-nuts, salt, and sugar. The extent of made roads in Hoshangábád is returned at 498 miles. The Great Indian Peninsula Railway intersects the whole district from east to west, with stations at the principal towns. Besides roads and railway, the Nerbudda, with its tributaries, supplies means of communication by water for 150 miles during part of the year. The district is generally free from violent alternations of temperature, hot winds are rare, and the nights during the sultry weather and rains are always cool. The rainfall is exceedingly variable, ranging between the limits of 40 and 60 inches for the year. The prevailing diseases are fevers and bowel complaints. In 1876 five charitable dispensaries afforded medical relief to 18,206 in-door and out-door patients.

History.—Little is known of the history of Hoshangábád prior to the Marhattá invasion. When the Mughal troops occupied Handiá, the eastern part of the district inhabited by Gonds, who still retain their possession, maintained a rude independence. About 1720 Dost Muhammad, the founder of the Bhopál family, captured the town of Hoshangábád, and annexed a considerable territory with it. In 1750 Rájá Raghují Bhonslá of Nágpur reduced the country east of Handiá and south of the Nerbudda, except the portion held by Bhopál. In 1795 the rival dynasties of Bhopál and Nágpur came into conflict, and the town and fort of Hoshangábád were captured by the Nágpur forces. In 1802 the Bhopáls retrieved their loss. The Nágpur army again besieged the fort, but failed in their attack, and contented themselves with burning the town. In 1809 Hoshangábád was again assailed by a Nágpur force, and the Bhopáls, finding their communications with Bhopál cut off, surrendered. Overcome by these disasters, the Bhopáls called in the Pindháris to their help, and till they were finally extirpated in 1817 the whole of this fertile region became a prey to ravage and massacre. Under the order which the British Government has restored, the prosperity of the country is gradually returning. In 1818 that part of the district held by Nágpur was ceded under an agreement. In 1844 the region of Harda Handiá was made over by Sindhiá in part payment of the Gwalior contingent, and by the treaty of 1860 became British territory.

HOSHANGÁBÁD, the headquarters town of the above district, 22° 45′ 30″ N. lat., 77° 46′ E. long., is situated on the south side of the Nerbudda. Population (1877) 11,613. It is supposed to have been founded by Hoshang Sháh, the second of the Ghorí kings of Málwá; but it remained an insignificant place till the Bhopál conquest about 1720, when a massive stone fort was constructed, with its base on the river, commanding the Bhopál road. It sustained several sieges, and passed alternately into the hands of the Bhopál and Nágpur troops. From 1818 it has been the residence of the chief British officials in charge of the district. A church has been built, and a first-class jail constructed. The town has a dispensary and school-houses. It is the chief seat of the English piece-goods trade of the district, and has a brisk trade in cotton, grain, and bills of exchange.

HOSIERY. Under this name is embraced a wide range of manufactured textiles, which are classed together more on account of their manner of fabrication than from similarity of application or use. The term, as is quite obvious, has its origin in hose or stockings; but although stockings continue to be one of the staples of hosiery, that department is only one of a very numerous and diversified range of applications of the entire industry, it having been officially stated that not fewer than 5000 distinct articles are made in the trade. All kinds of hosiery proper are made by the process of knitting, and the industry has principally to deal with the fabrication of knitted under-clothing.

The art of knitting is the youngest of all the important textile manufactures, and, compared with the others, its origin is quite modern. No certain allusion to the art occurs before the beginning of the 15th century. In an Act of Parliament of Henry VII. (1488) knitted woollen caps are mentioned. It is supposed that the art was first practised in Scotland, and thence carried into England, and that caps were made by knitting for some period before the more difficult feat of stocking-making was attempted. In an Act of Edward VI. (1553) "knitte hose, knitte peticotes, knitte gloves, and knitte slieves" are enumerated, and the trade of hosiers is, among others, included in an Act dated 1563. Spanish silk stockings were worn on rare occasions by Henry VIII., and the same much-prized articles are also mentioned in connexion with the wardrobe of Edward VI.

The peculiarity of knitting consists in the use of a single thread for the entire texture, and in the formation therewith of a singularly elastic yet strong and firm looped web.

The process of hand-knitting is universally known, and the endless details of fancy stitches and loops whereby ornamented work can be produced do not come within the scope of hosiery proper. While a vast quantity of the best and most comfortable hosiery is made with implements so simple and inexpensive as four knitting wires or needles, the manufacturing industry is carried on with machinery of unsurpassed ingenuity and complexity. Moreover, domestic knitting machines, mostly of American origin, have of late years been introduced, and, although these can never be expected to attain the popular favour of the sewing-machine, yet they have been widely adopted.

In the year 1589 the stocking-frame, the machine which mechanically produces the looped stitch in hosiery, was invented by the Rev. William Lee, a graduate of Cambridge, and native of Woodborough, near Nottingham. The fundamental principle of the apparatus consists in the substitution of a separate hooked or barbed needle for the support and working of each loop, in place of the system whereby an indefinite number of loops are skewered on one or more wires or needles. The method on which the machine is worked will be easily comprehended by aid of the accompanying diagram (fig. 1), which represents a few of Lee's peculiar barbed needles from a frame with yarn in process of knitting. At R is seen a thread of yarn passed over the needle stalks and within the terminal hooks. The yarn, it will be observed, is waved or depressed between each pair of needles, whereby sufficient yarn is secured to form the separate loops of uniform size, and thus produce a regular equal fabric. The waving or depression of the yarn is produced by allowing thin plates of shaped metal termed sinkers to fall between each pair of needles after the yarn has been thrown across the whole range, and these sinkers, according to their depth of fall, carry down material for a large or small loop as the case may be. The elastic points of the needle-hooks are next pressed into a groove in the stem by means of a presser bar which acts on the whole row of barbs, and thus a range of temporarily closed metallic hooks is formed, through which the waved yarn is threaded. Over these hooks the loops of the already formed web SS have only to be drawn to form with the material R a new series of loops; the pressure is then relieved, and now R forms a new row in the work in place of S, and the operation is ready to be repeated for a succeeding row. It is not necessary here to enter into a description of the various mechanical devices by which Lee perfected the complex movements of his stocking-frame. It is sufficient to say that so perfectly did he succeed in his adaptations that to this day the essential features of his machine continue in use for the class of work to which he applied it. At first Lee was only able to work a flat even web, which when joined at the selvages made an unshapen cylinder; but he soon learned to shape the work at pleasure by removing loops from time to time from the outer edges of the web for narrowing or taking in, and to reverse that process for widening or letting out.

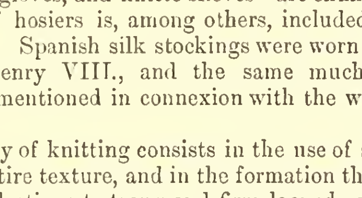

Fig. 1.

Neither Lee nor any of his relatives during their lifetime reaped an adequate reward for the great boon he conferred on mankind. His stocking-frame came gradually into extensive use, and an important industry was thereby created. No improvement of essential consequence was effected on the apparatus till in 1758 Mr Jedediah Strutt, originally a Derbyshire farmer, adapted it to the production of ribbed work. Mr Strutt's invention consisted of an addition to the original frame, which could be brought into use or not according as plain or ribbed work was desired. The addition consisted of a set of ribbing-needles placed at right angles to Lee's plain needles, and at the intervals required for producing ribbed courses. On the completion of a row of plain loops, the rib needles are raised; at their respective intervals they lay hold of the last-formed loop, and, bringing that through the loop which was on the rib-needle itself before, they give an additional or double looping or twisting, which reverses the line of chaining, and produces the ribbed appearance characteristic of this variety of work. For his invention Strutt in conjunction with his brother-in-law Woollett, a hosier, secured a patent, and they commenced the manufacture at Derby, where their "Derby-ribs" became exceedingly popular. The idea of adding parts to the plain frame of Lee, thus originated by Strutt, became the fertile source of a great number of the later adaptations and modifications of the apparatus. Strutt's invention was the starting-point of a great and most honourable business in the hands of himself and his family, and the elevation of his grandson, Lord Belper, to the peerage was a direct tribute to the industrial interests of the nation.

Down till almost the middle of this century only a flat web could be knitted in the machines in use, and for the finishing of stockings, &c., it was necessary to seam up the selvages of web shaped on the frame (fashioned work), or to cut and seam them from even web (cut work). The introduction of any device by which seamless garments could be fabricated was obviously a great desideratum, and it is a singular fact that a machine capable of doing that in a perfect manner should have been patented in 1816, while it was not seen in actual use in Nottingham, the capital of the hosiery trade, till 1845. The inventor of the round stocking-frame was no other than Sir Marc I. Brunel, who in 1816 patented his machine under the name of the *Tricoteur*. In Brunel's apparatus the needles are fixed on the rim of a rotating wheel. The yarn is delivered, the loops formed, the beards of the needles pressed down, and all the other operations performed by means of a series of arms and wheels which act on the circumference of the ring or circle of needles. As the working of such a machine is continuous, and as several sets of wheels and arms may work simultaneously around a ring of sufficient diameter, Brunel's machine was really capable of doing work with very great rapidity. He appears not, however, to have regarded his invention as worthy of being pushed into notice, and it was not till 1845 that in an improved form it was brought forward as an original invention by Mr Peter Claussen, who, however, reaped no profit from his undoubted ingenuity and merit.

Another improvement of very great importance in the hosiery trade was effected through the invention of the tumbler needle, patented by Mr M. Townsend in 1858. The tumbler needle (fig. 2) consists of a stem somewhat bulged near the point. The bulged part contains a groove in which there is hinged a short pin. The pin is so placed that, when turned to the hooked or curved point, its own point falls into a spoon-like indent, thus forming a smooth metal loop. When reversed the pin falls into the groove of the stem, making a smooth stalk. In this way, as will be clear from the figure, when the yarn is caught in the curved point of the needles, the already formed loops in being brought forward to pass off the needles carry forward the hinged pin and close the steel loop, over which they pass quite smoothly. The newly-formed loop then pushes over the tumbler pin into its groove, and the hook is once more ready to seize the yarn as it passes along. The tumbler needle and the revolving frame together form the basis of the various domestic machines which are now in the market. In machines in which the tumbler needle is adopted the needles themselves move in grooves, each being carried forward in succession as the feed of yarn comes opposite its position.

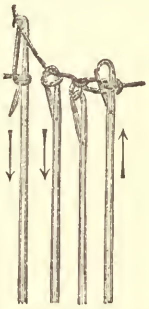

Fig. 2.

The varieties of frame now in use are embraced under narrow hand-machines, wide hand-machines, power rotary-frames, and power round-frames, the first two being exclusively used in the houses of the operatives, while the latter are factory machines driven by steam. "It will be an explanation of some interest," says the late Mr Felkin, in a paper before the British Association (Nottingham meeting, 1866), "to those who are strangers to the process of these trades, to state that the hand-knitter of a stocking, if assiduous and clever, will knit 100 loops a minute, and that Lee on his first machine made 1000 of worsted, and on his second 1500 loops of silk per minute. The visitor may now see on the round frame, patented by Brunel in 1816, but since modified and improved, without any effort but to supply yarn, 250,000 loops of the finest textures made, in various colours, per minute, with safety,—an advance of 2500-fold upon the hand-knitter."

The principle centre of the hosiery trade of the United Kingdom is Nottingham town and county; and in Leicestershire and Derbyshire the industry is also of importance. It was computed by Mr Felkin that the English hosiery trade gave employment in 1866 to about 150,000 persons, of whom about 100,000 were occupied in the preliminary and finishing operations of winding, cutting, mending, seaming, &c. At that time the industry was largely domestic, frames being hired out to operatives; but the trade tends steadily towards factories. According to a parliamentary return issued 31st July 1879, there were in the United Kingdom 186 hosiery factories, giving employment to 14,992 persons, 6683 males and 8309 females. Of these, 175 factories were in England, 10 in Scotland, and 1 in Ireland; and centred in Nottingham, Leicester, Lincoln, Rutland, and Derbyshire there were 173 of the establishments employing 13,680 of the operatives. The exports in 1878, which of course represent only a small proportion of the total output, amounted in value to £860,318. In the United States the industry is conducted on a manufacturing scale in New York State, Massachusetts, New Hampshire, Rhode Island, Vermont, Connecticut, and Maine; besides which family machines are extensively employed in that country. In Saxony also the trade is an important industrial feature, and there its development has been strikingly rapid. Throughout France, Spain, and Italy there are numerous frames at work, and indeed the trade may be regarded as in some degree commensurate with civilized industrial communities. (J. PA.)

HOSIUS, or OSIUS, bishop of Cordova, the friend of Athanasius, and the favourite of Constantine, was born about 256 A.D., most probably at Cordova, although from a passage in Zosimus it has sometimes been conjectured that he was believed by that writer to be a native of Egypt. Elected to the see of Cordova before the end of the 3d century, he narrowly escaped martyrdom in the persecution of Maximian (303–305); in 305 or 306 he attended the council of Illiberis or Elvira, his name appearing second in the list of those present; and in 313 we find him already at the court of Constantine, he being expressly mentioned by name in a constitution directed by the emperor to Cæcilianus of Carthage in that year. In 323 he was the bearer and not impossibly the writer of Constantine's letter to bishop Alexander of Alexandria and Arius his deacon, designed to promote the cause of peace; and, on the failure of the negotiations in Egypt, it was doubtless with the active concurrence of Hosius that the council of Nice was convened. He certainly took part in its proceedings; according to some Roman Catholic writers he presided, and did so as representing the bishop of Rome, but both these statements are made on totally inadequate grounds. Equally doubtful is the assertion that he was the principal author of the Nicene creed; but manifestly he powerfully influenced the judgment of the emperor in favour of the orthodox party. After a period of retirement in his diocese, Hosius presided in 347 at the fruitless synod of Sardica, which showed itself so hostile to Arianism; and afterwards he spoke and wrote in favour of Athanasius in such a way as to bring upon himself a sentence of banishment to Sirmium (355). From his exile he wrote to Constantius II. his only extant composition, a letter not unjustly characterized by Tillemont as displaying gravity, dignity, gentleness, wisdom, generosity, and in fact all the qualities of a great soul and a great bishop. Subjected to continual pressure, the old man, who was approaching, if he had not already passed, his hundredth year, was weak enough to sign the Arian formula adopted by the second synod of Sirmium in 357. Shortly afterwards he was permitted to return to his diocese, where he died in 359. Apart from some human touches of worldliness and latterly of weakness, Hosius was a consistent and creditable as well as prominent defender of orthodoxy, and as such he is recognized even by those who most bitterly resent his apostasy.

See Tillemont, *Mémoires*, vol. vii. 300–321 (1700), and Hefele, *Conciliengeschichte*, vol. i.

HOSPITAL is derived from the Latin *hospitalis* (adj.), and this again from the noun *hospes*, a host or guest. The place in which a guest was received was in Latin *hospitium* (hence the French, *hospice*), but in course of time the adjective became used as a noun, and the words *hospitalis*, *hospitale*, and *hospitalia* were adopted in the same sense as *hospitium*, by dropping the nouns *domus*, *cubiculum*, or *cubicula*. In this sense Vitruvius uses *hospitalia* to mean the chambers where guests were received. The English word *hospital* (often reduced to *spital*) comes from the old French *hospital*, now *hôpital*, of which Littré says that it was remade from the Latin many centuries ago, although originally *hospitalis* had given rise quite regularly to *hostel*, now *hôtel*. The three words, *hôpital*, *hospice*, and *hôtel*, although from the same source, are used now in very different meanings, the first being usually restricted to establishments for temporary occupation by the sick and hurt, for the purposes of medical and surgical treatment; the second (*hospice*) to places for permanent occupation by the poor, the infirm, the incurable, or the insane; and the last (*hôtel*) to dwellings, either public or private, for ordinary occupation. To the last, however, there is one exception, viz., when the term *hôtel-Dieu* (that is, *hôtel de Dieu*) is applied to the chief hospital or infirmary of a town or city. In English we have no equivalent to *hospice*, so that the word *hospital* has been, and is still, used in the double sense, viz., as a place for medical treatment, and also as a retreat or almshouse for the poor, the infirm, &c. On the other hand the word *infirmary*, which originally meant a place or room set apart in an establishment (such as a monastery) for the reception of the sick members, and also for those who were through age or infirmity incapacitated from work, is not infrequently employed in the same sense as *hospital*, namely, as a separate establishment for the treatment of the sick.

Although in ancient times there may have been places for the reception of strangers and travellers, it seems at least doubtful if there was anything of the nature of a charitable institution for the reception of the sick, such as existed after the introduction of Christianity. The Bethesda of Scripture (Aramaic, from בֵּית, a house, and חֶסְדָּא, charity) was probably no more than a collection of mere sheds built round the pool to whose waters miraculous healing powers were attributed. Among the Greeks there seems little evidence of the existence of establishments for the sick; ξενών, described by Plato as a place of shelter for travellers, is also explained as a νοσοκομεῖον, or hospital, by Suidas; but that lexicographer is a late writer (10th or 11th century A.D.), and the word νοσοκομεῖον itself does not appear to be earlier in use than the 4th century A.D. The word is used by St Jerome in the 4th century, and in the Code of Justinian in the 6th, from which it is possible Suidas may have got his definition, although ξενοδοχεῖον is distinctly used by Justinian as a shelter for travellers, as indeed its name implies. Even for sick and wounded soldiers but little provision seems to have been made, although we do not know much of the *valetudinarium*, which appears to have existed in a Roman camp. That the Romans had a medical staff has been shown by the monuments discovered in Great Britain, and the subject has been carefully examined by the late Sir James Simpson (*Transactions of the Society of Antiquaries of Scotland*, *Edinburgh Monthly Journal of Medicine*, &c.). Among the earliest hospitals on record are that said to have been founded by Valens in Cæsarea 370–80 A.D., and the one built at Rome by Fabiola, a Roman lady and friend of St Jerome, although like most others of that and even later times both were probably almshouses as well.

The origin of our present hospitals must, however, be looked for in the monastic arrangements for the care of the sick and indigent. Every monastery had its *infirmaria*, managed by an *infirmarius*, in which not only were sick and convalescents treated, but also the aged, the blind, the weak, &c., were housed.[1] In course of time separate buildings were erected for the purpose, and special revenues, augmented from time to time by benefactions, appropriated for their maintenance. In numerous instances, however, the hospitals were converted into benefices by the priests, and the scandal had to be dealt with by the authority of general councils, which, like that of Vienne, forbade the practice. About the earliest distinct record of the building of a hospital in England is in the life of Lanfranc, archbishop of Canterbury, who in 1080 founded two, one for leprosy and one for ordinary diseases. The former is referred to in the *Vie de St Thomas le Martyr*, a work of the 12th century. The establishments for the sick remained in the hands of the clergy until the Reformation, when some of the monasteries and church property were appropriated and set apart for the use of the sick. Of those the most noted instances were St Bartholomew's in Smithfield, St Thomas's in the Borough, Bethlehem or Bedlam, Bridewell, and Christ's Hospital, which were long known as the "Five Royal Hospitals." St Bartholomew's was a priory, founded by Rahere, a minstrel, in 1102, and the ancient hospital chapel is still the parish church of St Bartholomew the Less. It was handed over to the citizens of London as a hospital in 1547; it escaped the fire of 1666, and was rebuilt in 1729. St Thomas's was founded by Richard, prior of Bermondsey, in 1213, surrendered in 1538, and purchased by the mayor and citizens of London in 1551, and opened for 260 sick. It was incorporated in 1553, rebuilt in 1693, added to in 1732, removed temporarily to Surrey Gardens in 1862, and finally transferred to Lambeth, its present site, in 1871. Bethlehem (or Bedlam) was a priory, founded by Simon Fitzmary, in 1247. In 1547 it was handed over by Henry VIII. for the reception of lunatics. It was rebuilt in 1676, and wings were added in 1733. The present building was constructed in 1810. Bridewell and Christ's Hospital early ceased to be receptacles for the sick. (For further information regarding charitable institutions see ENGLAND, vol. viii. p. 253.)

But the great movement in hospital building took place in the 18th century, and the following table from Dr Steele's paper, "On the mortality of Hospitals" (Howard prize essay for 1876), gives a list of the chief institutions founded during that period :—

London.	Date of Foundation.	Provincial.	Date of Foundation.	Irish.	Date of Foundation.
Westminster	1719	York	1710	*Dublin.*	
Guy's	1723	Salisbury	1716	Jervis Street	1726
St George's	1733	Cambridge	1719	Steevens's	1733
London	1740	Bristol	1735	Mercer's	1734
Middlesex	1745	Edinburgh	1736	Meath	1756
		Windsor	1736	House of Industry	1774
		Aberdeen	1739		
Special Hospitals.		Northampton	1743		
		Exeter	1745	*Special (Dublin).*	
The British Lying-in	1749	Worcester	1745		
		Newcastle	1751	The Rotunda Lying-in	1745
City of London Lying-in	1750	Manchester	1753		
		Chester	1755	The Lock	1754
Queen Charlotte's Lying-in	1752	Leeds	1767	The Westmoreland Lock	1755
		Stafford	1769		
Small-pox	1746	Oxford	1770		
Lock, female	1745	Leicester	1771		
„ male	1747	Norwich	1771	Cork	1720-1722
		Dumfries	1775		
		Hereford	1776	Limerick	1759
		Birmingham	1778	Belfast	1797
		Montrose	1780		
		Nottingham	1782		
		Canterbury	1793		
		Glasgow	1794		
		Dundee	1795		
		Stafford	1797		

[1] *Liber ordinis Sancti Victoris Parisiensis*, MS. cap. 40. See Ducange's *Glossary*, *s.v.* "Infirmaria."

During the present century the increase of hospitals has continued, seven general and many special having been founded in London alone. Dr Steele gives statistics of 27 metropolitan hospitals, having an aggregate of nearly 6000 beds, and receiving about 46,000 in-patients annually. This does not take into account the infirmaries attached to the workhouses or the metropolitan asylums hospitals. In addition to this probably from ten to twelve times the number of out-patients are treated in the course of the year.

Hospitals are usually divided into *General* and *Special*. In *General Hospitals* cases of all kinds are admitted in some, whilst in others certain classes are excluded. Thus cases of contagious zymotic disease are not admitted now in many instances, especially in London since the establishment of the metropolitan asylums, fever and small-pox hospitals. Lying-in cases, venereal cases, &c., are also frequently excluded.

Special Hospitals are of various kinds, such as lying-in hospitals, ophthalmic, lock (for venereal diseases), cancer, consumption, &c., besides fever and small-pox hospitals. At the end of the last and beginning of this century fever hospitals were generally called "houses of recovery," with a view of not alarming the people too much who had to resort to them. Special hospitals are also set apart for the treatment of diseases of children.

Besides the various civil hospitals there are also naval and military hospitals for the cure of sailors and soldiers.

Although hospitals have been intended as a blessing and benefit to the poor, they have too often proved the reverse, on account of the ignorance, on the part of their administrators, of the true principles of health. So much was this the case formerly that it has been not infrequently debated whether hospitals are or are not gigantic evils; and even where it is admitted that they are of value in cases of actual disease, it is still doubtful if they are really of benefit in cases of confinement It may be of use to consider briefly the statistics of mortality at different times and in different places. It is very difficult to compare former death-rates with present or recent if we consider cases in bulk, because previous to the present century it was but little the custom to classify cases; so that a preponderance of surgical cases might exist at one period and of medical at another, with a corresponding variation of the death-rate. Of course in some exceptional instances we can point to remarkable differences due to known causes of unhealthiness. Thus in the Hôtel Dieu of Paris, in the last century, a terrible mortality occurred, amounting to 1 in 4½, or 220 per 1000 (Tenon);—and in the British hospitals at Scutari the mortality reached between 400 and 500 per 1000. In both of those cases there was inordinate crowding, such as is hardly likely to be met with again. But in dealing with ordinary hospitals there are so many modifying causes that the comparison, without careful analysis, may be misleading. Thus Dr Steele has shown that in the last century (1730–1800) the death-rate of St Thomas's was 86 per 1000, whilst that of Guy's was 119; but this, as he points out, may have arisen from the latter being looked upon as an asylum for incurables. In 1875 the death-rates of the general hospitals in London ranged from 72 per 1000 in the Royal Free to 127 in King's College; in the Edinburgh Royal Infirmary it was 92, and in the Glasgow 118. But it is when we examine the mortality of special cases that the most instructive lessons are to be learned; and the best for this purpose are surgical cases and lying-in cases. From these we gather that the mortality is pretty generally in the ratio of the size of the hospital and the consequent aggregation of patients, the crowding together of patients in the wards, the deficiency of ventilation, defective sewerage arrangements, and the want of constant attention to the details of cleanliness. Thus Sir James Simpson showed in his paper on "Hospitalism" the following statistics of mortality from amputations:—

	Deaths per 1000.
St Bartholomew's	366
London Hospital, Whitechapel	473
Guy's	382
St George's	388
Nine London hospitals	411
Royal Infirmary, Edinburgh	433
,, ,, Glasgow	391
Eleven large and Metropolitan hospitals	410

On the other hand, amputations in country practice give a death-rate of only 108 per 1000.

Comparing the results with the size of the hospital, that is, the aggregation of cases, we find:—

	Deaths per 1000.
Large Parisian hospitals, with more than 600 beds (Husson)	620
English hospitals, 301 to 600 beds	410
,, ,, 201 to 300 ,,	300
,, ,, 101 to 200 ,,	230
,, ,, 25 to 100 ,,	180
Cottage hospitals under 25 beds	140
Isolated rooms in country practice	108

The question of lying-in cases is even more remarkable. Dr Lefort, having collected the statistics of 888,302 delivered in hospitals, and of 934,781 delivered at home, shows that in hospitals 35 per 1000 die, and at home 4¾.

Dr Steele gives the statistics of the four great lying-in hospitals of London, compared with the "extern-maternity" charities of Guy's, St Bartholomew's, and St Thomas's:—

	Queen Charlotte's Lying in.	British Lying-in.	General Lying in.	City of London Lying-in.	Guy's.	St Bartholomew's.	St Thomas's.
Deaths per 1000	28·2	15·7	14·8	13·5	4·1	3·1	3·5

Baron Meydell, chief of the sanitary department of St Petersburg, has shown that in the largest lying-in hospital there, in which 2000 women are confined in a year, the death-rate is from 30 to 40 per 1000; in the second, in which about 1000 women per annum are received, only 25 die; in the third, where 400 are received, only 20 die per 1000; in the small detached asylums of 2 or 3 beds, of which there are 11 in different parts of the city, giving accommodation to 1600 women per annum, or about 155 each, only 9 per 1000 die; whilst amongst those confined in their own homes, including the poorest and most wretched, only 5 per 1000 die (*Rapport du Congrès International d'Hygiène et de Sauvetage*, Brussels, 1876, vol. i. p. 226). These numbers correspond with the observations above.

It can also be shown that outbreaks of disease are coincident with individual overcrowding, whether the hospital be large or small. Thus the terrible mortality of the Hôtel-Dieu of Paris in the last century was due as much to actual overcrowding as to the enormous aggregation of patients. The extraordinary spectacle was to be seen there of two or three small-pox patients, or several surgical cases, or sometimes even four parturient women, lying in one bed. A large proportion of the beds were purposely made for four patients, and six were frequently crowded in. In the Salle St Charles and St Antoine there were 139 large beds (intended for four patients each, but often holding six), and 38 small beds for one patient each. Those beds were generally full, giving under ordinary conditions 558 patients, and in times of pressure 836. To this might be added the Salle St Roch, opening directly from and really forming part of the great ward; this contained 35 large beds and 3 small,—normal number of patients 143, with a possible increase to 213. This gives a grand total of 701 patients as a normal amount, with a possible increase to 1049.

There was thus collected in one enormous ward a larger number of patients than any hospital in England contained altogether, if we except the Royal Naval Hospital at Haslar. In addition, however, to the above inordinate number, there were in the three stories placed above this great ward 1926 patients, which number might be increased to 2596,—without reckoning the serving staff of the institution;—or (including the wards on the Pont Double) a total in one block of building equal to 3418, which might be increased to 4320. The law forbade the hospital authorities to refuse admission to any one, and in 1773 there were 5000 patients in the hospital, which occupied a space of little more than 3 English acres,—giving a total gross area of only 30 square feet per head. The gross area per bed of the modern Hôtel-Dieu is just ten times this amount, being 311 square feet, according to M. Tollet; but even this is much too small, 100 square metres (1076 square feet) being the minimum proposed by Tollet, who estimates the general average per inhabitant of Paris at 430 square feet, whereas that of London is nearly double. We cannot point to any such overcrowding in England as that of the old Hôtel-Dieu, but in many cases there has been enough to produce very grave results. The ill effects are seen in outbreaks of erysipelas, hospital gangrene, and surgical fever among surgical cases, and in puerperal fever in lying-in cases,—whilst in all communicable diseases the danger of spreading is greatly intensified. It was observed in 1877 in the General Lying-in Hospital, the year before it was closed for alterations, that when only two or three women were in a ward, puerperal disease rarely showed itself, but that when, in consequence of pressure of applications, five or six were put in, disease generally broke out. Similar results have been observed elsewhere.

Another great cause of mortality has been inefficient ventilation. If we can scatter our sick population and give them individually plenty of space in their wards, we shall have done much,—but, if we do not also change the air sufficiently often we may still have evil results with all our care. Formerly no arrangements were made for ventilation in hospitals, schools, barracks, churches, or indeed in any buildings whatsoever. An immense deal remains to be desired in this direction still, but in recent hospitals, at least, more or less efficient means have been introduced, whilst efforts have been made to improve the conditions of the old. The want of fresh air aggravates all diseases, increases the power of infection, retards the convalescence, and hastens the death of patients; moreover, it lowers the tone of the healthy, and is the most potent of all agents in the propagation of phthisis or destructive lung disease. The labours of the Royal Commission of 1857, appointed to inquire into the health of the army, brought out in full relief the disastrous effects of want of proper ventilation in the sleeping rooms of our soldiers. It was there shown that the death-rate of Her Majesty's Foot Guards was more than 20 per 1000 per annum, 67 per cent. greater than the death-rate at the same ages in Manchester, our most unhealthy town, double the general death-rate of England, and nearly three times that of the most healthy country districts. As regards phthisis alone the death-rate was 10·8 per 1000 from 1830–1836, and 11·9 from 1837 to 1846, or an average of 11·4 per 1000 for the period, an amount more than the total mortality of the civil male population of England and Wales at the same ages. In the army generally the proportion was 7·86. Since the evil was recognized steps have been taken to remedy the conditions, particularly in the direction of giving more space in barrack-rooms, and securing a certain standard of air renewal. The results are seen in the present death-rate from phthisis, which is reduced to 2·5 per 1000, about one-third of the old, and not much above that of the best districts in England. It is still, however, too high, as a large number of men are invalided for disease who go to swell the returns of sickness and mortality in civil life. That this is mainly owing to defective air renewal is evident from the fact that in civil life starvation, crowding, and poverty are insufficient to produce the same evil results we have seen in our army,—because, in all likelihood, the very wretchedness of the dwellings of the poor has brought about an amount of involuntary air renewal, which has been their safeguard.

Defective arrangements for the removal of excreta have constituted another cause of mortality. Water closets opening directly out of wards, and sinks, waste-pipes, bath-pipes, &c., in direct communication with the sewers, have been the means of introducing sewer poison into hospitals, producing surgical and puerperal diseases, enteric fever, and diphtheria, and aggravating every other form of malady.

A want of constant attention to the details of cleanliness has been a fertile source of hospital disease. Dr B. W. Richardson has traced out in a very instructive way the remarkable immunity of the Jews from epidemic and other diseases, and has shown that their religious attention to the details of the periodic cleansing enjoined by the Mosaic law appears to be the main cause of this notable circumstance. An instructive instance of the importance of this point is recorded by Mr W. Cadge, surgeon of the Norwich Infirmary, which institution had long suffered from surgical diseases, such as erysipelas, pyæmia, and the like. These, it was supposed, were mainly due to the age and structural defects of the building, so that it was determined to pull it down and reconstruct it throughout. In the meantime a change of administration took place, and a new matron was introduced, who effected an entire alteration in the arrangements, and in particular insisted on an absolute and unremitting attention to every detail of cleanliness, both of building, clothing, bedding, and person. The result was an immediate cessation of the dreaded complications which had so vexed the hospital, and from that time there has been no return of them.

Faulty diet had also, doubtless, its influence on mortality, although its effects would be less easy to trace. One singular feature in the last century was the enormous allowance of beer given to patients in hospital,—from two to three pints being common, and the allowance sometimes reaching half a gallon per diem. The absence of fresh vegetables from the diet, not only of hospitals but also of the populace at large, probably introduced a scorbutic taint which may have had some part in aggravating or modifying disease.

Some influence must also be allowed to the indiscriminate mixture of cases. The evil of this, especially in the more or less crowded state of the older hospitals, was recognized even in the last century, and was referred to by Tenon among others Although the danger is materially lessened when ample space per bed is allowed, it is still unadvisable, not to say unfair, to place contagious cases with other patients. The argument has been advanced that by distributing infectious cases there is less danger of concentration of poison than when they are congregated together by themselves. With proper hygienic precautions, however, this concentration may be minimized, whilst the isolation of such cases gives the greatest immunity to others.

This question of concentration has been pushed still further, so as to bear against the existence of all hospitals whatsoever, and so far as lying-in hospitals are concerned we have seen that the objections are well founded. But when we consider the subject in its various aspects it must be admitted that it would be difficult to do without hospitals in some form or another. It would hardly be possible to afford people the same advantages of treatment, attendance, nursing, and comforts at their own homes, although in some cases the system of home treatment might be advantageously substituted, as has been done for so many years with so much success in Edinburgh and other towns of Scotland on the dispensary system. Another most important aspect of the question is the necessity for hospitals as places of instruction for those entering the profession of medicine. Although it would be wrong to subordinate in any serious way the claims of patients of any class to the requirements of teaching, it must yet be admitted that the only sound way of learning medicine and surgery is by clinical or bedside instruction, and we may therefore reasonably demand that those who owe their treatment and care to public charity should be willing so far to contribute to the general welfare. Now it is clear that in dealing with large classes of students it would hardly be possible to convey proper clinical instruction except in a hospital. For this purpose the provincial hospitals ought to be more largely utilized, in addition to the metropolitan; at present the resources of the former are to a great extent wasted for teaching purposes.

Assuming then the necessity for hospitals, there still remains the question of the kind of hospital that should be constructed or approved of. It is certainly open to doubt whether we should continue to build monumental hospitals, and not rather construct slighter buildings, which may be destroyed and rebuilt from time to time, thus both scattering patients over a wider area and lessening the risk from long accumulation of infective material. This latter has been named the cottage or hut system of construction. The difficulties attending it are chiefly connected with original expense of site and with the current expenses of nursing and administration. On the other hand, it may be urged with some reason that with correct hygienic management there is no reason why a large hospital should not be kept in a healthy condition.

We may now consider the principles of hospital construction.

1. *Locality and Site.*—Hospitals are required for the use of the community in a certain locality, and to be of use they must be within reach of the centre of population. Formerly the greater difficulty of locomotion made it necessary that they should be actually in the midst of towns and cities, and to some extent this continues to prevail. It is at least doubtful if this be the best plan. Fresh and pure air being a prime necessity, as well as a considerable amount of space of actual area in proportion to population, it would certainly appear to be better to place hospitals as much in the outskirts as is consistent with considerations of usefulness and convenience. In short, the best site would be open fields; but, if that be impracticable, a large space—a "sanitary zone," as it is called by Tollet—should be kept permanently free between them and surrounding buildings, certainly never less than double the height of the highest building. The difference between the expense of purchase of land in a town and in the environs is generally considerable;—and this is therefore an additional reason for choosing a suburban locality. Even with existing hospitals it would be in most cases pecuniarily advantageous to dispose of the present building and site and retain only a receiving house in the town. St Thomas's in London, the Hôtel-Dieu in Paris, and the Royal Infirmary in Manchester are all good examples where this might have been carried out. In none, however, has this been done, the first two having been rebuilt, at enormous outlay, in the cities as before, although not exactly in the same locality, while the last is still retained with a few structural alterations. In Edinburgh, on the other hand, an open space of a much more favourable character has been obtained, which, although within the limits of the city, is almost rural in character.

As regards the actual site itself, where circumstances admit of choice, a dry gravelly or sandy soil should be selected, in a position where the ground water is low and but little subject to fluctuations of level, and where the means of drainage are capable of being effectually carried out. There should also be a cheerful sunny aspect, and some protection from the coldest winds.

2. *Form of Building.*—A form of building must be selected which answers the following conditions:—(*a*) the freest possible circulation of air round each ward, with no *cul-de-sac* or enclosed spaces where air can stagnate; (*b*) free play of sunlight upon each ward during at least some portion of the day; (*c*) the possibility of isolating any ward, or group of wards, effectually, in case of infectious disease breaking out; (*d*) the possibility of ventilating every ward independently of any other part of the establishment. Those conditions can only be fulfilled by one system, viz., a congeries of houses or pavilions, more or less connected with each other by covered ways, so as to facilitate convenient and economical administration. The older plans of huge blocks of building, arranged in squares or rectangles, enclosing spaces without free circulation of air, are obviously objectionable. Even when arranged in single lines or crosses they are not desirable, as the wards either communicate with each other or with common passages or corridors, rendering separation impossible. On this point it may be remarked that some of the buildings of the last century were more wisely constructed than many of those in the first half of the present, and that the older buildings have been from time to time spoilt by ignorant additions made in later times. The question next arises —Is it better to have pavilions of two or more stories high, or to have single-storied huts or cottages, scattered more widely? Where land is expensive the former plan is of course more economical, but where land is easily got the latter ought to be adopted. The pavilions may be arranged in various ways: they may be joined at one end by a corridor, or may be divided by a central corridor at right angles to them, &c. In fact, the plan is very elastic, and adapts itself to almost any circumstances. A certain distance, not less than twice the height of the pavilions, ought to be preserved between them. By this means free circulation of air and plenty of light are secured, whilst separation or isolation may be at once accomplished if required.

3. *Foundations, Building Materials, &c.*—It is of the first consequence that a hospital should be dry; therefore the foundation and walls ought to be constructed so as to prevent the inroads of damp. An impervious foundation has the further advantage of preventing emanations from the soil rising up in consequence of the suction force produced by the higher temperature of the internal atmosphere of the building itself. There should be free ventilation in the basement, and the raising of the whole on arches is a good plan, now generally carried out in hot climates. If the pavilions are two or more stories high it is advisable to use fire-proof material as much as possible, but single-storied huts may be of wood. In any case effectual means of excluding damp must be employed. The interiors of wards ought to be rendered as non-absorbent as possible, by being covered with impervious coatings, such as glazed tiles (parian, though much used, is apt to crack), silicate paint, soluble glass, or the like. The ceilings ought to be treated in the same way as the walls, or, perhaps better still, they might be made like the deck of a ship, without any lath and plaster, so as to have nothing but the floor itself between room and room. For the floors themselves various materials have been suggested: in France there is a preference for flags (dalles), but in England wood is more liked; and indeed hard well-fitting wood, such as teak, oak, or pitch-pine, leaves nothing to be desired. The surface should be waxed and polished or varnished. Even deal floors can be rendered non-absorbent by waxing, by impregnating them with solid paraffin as recommended by Dr Langstaff, or by painting with soluble glass as suggested by Dr Luther of Philadelphia.

4. *Shape and Arrangement of Wards.*—It is now generally agreed that wards should have windows on at least two opposite sides, and three main shapes have been proposed, viz., (*a*) long wards with windows down each side, and (generally) one at the further end; (*b*) wards nearly square, with windows on three sides; and (*c*) circular wards, with windows all round. The first (*a*) is the form usually adopted in pavilions; (*b*) is recommended by Dr Folsom (*Plans for the Johns Hopkins Hospital*); and (*c*) has been suggested by Mr John Marshall, F.R.S. (*Nat. Assoc. for Promotion of Social Science*, 1878). Of these (*b*) seems the least to be commended, and (*c*) has not yet been tried in practice; we may therefore confine our attention to the long or oblong wards. The length is to be determined chiefly by the number of patients to be accommodated, but the breadth admits of less variation. Each bed should be a little distance, say from 8 inches to 1 foot from the wall, and each bed may be reckoned as 6½ feet long; this gives 7½ feet on each side. Between the ends of the beds about 10 feet space is necessary, so that 25 or 26 feet of total breadth may be taken as a favourable width. The wards of the Herbert Hospital are 26 feet; but some exceed this, as, for instance, St Thomas's, London, and the New Royal Infirmary, Edinburgh, 28; New Hôtel-Dieu, 29; and Lariboisière, 30. There seems no necessity for exceeding 26, but if the breadth be greater there ought to be more window-space,—the great difficulty being to get a wide space thoroughly ventilated. There ought to be only two rows of beds, one down each wall, with if possible a window to each bed, and never less than one to every two beds.

5. *Ventilation, Warming, and Lighting.*—For ventilation two things are required,—sufficient space and sufficiently frequent change or renewal of air. As regards space, this must be considered

with reference both to total space and to lateral or floor space. Unless a minimum of floor space be laid down, we shall always be in danger of overcrowding, for cubic space may be supplied vertically with little or no advantage to the occupier. If we allow a minimum distance of 4 feet between the beds and 10 feet between the ends of the beds, this gives 100 square feet of space per bed ; less than this is undesirable. In severe surgical cases, fever cases, and the like, a much larger space is required ; and in the Edinburgh New Infirmary 150 square feet is allowed. Cubic space must be regulated by the means of ventilation ; we can rarely change the air oftener than three times an hour, and therefore the space ought to be at least one-third of the hourly supply. This ought not to be less than 4000 cubic feet per bed, even in ordinary cases of sickness,—and the third of that is 1333 cubic feet of space. With 100 square feet of floor space a ward of 13½ feet high would supply this amount, and there is but little to be gained by raising the ceiling higher,—ndeed, 12 feet is practically enough. The experiments of Drs Cowles and Wood of Boston (see *Report of State Board of Health of Massachusetts* for 1879) show that above 12 feet there is little or no movement in the air except towards the outlet ventilator; the space above is therefore of little value as ventilation space. Additional height adds also to the cost of construction, increases the expense of warming, makes cleaning more difficult, and to some extent hampers ventilation. Whatever be the height of wards, the windows must reach to the ceiling, or there must be ventilators in the ceiling or at the top of the side walls. If this be not arranged for a mass of foul air is apt to stagnate near the ceiling, and sooner or later to be driven down upon the inmates. The reasons for a large and constant renewal of air are of course the immediate removal and dilution of the organic matter given off by the inmates ; and, as this is greater in quantity and more offensive and dangerous in sickness than in health, the change of air in the former case must be greater than in the latter. Hence in serious cases an amount of air practically unlimited is desirable,—the aim of true ventilation being to approach as near as possible to the condition of pure external air. Without going too much into details, a few general rules may be laid down :—(1) Fresh air ought if possible to be brought in at the lowest part of the ward, warmed if necessary; (2) foul air ought to be taken out at the highest part of the ward ; (3) fresh air should reach each patient without passing over the bed of any other ; (4) the vitiated air should be removed from each patient without passing over the bed of any other ; (5) 4000 cubic feet of fresh air per head per hour should be the minimum in ordinary cases of sickness, to be increased without limit in severer cases ; (6) the air should move in no part of a ward at a greater rate than 1½ feet per second, except at the point of entry, where it should not exceed 5 feet per second, and at the outlet, where the rate may be somewhat higher ; about 64 square inches of inlet and outlet sectional area ought to be supplied per head as a minimum ; (7) every opportunity ought to be taken of freely flushing the wards with air, by means of open windows, when this can be done with safety.

Warming is a question of great importance in most climates, especially in such a climate as ours, where every system of ventilation must involve either the warming of some portion of the incoming air, or the contriving its delivery without too great lowering of temperature ; at the same time it cannot be too strongly insisted upon that the tendency is too much in the direction of allowing warmth to supersede freshness of air. There are very few cases of disease (if any) that are not more injured by foul air than by low temperature ; and in the zymotic diseases, such as typhus, enteric fever, small-pox, &c., satisfactory results have been obtained even in winter weather by almost open-air treatment. At the same time a reasonable warmth is desirable on all grounds if it can be obtained without sacrificing purity of atmosphere. For all practical purposes 60° to 63° F. is quite sufficient, and surgical and lying-in cases do well in lower temperatures. Various plans of warming have been recommended, but probably a combination is the best. It is unadvisable to do away altogether with radiant heat, although it is not always possible to supply sufficient warmth with open fireplaces alone. A portion of the air may be warmed by being passed over a heating apparatus before it enters the ward, by having an air chamber round the fire-place or stove, or by the use of hot-water pipes in the ward itself. In each case, however, the air must be supplied independently to each ward, so that no general system of ventilation is applicable.

The lighting of wards at night will be most conveniently done by means of gas, in the form of a jet over each bed, with a special ventilator to carry off combustion products, as in the Edinburgh New Infirmary.

6. *Furniture of Wards.*—This should be simple, clean, and non-absorbent; the bedsteads of iron, mattresses hair, laid on spring bottoms without sacking. No curtains should be permitted.

7. *Water.*—The water-supply ought to be on the constant system, and plentiful ; 50 gallons per head per diem may be taken as a fair minimum estimate.

8. *Closets, Baths,* &c.—The closets ought to be of the simplest construction, the pans of earthenware all in one piece, the flushing arrangements moved by opening the door,—the supply of water ample. Each ward should have its own closets, lavatories, &c., built in small annexes, with a cross-ventilated vestibule separating them from the ward. All the pipes should be disconnected from the drains, the closets by intercepting traps, the sink and waste pipes by being made to pour their contents over trapped gratings. The soil pipes should be ventilated, and placed outside the walls, protected as may be necessary from frost. Each ward should have a movable bath which can be wheeled to the patient's bedside.

9. Each ward should have attached to it a room for the nurse from which she can look into the ward, a small kitchen for any special cooking that may be required, a room for the physician or surgeon, and generally a room with one or two separate beds. No cooking should be done in the wards, nor ought washing, airing, or drying of linen to be allowed there.

10. *Nursing.*—The arrangements for nursing the sick have greatly improved in recent times, although controversy still goes on as to the best method of carrying it out. In arranging for the nursing in a hospital both efficiency and economy have to be considered. Miss Nightingale recommends large wards of 32 beds each, as at the Herbert Hospital, on the ground that one head-nurse is sufficient for such a number by day and one nurse by night. In the Edinburgh New Infirmary the wards are not so large, the medical being arranged for 21, and the surgical for 14 patients. Circumstances must to a large extent determine the arrangement, but it seems desirable on the whole that the work of a nurse should be confined to a single ward at a time if possible. The duties of nurses ought also to be distinctly confined to attendance on the sick, and no menial work, such as scrubbing floors and the like, should be demanded of them ; a proper staff of servants ought to be employed for such purposes. It is also desirable that a separate pavilion for lodging the nurses should be set apart, and that fair and reasonable time for rest and recreation should be allowed. Some discussion has taken place as to the advisability of placing the nursing of a hospital in the hands of a sisterhood or separate corporation. It will, however, be admitted that the best plan is for the nursing staff of each hospital to be special and under one head within the establishment itself, even although it may be connected with some main institution outside. The nursing must of course be carried on in accordance with the directions and treatment of the physicians and surgeons.

11. The kitchen, laundry, dispensary, and other offices must be in a separate pavilion or pavilions, away from the wards, but within convenient access.

12. A separate pavilion for isolation of infectious cases is desirable. This may be a wooden hut, or in some cases even a tent ; either is probably preferable to a permanent block of building.

13. A *Disinfecting Chamber* ought to be provided, where heat can be applied to clothes and bedding, for the destruction both of vermin and of the germs of disease. It is advisable to expose all bedding and clothing to its influence after each occasion of wear. Although this may entail additional expense from deterioration of fabric, it is worth the outlay to secure immunity from disease. This plan is rigidly followed at the Royal South Hants Infirmary at Southampton.

14. It is of great importance that the wards should be periodically emptied, and kept unoccupied for not less than one month in each year, and longer if possible. During such period thorough cleansing and flushing with air could be carried out, so as to prevent any continuous deposit of organic matter.

Up to quite lately hospital accommodation was confined to the larger towns, but the desirability of having it more accessible in smaller towns and villages has made itself more and more felt. Accordingly in many places *cottage hospitals* have been established with advantage. One great advantage of the pavilion system is that the principles of its construction and arrangements are equally applicable to large and small establishments, so that we may either look upon a large hospital as an extension of a cottage hospital, or upon a small one as a section of a pavilion one. The importance of increased accommodation for the reception of infectious cases is now very generally acknowledged, as shown not only by the establishment of the Metropolitan Asylums Hospitals, but also of others in various parts of the country. In some instances they have apparently been the means of arresting the spread of disease and protecting the locality from epidemics.

Paying Hospitals, Pay-Wards, Provident Dispensaries.—The general object for which hospitals have been established may be stated to be the gratuitous medical and surgical treatment of the indigent sick. Many abuses have, however, crept in, and large numbers of persons yearly receive medical treatment gratuitously who are quite able to pay for it. The numbers have been stated at one in four in London and one in two in Liverpool of the entire population. To obviate this evil the establishment of paying institutions has been much recommended. There is a large class above the very poor who are but ill able to afford the most skilled attendance and nursing at their own homes, which in most cases do not supply the accommodation necessary for sickness. It is not desirable, nor is it always their own wish, that those persons should be objects of charity, and the establishment of hospitals and dispensaries at which they could contribute something towards the expense of their treatment and attendance would meet the difficulty to some extent. Numerous arrangements of the kind are to be found on the continent of Europe, in America, and in the British colonies. Attempts have recently been made to introduce the system into England, and it is highly desirable that it should be accomplished, if it can be done with fairness to all concerned.

Administration.—In the civil hospitals of Britain this is usually carried on by a body of governors, who are either specially appointed or are benefactors of the institution. From them an executive committee is chosen, or the executive power may be vested in a single official, often the treasurer. A secretary or superintendent is usually charged with the financial and general management of the affairs of the hospital, whilst an apothecary superintends the pharmaceutic department. The treatment of the sick is of course entirely in the hands of the physicians and surgeons, whose appointments are for the most part honorary, in the sense of being unpaid, and under whom resident medical officers act. The medical staff ought always to be represented on the governing body as a means of preventing unnecessary friction. The appointment seems desirable in every hospital of a sanitary officer, whose duty it should be to watch and supervise the carrying out of every detail of ventilation, warming, cleanliness, disinfection, &c.

On the Continent hospitals are more directly under state control, and their arrangement is therefore considerably modified.

Naval and Military Hospitals.—These are provided in all civilized countries for the care of the sailors and soldiers of the state. The two great English hospitals of Greenwich and Chelsea were founded as asylums for disabled and superannuated sailors and soldiers, but the former is now given up for that purpose, although a part is appropriated as a hospital for sick merchant seamen of all nations. The chief naval hospitals are those of Haslar, Plymouth, and Chatham. Haslar is the largest hospital in the country, having been originally intended for 2000 sick, and even now, with increased allowance of space per bed, accommodating 1500 patients. There are also hospitals in most of the principal naval stations abroad, such as Malta, Jamaica, Halifax, Hong-Kong, &c. The principal military hospitals are the Royal Victoria Hospital at Netley (the invaliding hospital of the army and the locality of the army medical school), the Herbert Hospital at Woolwich, the Cambridge Hospital at Aldershott, and numerous others at the principal stations. The cubic space allotted by regulation is 1200 cubic feet at home and 1500 to 2000 cubic feet in the tropics per bed. Formerly every regiment of cavalry and infantry and each battery or troop of artillery had its own hospital, but this plan is now given up, and station hospitals with a fixed staff are being arranged at the chief centres of military districts. In both the army and the navy the regulations place the administration and command of hospitals in the hands of the respective medical departments; in the army this is as yet only partially carried out, but it has been accomplished in the navy with the advantage of both efficiency and economy. In time of war general hospitals are established at the base of operations, whilst field hospitals move with the troops as the campaign progresses.

In France there have long been hospitals established for the navy, such as those at Rochefort, Toulon, Brest, &c., as well as schools of instruction for medical officers. The chief military hospital is the Val de Grâce at Paris, formerly a convent; it is there that the medical school for the army is located. Large hospitals are also established in all the great stations. Great attention to military hospitals is also paid in Germany, Austria, and other countries of Europe. In most of them the administration is in the hands of the medical department, except in France, where the intendance still holds the reins, much to the disadvantage of efficiency and good working.

In the United States of America the army is small and chiefly employed on frontier duties, so that the hospitals are all what are called post hospitals, and as a rule are wooden huts or temporary structures, built to last ten years, and to hold 12 to 24 beds. There are, however, two permanent hospitals, one for cadets at West Point, and the other, the Barnes Hospital, at the Soldier's Home near Washington. All the arrangements are under the army medical department. The navy and the mercantile marine were long amalgamated in America, so far as hospital arrangements went. The Marine Hospital Service was formed in 1798, and the navy was not separated from it until 1811, although it was not for some years after that special naval hospitals were built. In connexion with the marine hospital service, hospitals have been established at a great number of ports, both sea, river, and lake. Up to 1870 each of these hospitals had its own organization, but since that time a regular service has been established under a supervising surgeon-general. A tax of 40 cents a month is levied for the service upon all seamen or members whatsoever of a ship's company. One of the finest hospitals is the Mercantile Marine Hospital at Chicago, a pavilion building of several stories, and of considerable architectural pretensions. But in America, as in Europe, the tendency has latterly been to abandon such monumental hospitals, and to construct single-storied pavilions on the hut or "barrack" principle,—the word barrack being employed in this sense as equivalent to the French *baraque*, a wooden hut. Accordingly the new marine hospital at San Francisco has been thus constructed, three one-storied pavilions of Californian redwood radiating from the outside of a curved corridor, from the ends and inner centre of which project the administrative blocks. The cost is about £120 ($600) per bed, whereas the average cost of the older ones was fully seven times that amount, with the drawback that in course of time they became extremely unhealthy, and showed all the evils of hospitalism.

A brief notice may be added here of the history of hospital construction in recent times, particularly with reference to the pavilion system. It is to France that we must look for the commencement of that system, although it has been carried out with even greater success in other countries. Its origin may be traced to the discussions which arose from time to time as to the advisability of reconstructing the Hôtel-Dieu at Paris. So long ago as the 17th century, Desgodets, architect to Louis XIV., presented a plan for reconstructing the hospital in "rayons." But it was after the fire that took place in 1772 that the question was taken up with real interest. In 1773 it was proposed to transfer the hospital to the plain of Grenelle, and in 1774 M. Petit proposed a radiating building of four stories at the base of the hill of Belleville (probably at no great distance from the existing hospital of Ménilmontant). M. le Roi presented a plan for a hospital at Chaillot, consisting of long single-story pavilions, arranged alternately, with the roof open at intervals,—each patient to be screened off by partitions. Finally, the committee of the Académie des Sciences reported favourably in 1788 on a proposal of M. Poyet's to construct a hospital on the Ile des Cygnes (between Grenelle and Passy), consisting of isolated pavilions radiating from a central rotunda, the hospital to hold 5000 patients,—each pavilion to be 115 feet long, by 24 broad and 14 to 15 high, to contain 34 to 36 patients, and to have windows to the ceiling. These proportions would give 77 to 80 square feet of floor space, 6½ to 6¾ feet of wall space, and 1080 to 1200 cubic feet of total space, an immense advance upon then existing arrangements. The Revolution put a stop to those projects, and half a century elapsed before a pavilion building, as now understood, was actually constructed. Curiously enough, revolution again stepped in to arrest the movement, for the first building of the kind, the Hôpital Louis-Philippe, was begun in the last years of that monarch's reign, and suspended in consequence of the revolution of February 1848. Some years later, in 1854, it was completed and renamed Lariboisière, from the name of the benefactress whose munificence helped to bring it to a successful conclusion. The building is oblong, enclosing a space in the centre, the front (south end) containing the administration, and the opposite (north) end the chapel, kitchens, &c. From the two sides the pavilion wards jut out. The building is on the whole not a good one; the distance between the pavilions is only half what is required, and the wards are frequently overcrowded. Unfortunately most of the defects, with some additional ones, have been reproduced in the new Hôtel-Dieu. The new hospital at Ménilmontant, in the north-east of Paris, is also a pavilion one, differing somewhat in detail, but of great size, each pavilion having numerous stories. The military hospital at Vincennes is a good specimen of modern construction. A small experimental pavilion, built on the suggestions of Dr Tarnier in the garden of the Maternité in Paris, merits notice. It consists of two stories, each containing four wards for one parturient woman each. The kitchen, office, &c., are in the centre, but the only access to each ward is by the verandah direct from the open air. The walls, floors, and ceilings are non-absorbent, and there is a space of 56 cubic metres, or nearly 2000 cubic feet for each inmate. The chief objection is that there are no means of ventilation except by the door or window;—otherwise the plan is excellent. This plan of making each ward open directly from the open air was proposed by the late Sir James Simpson, as a means of improving the sanitary state of existing old hospitals. The plans of M. Tollet ought not to be passed unnoticed. In addition to the ordinary principles of pavilion construction, he insists upon the ogival or Gothic form of architecture, which he thinks was adopted in the Middle Ages as much for sanitary as for architectural reasons.

In England the question of hospital improvement slept until the disasters at Scutari, in 1854–55, roused the attention of the Government and the public to the necessities of the case, and the report of the Army Sanitary Commission and of the Barrack and Hospital Committee, and Miss Nightingale's *Notes on Hospitals*, led the way in advocating hospital reform. Unfortunately just before this movement the plans of Netley Hospital were made, and the building begun on the corridor system. Efforts were made to arrest its progress, but unhappily without effect, and the country which has led the van in sanitary science has as its chief military hospital a building far from satisfactory. The first pavilion hospital in England was the Blackburn Infirmary, built rather more than twenty years ago. The pavilions are there at right angles to a centre corridor, and are alternate; a similar arrangement is followed out at the Children's Hospital at Pendlebury, near Manchester. St Thomas's at Westminster Bridge consists of a row of parallel pavilions united by a corridor at one end. A plan practically identical was proposed for a new hospital at Valetta (Malta), but this building, though frequently referred to in books, has never been constructed. The Herbert Hospital at Woolwich consists of parallel pavilions jutting out from the sides of a centre corridor at right angles; although it is now nearly twenty years old, it is still one of the best examples of a pavilion hospital. The latest pavilion hospital is the New Royal Infirmary at Edinburgh, to which reference has already been made. Every care seems to have been bestowed on its construction and arrangement; the space allowed per head is ample and the site excellent.

In Germany the Friedrichshain Hospital at Berlin is one of the best specimens of a pavilion building. The pavilions are 160 feet apart, six two-storied and four one-storied, with isolation wards and the necessary administrative buildings. The hut hospital erected during the late war at Tempelhof near the same city was a good example of how the pavilion system may be indefinitely extended, the huts being placed in échelon in wide zigzag lines.

In America great attention has been paid to the question of hospitals, especially since its importance was so roughly thrust upon the country's notice in the great civil war of 1861–64. During that time numerous plans were tried, and among others the old plan of Petit, Poyet, &c., namely, radiating pavilions from a circular or oval centre, which contained the offices and administration. This plan was found not to be a good one, as it interfered with both lighting and ventilation. The earliest American hospital of any size was the Pennsylvanian Hospital of Philadelphia, which was begun in 1755, under the auspices of Dr Thomas Bond and Benjamin Franklin, and finished in 1805. It was also in Philadelphia that the first pavilion hospital of a permanent character was erected, the corner stone being laid in 1860; in it the pavilions are parallel, two stories besides basement and attics. The space allowed is ample, but the wards are too wide, nearly 31 feet. In New York there is a large amount of hospital accommodation—about 6000 beds, or about 1 in 1500 of the population. The New York Hospital new pavilions give 112 square feet of floor space and 1800 cubic feet of total space. The Roosevelt Hospital has somewhat the same dimensions, but with a much greater space for surgical patients. One peculiarity of arrangement in that building is that the closets are not at the end of the wards as usual, but in the centre, grouped round a central shaft which extends through all the stories, cellar and basement. In this the water and steam pipes are placed, as also the foul linen shafts; the closets are cleaned by a steam jet. This plan does not seem very commendable. The Massachusetts General Hospital at Boston is the oldest in America, except the Pennsylvania Hospital. Since 1872 four new pavilions have been built on peculiar plans: two are square, one containing one large ward for 20 patients, and the other divided into small rooms of 2 beds each, giving each about 97 feet of floor space and 1500 to 1850 feet of total space; the other two are oblong, divided into rows of single rooms, with a dividing corridor, something like an arrangement of prison cells. The floor space is about the same, with less height. The Johns Hopkins Hospital at Baltimore will be memorable for the care bestowed upon the consideration of its plans. The one finally adopted is on the pavilion principle, scattered over a wide space of ground.

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HOSPITIUM. The power the Greeks possessed of travelling safely among other Greek states depended on the feeling which made hospitality a matter of religion, and looked on strangers as under the protection of Zeus Xenios. A stranger was received and protected during his stay. Violation of the duties of hospitality was likely to provoke the wrath of the gods; but it does not appear that anything beyond this religious sanction existed to guard the rights of a traveller. There is, however, no ground for the common statement that a stranger was *ipso facto* considered as an enemy. In truth he was a guest. The roads were all sacred; he who passed over them was the guest of the land; he found along their courses statues of the tutelary deity of the road, generally Hermes; and the offerings of food, &c., in front of these he was at liberty to appropriate. Hence the word ἕρμαιον was used in the sense of a lucky find. (See Curtius, "Griech. Wegebau," *Berlin Abhandl.*, 1854.) When the guest parted from his host he was often presented with gifts (ξένια), and sometimes a die (ἀστράγαλος) was broken between them. Each then took a part, a family connexion was established, and the broken die served as a symbol of recognition; thus the members of each family found in the other hosts and protectors in case of need. As the foreigner was not recognized by the law of the state in which he travelled, he could appear in a court of justice only through his host. Similar customs seem to have existed among the Italian races. In Rome there was a tie recognized by the law between host and guest, almost as strong as that which connected patron and client. Jupiter Hospitalis watched over the jus hospitii. As in Greece the connexion often became hereditary; and a tessera hospitalis was broken between the parties.

Besides this private connexion there was a custom according to which a state appointed among the citizens of another state one man called πρόξενος to protect any of their citizens travelling in his country. Sometimes an individual came forward voluntarily to perform these duties on behalf of another state (ἐθελοπρόξενος). Many cases occur where such an office was hereditary; thus the family of Callias at Athens were proxenoi of the Spartans. We find the office mentioned in a Corcyræan inscription dating probably from the 7th century B.C., and it continued to grow more important and frequent throughout Greek history. There is no proof that any direct emolument was ever attached to the office, while the expense and trouble entailed by it must often have been very great. Probably the honours which it brought with it were sufficient recompense. These consisted partly in the general respect and esteem paid to a proxenos, and partly in many more substantial honours conferred by special decree of the state whose representative he was, such as ἐπιγαμία, γῆς ἔγκτησις, ἀτέλεια, ἀσυλία, προεδρία, and sometimes full citizenship. Public hospitium seems also to have existed among the Italian races; but the circumstances of their history prevented it from becoming so important as in Greece.

HOTCH-POT (or HOTCH-POTCH, HODGE-PODGE), in law, is the name given to a rule of equity whereby a person, interested along with others in a common fund, and having already received something in the same interest, is required to surrender what has been so acquired into the common fund, on pain of being excluded from the distribution. The following is an old example given in Coke on Littleton:—"If a man seized of 30 acres of land in fee hath issue only two daughters, and he gives with one of them 10 acres in marriage to the man that marries her, and dies seized of the other 20; now she that is thus married, to gain her share of the rest of the land, must put her part given in marriage into hotch-pot; *i.e.*, she must refuse to take the profits thereof, and cause her land to be so mingled with the other that an equal division of the whole may be made between her and her sister, as if none had been given to her; and thus for her 10 acres she shall have 15, or otherwise the sister will have the 20." In the common law this seems to have been the only instance in which the rule was applied, and the reason assigned for it is that, inasmuch as daughters succeeding to lands take together as coparceners and not by primogeniture, the policy of the law is that the land in such cases should be equally divided. The law of hotch-pot applies only to lands descending in fee-simple. The same principle is noticed by Blackstone as applying in the customs of York and London to personal property. It is also expressly enacted in the Statute of Distributions (§ 5) that no child of the intestate, except his heir-at-law, who shall have any estate in land by the settlement of the intestate, or who shall be advanced by the intestate in his life time by pecuniary portion equal to the distributive shares of the other children, shall participate with them in the surplus; but if the estate so given to such child by way of advancement be not equivalent to their shares, then such part of the surplus as will make it equal shall be allotted to him. It has been decided that this provision applies only to advancements by *fathers*, on the ground that the rule was founded on the custom of London, which never affected a widow's personal estate. The heir-at-law is not required to bring any land which he has by descent or otherwise from the deceased into hotch-pot, but advancements made to him out of the personal property must be brought in. The same principle is to be found in the *collatio bonorum* of the Roman law: emancipated children, in order to share the inheritance of their father with the children unemancipated, were required to bring their property into the common fund. It is also found in the law of Scotland. "It seemeth," says Littleton, "that this word *hotch-pot* is in English a pudding; for in a pudding is not commonly put one thing alone, but one thing with other things together."

HOTHO, HEINRICH GUSTAV, was born at Berlin in 1802, and died in his native city on Christmas day 1873. He made a name for himself in Germany as an historian rather than as a critic of art. Yet he remained second to his contemporary Waagen in experience, grasp of subject matter, and subtlety of eye. Nor had he the good fortune which accompanied Waagen through life to find patrons and friends in all countries of Europe. No one could have foreseen that Hotho would one day be an authority on art. During boyhood he was affected for two years with blindness consequent on an attack of measles. But recovering his sight he studied so hard as to take his degree at Berlin in 1826. A year of travel spent in visiting Paris, London, and the Low Countries determined his vocation. He came home delighted with the treasures which he had seen, worked laboriously for a higher examination, and passed as "docent" in æsthetics and art history. In 1829 he was made professor at the university of Berlin. In 1833 Waagen accepted him as assistant in the museum of the Prussian capital; and in 1858, after the death of Schorn, he was promoted to the directorship of the print-room. This was Hotho's last step in life. When Waagen died he had hopes of succeeding him, but these hopes were disappointed, not because in this walk Hotho was unfitted for the duties he was ambitious of performing, but probably because his experience was not considered sufficiently extensive. During a long and busy life, in which his time was divided between literature and official duties, Hotho's ambition had always been to master the history of the schools of Germany and the Netherlands. Accordingly what he published was generally confined to those countries. In 1842–43 he gave to the world his account of German and Flemish painting. From 1853 to 1858 he revised and published anew a part of this work, which he called "the school of Hubert van Eyck, with his German precursors and contemporaries." His attempt later on to write a history of Christian painting overtasked his strength, and was far from finished when the last sickness fell on him. Hotho's name will be honourably remembered as that of an amiable and industrious man, earnest from the first in his effort to throw light on an obscure and recondite subject. His training unfortunately confined him to one section of the field in which art history is comprised, and his comparative ignorance of Italian painting was the cause why he did not climb the last step to which Waagen had been able to ascend.

HOTMAN, or HOTTOMAN, FRANÇOIS (1524–1590), one of the most learned of French civilians, and a brilliant publicist, was born at Paris in 1524, of a family which had come, in the days of his grandfather, from Silesia. His father a counsellor of the parliament of Paris, naturally hoped to see his eldest son his successor, and gave him a legal education at Orleans. After three years' study he was made a doctor of laws, and immediately began to practise at the Paris bar. But the quibbles of pleading soon disgusted him, and to his father's annoyance he turned to the calmer study of jurisprudence. At the age of twenty-two he was named public lecturer with Baudouin at Paris, and at once gained high repute. The fortitude of Anne Dubourg under torture roused his latent enthusiasm for the Reformed opinions; he at once gave up his career, and went in 1547 to Lyons, the outpost of Genevan theology, and thence to Geneva and Lausanne. At Lausanne he became professor of belles-lettres and history, and married a French refugee from Orleans; in 1550 we find him in high repute as a teacher at Strasburg, where he lectured for several years to large crowds of students. In 1560, in the beginning of the civil troubles, he attached himself to Antony of Navarre, and was trusted with delicate missions from the Huguenot chiefs to German princes; he even at one time carried credentials from Catherine de' Medici, and his speech at the Frankfort diet, which is extant, is "a model of eloquence and political shrewdness." After a while we find him professor at Valence, expounding the civil law with such success as to restore the failing credit of that university. Three years later he succeeded Cujas at Bourges; but the civil war drove him to Orleans for refuge, whence he was sent down to Blois to negotiate the peace of 1568. He returned to Bourges only to encounter another outbreak of war and another flight, this time to Sancerre, where in the tedium of the obstinate siege he composed his *Consolatio*, a striking work drawn from the Bible and St Augustine. The peace of 1570 restored him once more; but the St Bartholomew drove him away again; and with wife and family he fled to Geneva, turning his back for ever on his country. As he went he shot at Charles IX. a Parthian shaft in his celebrated *Franco-Gallia*, a treatise much censured by Catholics and Huguenots alike. It breathed the true spirit of research and of Huguenot independence and even republicanism; for it boldly appealed, in the very citadel of hereditary succession, from rights of blood to popular election, and declared that the French monarchy rested on that foundation; the use soon made of the book by the Jesuits in their pamphlet war against Henry IV. added to its unpopularity. At Geneva Hotman was appointed professor of Roman law, and taught in peace for six years; in 1579, however, the threatening approach of the duke of Savoy frightened him away to Basel. Thence the plague sent him to Montbéliard in 1582, where he lost his faithful wife. After making trial of Geneva once more, he again in 1589 fled to Basel, where he died in 1590, and was buried in the cathedral.

Hotman was a man of unfeigned piety, nor were his firm and lofty ideas on religion ever shaken; the purity of his home-life, his devotion to wife and family, his courageous endurance of poverty and trouble, made him one of the finer characters of his age. His very timidity and restlessness were but the results of a parent's anxiety for the safety of his children; the infinite horrors of unbridled war filled him with fears for them. It was his quick intelligence and passionate temperament that made him a wanderer, and even laid him open to the suspicion of cowardice. As an author, if not original, he certainly was not Scaliger's "vulgare ingenium." His criticism is sound and acute, his learning beyond question scholarly and legal, his Latinity admirable, even eloquent; he is one of the best writers of his age; and it is not to be urged severely against him that he cheated himself with that snare of clever and needy men, alchemy, and sought to achieve the transmutation of metals.

His chief works were—the *Anti-Tribonien* (1567), a treatise to show that French law could not be based on Justinian; the *Franco-Gallia* (1573), with the pamphlets in its defence; his *Controversia patrui et nepotis* (1585); his *Brutum Fulmen* (1585), against the bull of Pope Sixtus; the *Consolatio* (published in 1593); *A Treatise on the Eucharist* (1566); *A Life of Coligny* (1575), with many other works on law, history, politics, or classical scholarship. These are mostly forgotten; but in their day they placed Francis Hotman in the first rank among the learned and accomplished authors of France. A collection of his letters was published at Amsterdam in 1700.

HOT SPRINGS, a post village in Hot Springs county, Arkansas, United States, is situated on a tributary of the Washita river, 55 miles S.W. of Little Rock. It is much resorted to by strangers on account of its hot springs, which are about sixty in number, and together have a daily flow of about 500,000 gallons. They vary in temperature from 93° to 150° Fahr., and their beneficial effects depend chiefly upon external application. The principal diseases in which they are efficacious are affections of the skin, malarial fever, and rheumatism. The number of persons who make use of them is about 20,000 annually. The town is well supplied with hotels and churches. The population, which in 1870 was 1276, was 5179 in 1880.

HOTTENTOTS was the generic name given by Europeans to the native tribes inhabiting the southern extremity of Africa. Some early writers termed them Hodmadods or Hodmandods, and others Hot-nots and Ottentots—all corruptions of the same word. The common denomination adopted by themselves was Khoi-Khoin (men of men), or Quæ Quæ, Kwekhena, t'Kuhkeub, the forms varying according to the several dialects.

These aborigines, totally distinct as they were in their primitive state from all other African races, have been generally regarded as the most ancient inhabitants of the land. A little more than two centuries ago they were a numerous people, whose nomadic tribes or clans and families were spread over the territory now distinguished as the Cape Colony; and tradition, as well as the evidence afforded by names of places and surviving peculiarities of manners and language, points to their having in prehistoric times extended much further to the north-westward and eastward, where they have been supplanted by the Kaffre or Negro tribes. The freedom, security, and protection enjoyed by the Hottentots since the Cape of Good Hope became a portion of the British empire have in no small degree arrested the process of extermination of the race which was rapidly proceeding at the close of last century. When Sir John Barrow described their condition in 1798, he estimated their numbers at about 15,000 souls. In 1806 the official return gave a population of 9784 males and 10,642 females. In 1824 they had increased to 31,000. At the census of 1865 they numbered 81,589; and the census of 1875 gave the Hottentot population within the Cape Colony at 98,561. In the returns for the last-mentioned periods, however, the designation "Hottentot" has no doubt embraced many persons of mixed race. It is only at the mission stations or in their vicinity that any genuine descendants of the early tribes are now to be met with. Beyond the colonial borders, however, they are numerically strong. Dr Theophilus Hahn gives the following as an approximate statement of their numbers (amounting in all to nearly 17,000) in Great Namaqualand and Damaraland:—*Pure Namaquas*—Geikous, or Red Nation, 2500; Topnaars, 750; Kharo-oas, 300; Khogeis, 100; Ogeis, or Great Deaths, 800; Khau-goas, or Young Red Nation, 1000; Habobes, or Velschoendragers, 1800; Karagei-Khois, 800; Gaminus, or Bondlezwaarts, 2000; Gunungu, or Lowlanders, 200. *Namaqua Hottentots* or *Oerlaams*—Eicha-ais, or Afrikaaners, 800; Kowisis, 2500; Amas, 2000; Khauas, 700; Gei-Khauas, or Gobabis people, 600.

The pure Namaquas claim to be the aboriginal tribes, while the "Oerlaam" are the new-comers, or those who migrated across the Orange river from the southern part of Cape colony. The latter tribes and many of the former may be said to be in a semi-civilized state, and have in a great measure adopted the customs, habits, language, and pursuits of the colonists. Some are in good circumstances, rich in waggons, horses, cattle, and sheep; while others retain all the improvident, idle, nomadic habits of the aborigines.

The primitive character of the Hottentot or Khoi-Khoin has been greatly changed by their forced migrations, and their gradual adoption of the habits of civilized life. The best information as to their original manners and customs is therefore to be obtained from the descriptions given of them by the older writers. The observations of Kolben, who was a resident at the Cape in the early part of last century, are by far the most complete; and, although doubts have been thrown upon some of his statements, yet travellers and missionaries who have resided among the tribes in Great Namaqualand confirm and endorse the greater part of them.

All authorities agree in representing the natural disposition of the Hottentots as mild, placable, and ingenuous. Mutual affection was the greatest of their virtues. They held in contempt the man who could eat, drink, or smoke alone. They were hospitable to strangers; indeed, their munificence often left them scarcely anything for themselves. Another characteristic was indolence. While not deficient in talents or capacity, they seemed to lack the energy to call them into action. They did not, however, disdain to look after their cattle. Hunting they pursued for pleasure as well as sustenance, and when once aroused they were nimble and active, as well as bold and ardent. In personal appearance they were of a medium height, the females rather smaller than the men. Their bodies were slender but well proportioned, with small hands and feet. Their skin was of a leathery brown colour; their face oval, with prominent projecting cheekbones; eyes dark chestnut or black and wide apart; nose broad and thick and flat at the root; chin pointed, and mouth large, with thick turned-up lips. Their woolly hair grew in short thick curly tufts on their head, and the beard very scanty. The women, especially as they advanced in years, had flabby breasts hanging down low; abnormal developments of fat were somewhat common among them; and cases occurred of extraordinary elongation of the *labia minora* and of the *præputium clitoridis*.[1]

The dress of the men was very simple. A cloak or kaross, varying according to the fashion of the tribe, was usually thrown across the shoulders and a smaller one across the loins. Those of the chiefs or captains were usually of tiger or wild-cat skins, those of the commonalty of sheep skins. They wore the cloaks all the year round, turning the hairy side inward in winter and outward in summer; they slept in them at night, and when they died they were interred in them. They had suspended around their necks little bags or pouches, containing their knives, their pipes and tobacco or daccha (*Cannabis*, or hemp), and an amulet of burnt wood. On their arms were rings of ivory. When they drove their herds to pasture they wore sandals on their feet, and some of them carried a jackal's tail fastened on a stick to wipe their face with when heated and drive away the flies. The women also wore karosses, a lesser under a greater, fashioned much like those of the men, but with the addition of a little apron, to which were appended their ornaments. In a leather bag suspended round their neck they carried daily, whether at home or abroad, some victuals, together with their daccha, tobacco, and pipe. They also wore an ornamented skin cap on their heads, armlets of iron or copper on their arms, strings of beads round their wrists, and round their legs thongs of ox-hide sometimes covering half the leg or more.

They loved to besmear their bodies and their dress with greasy substances. The wealthy Hottentots were very lavish in the matter of butter and fat, the use of which was the grand distinction between rich and poor. They also perfumed themselves with the powdered leaves of a shrub called by them bucchu (*Diosma crenata*). An ointment formed of soot and grease and the powder of bucchu was held in very high estimation.

The sites of their villages or kraals were usually on green meadow grounds. They never entirely exhausted the grass or herbage, but kept moving at intervals from one spot to another. The huts or tents, which they could strike, carry, or pitch where they chose, were ranged in circles, the area of which varied with the pastoral wealth of the community. The small cattle were placed inside the circle, and the larger cattle outside. In the centre of the huts a hole served for a fire-place, around which the members of the family were fond of squatting upon their haunches while they passed the tobacco pipe from one to another. On each side of the hearth small excavations an inch or two deep were made in the ground, and thereon mats were spread upon which the men, women, and children rolled up in their karosses lay down and slept. Their household effects consisted only of some earthen vessels for cookery, tortoise shells for spoons and dishes, and calabashes, bamboos, and skins for holding milk and butter. The weapons for hunting or warfare—the assegai, the bow and poisoned arrows, the shield, and the kerrie (a stick with a large knob at one end)—were also part of the furniture. Women were held in high repute: the most sacred oath a Khoi-Khoi could take was to swear by his sister or mother; yet the females ate apart from the men, and did all the work of the kraal. Their usual food consisted of milk, the flesh of the buffalo, hippopotamus, antelope, or other game, and edible roots and bulbs or wild fruits. Cows' milk was commonly drunk by both sexes, but ewes' milk only by the women, and when cows' milk was scarce the women were obliged to keep to ewes' milk or water. Meats were eaten either roasted or boiled, but for the most part half raw, without salt, spices, or bread. Some meats they carefully abstained from, such as swine's flesh. Hares and rabbits were forbidden to the men, but not to the women; while the pure blood of beasts and the flesh of the mole were forbidden to the women, but not to the men.

Their social pleasures consisted in feasting, smoking, dancing, and singing. Every signal event of life, and every change of abode and condition was celebrated with a feast. On the formation of a new kraal an arbour was constructed in the centre, and the women and children adorned and perfumed it with flowers and branches of trees and odoriferous herbs. The fattened ox was killed and cooked, and the men partook of it in the arbour, while the women sitting apart regaled themselves with broth. Upon such occasions they indulged in no other intoxication than what arose from their smoking tobacco or daccha.

Circumcision, which is common to the Kaffre tribes, was unknown to them, but when a youth entered upon manhood a particular ceremony was performed. One of the elders or officiating priests, using a knife of sharp quartz, made incisions on the young man's body, and afterwards besprinkled the same with urine. When a man for the first time distinguished himself by killing an elephant, hippopotamus, or rhinoceros, similar marks were made on his body, and were regarded as insignia of honour. There was no purchase of wives, but in every case of marriage the consent of the parents had to be first obtained. If his proposals were accepted, the suitor accompanied by all his kindred drove two or three fat oxen to the house from which he was to take his destined bride. There her assembled relations received them with kindly greetings and caresses; the oxen were then immediately slain, and

[1] See paper by Messrs Flower and Murie in *Journ. Comp. Anat. and Physiology*, 1867; and Fritsch, *Die Eingebornen Süd-Afrikas*, Breslau, 1873.

every one participated in the bridal feast. The nuptial ceremony was concluded by the priest besprinkling the happy pair. Among the colonial Hottentots these ancient usages have long been set aside; but they are still continued among some of the surviving tribes north of the Orange river. Polygamy was practised, but not to any great extent. Divorce was much more common. Family names were perpetuated in a peculiar manner—the sons took the family name of the mother, while the daughters took that of the father. Thus if the father's and mother's names were respectively Hagub and Daimūs, the sons would be called, according to their age, Daimūb geib (big one), Daimūb ! naga mab (of lower standing), and Daimūb ‡ Kham (younger); and the daughters, Hagu-geis (eldest), Hagu ! nagamas (second), and Hagu ‡ Khams (younger). The children were very respectful to their parents, by whom they were kindly and affectionately treated. Yet the superannuated or aged father or mother was sometimes exposed and left to die. Namaquas say this was done by very poor people if they had no food for their parents. But even when there was food enough, aged persons, especially women, who were believed to be possessed of the evil spirit or devil were placed in an enclosure of bushes with some meat and water, intended to be their last nourishment.

The Hottentots had neither warlike nor pastoral songs, and their musical instruments were but few and simple. One named the "gorah" was formed by stretching a piece of the twisted entrails of a sheep along a thin hollow stick about three feet in length in the manner of a bow and string. At one end there was a piece of quill fixed into the stick, to which the mouth was applied, and the tones were produced by inspiration and respiration. Another, the "ramkee," was constructed on the same principle as a guitar, with three or four strings stretched over a piece of hollow wood. The "rommel-pot" was a kind of drum. Reeds several feet long were likewise made use of as flutes.[1]

The system of government was patriarchal. Each tribe had its hereditary "khu-khoi" or "gao-ao" or chief, and each kraal or encampment its captain. These met in council whenever any great matters affecting the privileges of the people had to be decided. They had no salary, but their persons were held in great reverence, and they were installed in office with solemnities and feasting. In certain tribes the hind part of every bullock which was slaughtered was sent to the chief, and this he distributed among the males of the village. He also collected sufficient milk at the door of his hut to deal out amongst the poor. A part of every animal taken in hunting was exacted by the chief, even though it was in a state of putrefaction when brought to him.

The captains assisted by the men of each kraal attended to the settlement of disputes regarding property and to the trial of criminals. A murderer was beaten or stoned to death; but if one escaped and was at large for a whole year, he was allowed to go unpunished. Adultery seldom occurred; if any one found parties in the act and killed them he was no murderer, but on the contrary received praise for his deed. Women found offending were burnt. Theft, especially cattle-stealing, was severely punished.[2]

The religious ideas of the Hottentots were very obscure. Vaillant says they had "neither priests nor temples, nor idols, nor ceremonials, nor any traces of the notion of a deity." Kolben, Tachart, and others, however, assure us that they believed in an invisible deity or "Great Captain," whom they named Tik-guoa (*Tsu-goab*), a good man who did them no harm, and of whom therefore they need not be afraid. They also spoke of other captains of less power, and of a black captain named Gauna, who was the spirit of evil. The moon was a secondary divinity, supposed to have the disposal of the weather; and on each occasion of the appearance of the crescent moon in the sky they assembled from night till morning, dancing, clapping hands, and singing their hymns.[3] Schmidt, the first missionary to the Hottentots, says they also celebrated the anniversary of the appearance of the Pleiades above the eastern horizon. Hahn states that at the present day the Topnaars of Sandwich Harbour and of the ! Khomab mountains worship a being whom they name Tusib, the rain god. He also reports that he heard an old Namaqua saying, "The stars are the souls of the deceased," and mentions a form of imprecation, "Thou happy one, may misfortune fall on thee from the star of my grandfather."

Their notion of the supreme being and their relations to a life hereafter also took the form of ancestor-worship. The deified hero was named *Heitsi-Eibib*; and of him endless stories are told. The one most generally accepted is that he was a notable warrior of great physical strength, who once ruled the Khoi-Khoin, and that in a desperate struggle with one of his enemies, whom he finally overcame, he received a wound in the knee, from which event he got the name of "the wounded knee." He was held in high repute for extraordinary powers during life, and after death he continued to be invoked as one who could still relieve and protect. According to the tradition still preserved among the Namaquas, Heitsi-Eibib came from the east. Therefore they make the doors of their huts towards the east, and those who possess waggons and carts put their vehicles alongside the mat-house with the front turned towards the east. All the graves are in true west-easterly direction, so that the face of the deceased looks towards the east. The spirit of Heitsi-Eibib is supposed to exist in the old burial places, and, whenever a heathen Hottentot passes them, he throws stones on the spot as an offering, at the same time invoking the spirit's blessing and protection. Hahn asserts that there are many proofs which justify the conclusion that, to the minds of the Khoi-Khoin, Heitsi-Eibib and Tsu-goab (the supreme being) were identical. Both were higher powers who took great care of men. Both were believed to have died and risen again. They killed the bad beings and restored peace on earth; they promised men immortality, understood the secrets of nature, and could foretell the future. The Heitsi-Eibega are to be found all over South Africa.[4]

Various ceremonies were practised to ward off the evil influence of ghosts and spectres, and charms were freely

[1] These were always played at the reed-dance, which was commenced by a leader blowing on his reed, with head bent forwards, and stamping his feet violently on the ground to beat time. He was followed by the other musicians, who, forming a circle, also stooped forward and stamped. The women first ran round the circle of reed-players, clapping their hands and singing, and giving their bodies various odd twists. Then they got into the circle, and the men stamped and blew the reeds around them, and thus they continued frequently a whole night with but little interruption. On some occasions the performers described with appropriate action any incident of late occurrence, and in doing so the utmost poetical licence, as well as perfect freedom of speech, was permitted.

[2] The thief was bound hand and foot, and left on the ground without food for a long time; then, if his offence was slight, he received some blows with a kerrie or stick, but if the case was an aggravated one, he was severely beaten, and then unloosed and banished from the kraal. The family of even the worst criminal suffered nothing on his account in reputation, privilege, or property.

[3] An interesting notice of this form of worship occurs in the journal of an expedition which the Dutch governor, Ryk van Tulbagh, sent to the Great Namaquas in 1752, which reached as far as the Kamob or Lion river (about 27° S. lat.).

[4] On the religion and antiquities see Hahn's papers, "Graves of the Heitsi-Eibib," in *Cape Monthly Magazine*, 1879, and "Der Hottentotische Zai-goab und der Griechische Zeus," in *Zeitschr. für Geogr.*, Berlin, 1870.

employed.[1] There was also a belief that in every fountain there was a snake, and that as long as the snake remained there water would continue to flow, but that if the snake was killed or left the fountain it would cease. Offerings were sometimes made to the spirit of the fountain. Like all people sunk in barbarism, the Hottentots had great faith in witch-doctors, or sorcerers. When called to a sick-bed, these ordered the patient to lie on his back, and then pinched, cuffed, and beat him all over until they expelled the illness. After that they produced a bone, small snake, frog, or other object which they pretended to have extracted from the patient's body. If the treatment did not prove efficacious, the person was declared bewitched beyond the power of any one to cure him. Sometimes a joint of a finger was cut off from the idea that the disease would thereby pass away. If death occurred, the corpse was interred on the day of decease. It was wrapt in skins, and placed in the ground in the same position it once occupied in the mother's womb. Death was generally regarded in a very stoical manner.

Language.

The Hottentot language was regarded by the early travellers and colonists as an uncouth and barbarous tongue. The Portuguese called the native manner of speaking stammering; and the Dutch compared it to the "gobbling of a turkey-cock." These phonetic characteristics arose from the common use of "clicks,"—sounds produced by applying the tongue to the teeth or to various parts of the gums or roof of the mouth, and suddenly jerking it back. Three-fourths of the syllabic elements of the language begin with these clicks, and combined with them are several hard and deep gutturals and nasal accompaniments. The difficulty a European has in acquiring an accurate pronunciation is not so much in producing the clicking sound singly as in following it immediately with another letter or syllable. The four recognized clicks, with the symbols generally adopted to denote them, are as follows:—Dental = | ; palatal = ǂ ; lateral = || ; cerebral = !. According to Tindall, one of the best grammarians of the language, the dental click (similar to a sound of surprise or indignation) is produced by pressing the top of the tongue against the upper front teeth, and then suddenly and forcibly withdrawing it. The palatal click (like the crack of a whip) is produced by pressing the tongue with as flat a surface as possible against the termination of the palate at the gums, so that the top of the tongue touches the upper front teeth and the back of the tongue lies towards the palate, and then forcibly withdrawing the tongue. The cerebral click (compared to the popping of the cork of a bottle of champagne) is produced by curling up the tip of the tongue against the roof of the palate, and withdrawing it suddenly and forcibly. The lateral click (similar to the sound used in stimulating a horse to action) is articulated by covering with the tongue the whole of the palate and producing the sound as far back as possible; European learners imitate it by placing the tongue against the side teeth and then withdrawing it. The easiest Hottentot clicks, the dental and cerebral, have been adopted by the Kaffres; and it is a striking circumstance, in evidence of the past Hottentot influence upon the Kaffre languages, that the clicking decreases amongst these tribes almost in proportion to their distance from the former Hottentot domain.

The language in its grammatical structure is beautiful and regular. Dr Bleek describes it as having the distinctive features of the suffix-pronominal order or higher form of languages, in which the pronouns are identical with and borrowed from the derivative suffixes of the nouns. The words are mostly monosyllables, always ending, with two exceptions, in a vowel or nasal sound. Among the consonants neither *l*, *f*, nor *v* are found. There are two *g*'s, *g* hard and *g* guttural, and a deeper guttural *kh*. Diphthongs abound. There is no article, but the definite or indefinite sense of a noun is determined by the gender. In the fullest known dialect (that spoken by the Namaqua) nouns are formed with eight different suffixes, which in nouns designating persons distinguish masc. sing. (*-b*), masc. plur. (*-ku*), masc. dual (*kha*), fem. sing. (*-s*), fem. plur. (*-ti*), com. sing. (*-i*), com. plur. (*-u*), com. dual (*-ra*). The adjective is either prefixed to a noun or referred to it by a suffixed pronoun. This grammatical division of the nouns according to gender led to the classification of the language as "sex-denoting," thus suggesting if not identifying its relationship, in original structure, with the North-African species of the same family, such as the Coptic and Old Egyptian, Galla, Berberic, Houssa, Ethiopic, and others.

There are four dialectical varieties of the language, each with well-marked characteristics:—the Nama dialect, spoken by the Namaqua as well as by the Hau-Koin or Hill Damaras, a supposed Bantu or negro people who in some past period were conquered and enslaved by the Namaquas; the Kora dialect, spoken by the Korannas, or Koraquas, dwelling about the middle and upper part of the Orange, Vaal, and Modder Rivers; the Eastern dialect, spoken by the Gona or Gonaquas on the borders of Kaffreland; and the Cape dialect, now no longer spoken but preserved in the records of early voyagers and settlers. Of these dialects the Nama is the purest. It is described in three grammars:—Wallmann's (1857) and Hahn's in German, and Tindall's (1871) in English, the last being the best; and the four Gospels, with a large amount of missionary literature, have been published in it. This dialect is commonly spoken by a native population of not less than 100,000 souls south and north of the Orange river, and in parts of Damaraland (or Hereroland) and the Kaokoveld.

The vocabulary is not limited merely to the expression of the rude conceptions that are characteristic of primitive races. It possesses such words as *koi*, human being; *khoi-si*, kindly or friendly; *koi-si-b*, philanthropist; *khoi-si-s*, humanity; ǂ *ei*, to think; ǂ *ei-s*, thought; *amo*, eternal; *amo-si-b*, eternity; *tsa*, to feel; *tsa-b*, feeling, sentiment; *tsa-kha*, to condole; *amu*, true; *ama-b*, the truth; *anu*, sacred; *anu-si-b*, holiness; *esa*, pretty; *anu-xa*, full of beauty.

Folkl

A considerable mass of floating traditionary literature—fables, myths, and legends—exists amongst the Khoi-Khoin,—a fact which was first made known by Sir James Alexander, who in his journeyings through Great Namaqualand in 1835 jotted down the stories told him around the camp fire by his Hottentot followers. Since then missionaries and officials stationed in the country have made collections of them, and the result has been an unlooked for mine of literary lore among a nation whose mental qualifications it was customary to regard as of a very low grade. These Hottentot tales generally have much of the character of fables; some are in many points identical with northern nursery tales, and suggestive of European origin or of contact with the white man; but the majority bear evidence of being true native products. Bleek's *Reynard the Fox in South Africa* (1864) contains a translation of a legend written down from the lips of the Namaquas by the Rev. G. Krönlein, which is regarded as an excellent specimen of the national style. Another legend relating to the moon and the hare conveys the idea of an early conception of the hope of immortality. It is found in various versions, and, like many other stories, occurs in Bushman as well as in Hottentot mythology.

Ethno- graphi relatio

The supposed affinity of the Hottentot with the North African nations was first guessed at by the Rev. Dr Moffat from the resemblance between the language of the Namaquas and that of some slaves in the market of Cairo. This relationship was afterwards suggested by the Rev. Dr James Adamson, of Cape Town, from the identity of the signs of gender in Namaqua and Coptic, and the appearance of persons of the Hottentot form and colour, with their grease and *sibilo* dye, among the representations on Nubian tombs. Then came Dr Bleek's philological researches, showing that the Hottentot language from the sexual gender of its nouns was one of the very extensive "sex-denoting" family which has spread itself over North Africa, Europe, and part of Asia, and that it moreover surpassed all the others in a faithful preservation of the primitive type. This association of the language of the people of South Africa with that of their northern cousins promised to solve the problem of their pedigree and ancestry, for it at once suggested and implied early migrations of Hottentot and Bushmen from their primal home, and the intrusion upon them at some time or other of the Bantu or negroid tribes, who probably came from the west and drove the Hottentots on the eastern side of Africa southward before them. But the assumed kinship of the Old Egyptians and Hottentots has been disputed by other eminent authorities, such as Von Gabelentz, Pott, Fr. Müller, and Hahn, who have pronounced against it on ethnological and philological grounds. Hahn stoutly maintains that the Hottentots and Bushmen are but divisions of a single race—"the children of the same mother"—who formed the primeval inhabitants of the whole of South Africa as far as the Zambezi.[2]

Histor

The earliest accounts which we have of the Hottentots occur in the narratives of Vasco da Gama's first voyage to India round the Cape in 1497. They are described as small, of a brownish yellow complexion, and an ugly appearance; they freely bartered their sheep, but would not part with their cattle, on which the women

[1] If a Khoi-Khoi went out hunting his wife kindled a fire, and assiduously watched by it to keep it alive; if the fire should be extinguished her husband would not be lucky. If she did not make a fire, she went to the water and kept on throwing it about on the ground, believing that thereby her husband would be successful in getting game. Charms, consisting of bones, burnt wood, and roots of particular shrubs cut into small pieces, were generally worn round the neck.

[2] See the linguistic part of Dr Fr. Müller's work on the scientific results of the Novara expedition, and Hahn's contributions on the Hottentots in the *Proceedings* of the Geographical Society (Dresden, 1869) and in *Globus* (1870), and his *Sprache der Nama* (Leipsic, 1870).

rode with pack saddles. In 1509 the Portuguese viceroy, Francisco d'Almarda, count of Abrantes, met his death in a dispute with these natives; and down to the early part of the 17th century there was an idea that they were cannibals. Better knowledge was obtained after the Dutch East India Company took possession of the Cape in 1652. According to the accounts given by the early Dutch governors the Hottentots received the Europeans in a friendly manner. The Dutch upon their first settlement were not chargeable with cruelty or oppression to the natives. Their primary intention when they erected a fort and took possession of Table Valley was merely to secure supplies of water, cattle, and other fresh provisions for their passing fleets; and the only mode in which they could accomplish this object was by maintaining friendly relations with the aborigines. These relations continued until 1659, when a collision occurred which led to some bloodshed.

To prevent disputes about pasturage and cattle forays in the future, one of Van Riebeek's successors purchased in 1672, at the cost of goods about £10 value, from two of the Hottentot chiefs, who claimed to be hereditary sovereigns, all the country from the Cape peninsula to Saldanha Bay,—but on the condition that, where the colonists did not occupy the arable lands or pastures, the natives might erect their kraals and pasture their cattle freely.

During the years which followed, the European population, notwithstanding renewed hostilities in 1676 and 1677, considerably increased, and the settlement enlarged its boundaries, while the natives ejected from their former pastures retired upon their neighbours, and waged war among themselves. Simultaneously with the tribal disintegration and impoverishment which ensued, the occurrence of new and infectious diseases made sad havoc; and, while the tide of European occupation was gradually advancing inland from the south, a similar movement by the negro warrior tribes who have received the common appellation of Kaffres was taking place in the east, with the result that about the middle and the end of the last century the former inhabitants of the land were but occupants on sufferance. Straggling remnants still maintained their independence, living in small kraals or societies, but the mass of them voluntarily took service with the colonists as herdsmen, while others became hangers-on about the company's posts and grazing-farms, or roamed about the country. In 1787 the Dutch Government passed a law subjecting these wanderers to certain restrictions. They were required to have a residence, and were forbidden to change their place of abode without "passes" or certificates from the authorities or their masters. Another provision gave their employers the right to the services of their children from eight to eighteen years of age, if born on their estates. At the same time corporal punishment and confiscation of property were threatened against any colonist convicted of ill-treating Hottentots, or of forcibly separating them from their wives and children. The effect of these measures of restraint was to place the Hottentots in more immediate dependence upon the farmers, or to compel them to migrate to the northward beyond the colonial border. Those who chose the latter alternative had to encounter the hostility of their old foes, the Bushmen, who were widely spread over the plains from the Nieuwveld and Sneeuwberg mountains to the Orange river. The colonists also, pressing forward to those territories, came in contact with these aboriginal Ishmaelites,—their cattle and sheep, guarded only by a Hottentot herdsman, offering the strongest temptation to the Bushman. Reprisals followed; and the position became so desperate that the extermination of the Bushmen appeared to the Government the only safe alternative. "Commandoes" or military expeditions were sent out against them, and they were hunted down like wild beasts. Within a period of six years, it is said, upwards of 3000 were either killed or taken. In consequence of certain measures of restraint and conciliation insisted on by the authorities at a later period, the Boers rose in rebellion, and a state of anarchy ensued, which was prevalent when the British Government took possession of the Cape in 1795. No sooner was the English standard raised in the country than the Hottentots abandoned their former masters and joined the British troops, a step which helped to bring about the prompt submission of the Boer insurgents. Tranquillity being thus restored, the Hottentots, fearing to return to their Dutch masters on the withdrawal of the British troops, requested the Government to make some provision for them. This petition and appeal being neglected, many joined their barbarian neighbours, the Kaffres, and together with them fell suddenly upon the colonists all along the border and even as far westward as the district of George. It was not till 1800 that they were ultimately prevailed upon to deliver up their arms. The English governor of that day, General Francis Dundas, showed an earnest desire to do justice to the Hottentots. Such as were disposed to enlist were embodied in a militia corps named the Cape Regiment, afterwards known as the Cape Mounted Rifles.

The Hottentots were not rescued from their state of servitude, or released from the restraints and disabilities imposed upon them by the Dutch authorities until long after the British rule had been permanently established in South Africa. A proclamation issued in 1809 gave them a greater degree of security in their contracts of service with the colonists; and subsequent regulations provided for the better protection of their persons and property. But with the exception of those individuals who found asylums in the missionary institutions of the Moravian Brethren and of the London Missionary Society, or who served in the Cape regiment, they were still in the service of the farmers, subject to indentureship and to rigorous control in moving from place to place. At length in 1828 the representations of English philanthropists prevailed; a law was promulgated effectually emancipating the Hottentots and all free persons of colour from compulsory service and all other disabilities, and declaring them "to be in the most full and ample manner entitled to all and every right, benefit, and privilege to which any other British subjects within the colony were entitled."

Following upon this the Government adopted a measure allotting certain lands for the use of Hottentot families. A tract known as the Kat River Valley, from which the Kaffre chief Macomo had been expelled for his aggressions against the colony, was set apart for them. It was divided into locations, upon which villages were laid out, each family receiving a number of acres as their allotment for cultivation, and the pasturage being reserved for commonage. Numbers of Hottentots soon made their appearance and settled on the spot. Some were possessed of a quantity of live stock, which they had earned in the service of the farmers, or at the mission stations; but most of them owned no property. Those who had cattle assisted their poorer friends and relatives; those who had neither food nor friends lived upon "*veldkost*," *i.e.*, the wild roots and bulbs dug out of the ground until the land they had planted returned them a harvest. Within a few years they surmounted their first difficulties, and their progress and prosperity delighted the friends of the coloured race. Three or four years afterwards, however, they suffered a good deal from Kaffre aggressions, and in 1835 had to bear the brunt of the war, being exposed to the most determined attacks of the followers of Macomo and Tyali. They had scarcely recovered from the disasters then inflicted, when the outbreak of 1846 occurred, and all their able-bodied men had again to leave their homes and join the military encampments. When allowed to return to their locations, they found, like many other frontier inhabitants, the result of all their former labours destroyed; their houses had to be rebuilt, their lands to be cultivated, and their families to be fed. From this time a spirit of dissatisfaction crept in amongst them. They complained that while doing burgher duty they had not received the same treatment as others who were serving in defence of the colony, that they got no compensation for the losses they had sustained, and that they were in various ways made to feel they were a wronged and injured race. The location of a disloyal Kaffre, named Hermanus, with a number of disorderly followers in their neighbourhood, served to corrupt and estrange the feelings of many, and a secret combination was formed with the Kaffres to take up arms to sweep the Europeans away and establish a Hottentot republic. In 1851 about 900 of them broke out into rebellion, and their numbers were increased by deserters from the Hottentot regiment of Cape Mounted Rifles, and by several Hottentots in the service of the frontier farmers. A small body, however, remained loyal, and with the missionaries and the local magistrates withstood the rebels until military aid came to their relief. The Kat River population have since had a long period of peace and good government, and are now as loyal and happy as any subjects of the crown. (W. J. N.)

HOTTINGER, Johann Heinrich (1620–1667), a Swiss philologist and theologian, was born at Zurich, 10th March 1620. He studied at Ghent, Groningen, and Leyden, and after visiting England was in 1642 appointed professor of church history in his native town. To the duties of that chair those of Hebrew at the Carolinum were added in 1643, and in 1653 he was appointed ordinary professor of logic, rhetoric, and theology. Nothwithstanding this plurality of offices he found time to publish a number of pamphlets, chiefly on the original text of the Old Testament, which gained him such a reputation as an Oriental scholar that the elector palatine in 1655 appointed him professor of Oriental languages and biblical criticism at Heidelberg. In 1661 he, however, again returned to Zurich, where in 1662 he was chosen principal of the university. In 1667 he accepted an invitation to become professor in the university of Leyden; but on the journey thither he was drowned along with three of his children by the upsetting of a boat while crossing the river Limmath.

Hottinger was the author of a variety of learned theological works, the principal of which are *Historia ecclesiastica*, 9 vols., 1651–67; *Thesaurus philologicus seu clavis Scripturæ*, originally published in 1649; *Etymologicon orientale, sive Lexicon harmonicum heptaglotton*, 1661. He also wrote a Hebrew and a Chaldee grammar.

HOUBRAKEN, Jacobus (1698-1780), Dutch engraver, was born at Dort, December 25, 1698. All that his father, Arnold Houbraken, bequeathed to him was a fine constitution and a pure love for work. In 1707 he came to reside at Amsterdam, where for years he had to struggle incessantly against difficulties. He commenced the art of engraving by studying the works of Cornelis Cort, Suyderhoef, Edelinck, and the Visschers. He devoted himself almost entirely to portraiture, and as his reputation became known in and beyond the boundary of his country he soon found himself with commissions more than he could conveniently execute. Seeking happiness in the bosom of his family, and being temperate in his habits, he lived to an advanced age, and the work executed the last year of his life shows no failing of his power in the use of the burin. Among his best works are scenes from the comedy of *De Ontdekte Schijndeugd*, executed in his eightieth year, after Cornelis Troost, who was called by his countrymen the Dutch Hogarth, with, however, very small title to such a distinction. Houbraken died on the 14th of November 1780, having nearly completed his eighty-second year.

See A. Ver Hull, *Jacobus Houbraken et son Œuvre* Arnhem, 1875, where 120 engraved works are fully described.

HOUDON, Jean Antoine (1740-1828), was the most distinguished sculptor produced by France in the latter half of the 18th century. He was born at Versailles in 1740, and at the age of nineteen, having learnt all that he could from Michel Ange Slodtz and Pigalle, Houdon carried off the prix de Rome and left France for Italy, where he spent the next ten years of his life. His brilliant talent, which seems to have been formed by the influence of that world of statues with which Louis XIV. peopled the gardens of Versailles rather than by the lessons of his masters, delighted Clement XIV., who, on seeing the St Bruno executed by Houdon for the church of St Maria degli Angeli, said "he would speak, were it not that the rules of his order impose silence." In Italy Houdon had lived in the presence of that second Renaissance with which the name of Winckelmann is for ever associated, and the direct and simple treatment of the Morpheus which he sent to the Salon of 1771 bore witness to its influence. This work procured him his "agrégation" to the Academy of Painting and Sculpture, of which he was made a full member in 1775. Between these dates Houdon had not been idle; busts of Catharine II., Diderot, and Prince Galitzin were remarked at the Salon of 1773, and at that of 1775 he produced, not only his Morpheus in marble, but busts of Turgot, Gluck, and Sophie Arnould, together with his well-known marble relief, "Grive suspendue par les pattes." He took also an active part in the teaching of the academy, and executed for the instruction of his pupils the celebrated Écorché still in use. To every Salon Houdon was a chief contributor; most of the leading men of the day were his sitters; his busts of D'Alembert, Prince Henry of Prussia, Gerbier, Buffon (for Catharine of Russia), and Mirabeau are amongst the most remarkable portraits of modern times; and in 1778, when the news of Rousseau's death reached him, Houdon started at once for Ermenonville, and there took a cast of the dead man's face, from which he produced the grand and lifelike head at present in the Louvre. The celebrated draped statue of Voltaire, now in the vestibule of the Théâtre Français, was exhibited at the Salon of 1781, to which Houdon also sent a statue of Marshal de Tourville, commissioned by the king, and the Diana executed for Catharine II. This work was refused; the jury alleged that a statue of Diana demanded drapery; without drapery, they said, the goddess became a "suivante de Vénus," and not even the proud and frank chastity of the attitude and expression could save the Diana of Houdon (a bronze reproduction of which is now in the Louvre) from insult. Whether Houdon felt annoyance at this folly does not appear; but three years later he very readily accepted an invitation to go to America, there to carry out a statue of Washington. With Franklin, whose bust he had recently executed, Houdon left France in 1785, and, staying some time with Washington at Philadelphia, he modelled the bust, with which he decided to go back to Paris, there to complete the statue destined for the assembly hall of the State of Virginia. After his return to his native country Houdon executed for the king of Prussia, as a companion to a statue of Summer, La Frileuse, a naif embodiment of shivering cold, which is one of his best as well as one of his best-known works. The Revolution interrupted the busy flow of commissions, and Houdon took up a half-forgotten project for a statue of St Scholastica, which had long been put on one side in a corner of his studio. He was immediately denounced to the convention, and his life was only saved by his instant and ingenious adaptation of St Scholastica into an embodiment of Philosophy. Under Napoleon, Houdon received little employment; he was, however, commissioned to execute the colossal reliefs intended for the decoration of the column of the "Grand Army" at Boulogne (but which ultimately found a different destination); he also produced a statue of Cicero for the senate, and various busts, amongst which may be cited those of Marshal Ney, of Josephine, and of Napoleon himself, by whom Houdon was rewarded with the legion of honour. After the fall of the first empire Houdon suddenly aged; he lost his memory, and slept away the closing years of his life. He died at Paris in 1828.

The most striking characteristic of his work is the life by which it is animated, and which is the result of marvellous skill in execution and keenness in observation. He was, in all he did, great. His bust of Voltaire is deservedly one of the most famous in the whole range of modern sculpture, and his genial reading of Rousseau—a splendid yet brute virility tempered with the gift of tears—is a masterpiece of insight into character. But Houdon's power was no less triumphant in rendering the beauty of youth and the beauty of beautiful women. His Diana proved that he could penetrate the secret of an ideal of noble womanhood; his heads of young girls have been compared with the graceful children of his contemporary Greuze, but the innocent candour of Houdon's work is entirely free from the self-consciousness which disturbs the charm of La Cruche Cassée and her companions. Finally, Houdon cannot be claimed, like Greuze, as representing the popular tendencies of the society to which he belonged; for, whereas Greuze, like most men, bore the stamp of his time on all he did, Houdon was one of those rare spirits who, doing the work of their own time, set their own seal thereto.

HOUND. The foxhound, harrier, and beagle are now the only representatives of whatever varieties of hounds existed previously in England. The staghound proper is practically extinct, no pack of them having been kept since 1825, when the Devon and Somerset establishment was broken up and the pack sold. With the exception of Lord Wolverton's black St Huberts, all hounds now used for stag-hunting are simply those of the foxhound breed entered to deer instead of to fox. Most packs of staghounds are composed of hounds of the ordinary size, but it is said that the present master of the Devon and Somerset (1880) uses none under 25 inches, and excludes bitches altogether.

Foxhound

The modern English foxhound is about as near perfection as he can well be, and his excellence is all the more wonderful that less than 200 years ago there does not seem to have been in existence any hound bearing a resemblance to him; for, until fox-hunting by hounds kept for that especial purpose was instituted, there could have been no reason to breed foxhounds. According to old writers on hunting subjects, there appear to have been, amongst other varieties, the slow, plodding, southern hound, with a great square head and wondrous powers of working on a scent, and the lighter northern hound; and as all animals improve under the care and guidance of man, until they assume the character of a distinct breed, it is clear that such has been the case with foxhounds, the earlier breeders of which did their part towards the attainment of perfection, by breeding with much care and judgment from the best specimens at their disposal. Older breeders were satisfied if the result of their crossings possessed good noses, and were up to the standard of beauty of those days; but the time came, in the days of the great Meynell, when pace had to be added to the list of foxhound virtues, owing to the use of better bred horses in the hunting field, and at the present day the development of pace without sacrificing nose is one of the greatest difficulties a breeder has to contend with.

The mastership of a pack of foxhounds is an undertaking of great responsibility. In the article HUNTING mention is made of the difficulties which beset a master when he takes the field; but after all, the greatest exercise of judgment is called for in relation to the kennels, for upon the master, in conjunction to a greater or less extent with the huntsman or kennel huntsman, rests the responsibility of selecting suitable sires and dams for the young hounds he intends to breed; of drafting such hounds as it is thought desirable to part with owing to their being over or under sized, or possessed of some failing; and of obtaining drafts from other establishments. More than one opinion exists as to what is the proper size for a foxhound, but some of the greatest authorities having expressed their conviction that from 21 to 22 inches for bitches and from 23 to 24 inches for dogs is the proper standard, a master could hardly do wrong in adopting it. A hound's head should not be too large, nor, on the other hand, should it be too narrow, or else, like the greyhound, he will possess speed, but be deficient in nose. There was much truth in Mr Warde's remark, who, on overhearing a stranger finding fault with his hounds for having such large heads, said, "Their knowledge boxes (as he called them) are large, but size has this advantage, that when they once put their noses down to the ground they cannot get their heads up again." The neck should be neither too short nor throaty; that is to say, there should be no dewlap. The shoulder should slope like that of the horse, and there should be plenty of muscle in the arm. Below the knee a hound should be quite straight, and the distance should be short between the knee and the foot, which must be short and round like a cat's foot. So, too, with the hind legs; speed and strength alike call for great length from the hip to the hock, and as little as possible from the hock to the foot; the haunches or gaskins should be wide and well furnished with muscle. A flat-sided hound should be drafted at once, as he is sure to be a bad winded one; so should one that stands over at the knee when looked at sideways. How to combine all the good points in one hound requires no little judgment, but appearance is not all that must be thought of; the breeder must have an eye to nose, pace, stoutness, and the avoidance of certain faults in the field. In order to produce a good-looking puppy, dams and sires, perfect enough as regards make and shape, are often selected before they have taken the field long enough to have their good or bad points developed. Three years is quite early enough to begin to breed from any hound, male or female, and by that time it will be pretty well known what are the hunting capabilities of each. Out of every litter of whelps it may be necessary to destroy some,—four or five are quite enough for a mother to rear,—but a diversity of opinion exists amongst huntsmen as to which should be kept. As the points of a very young puppy cannot be seen, the selection is really one of colour; some men prefer light colours, others dark; the majority are in favour of the latter, light-coloured hounds and horses being popularly supposed to have weak constitutions and uncertain tempers.

When the puppies are three or four days old the dew-claws should be severed with a small and sharp pair of scissors, and after another day or two it is usual to cut off about an inch of the tail. Rounding is the last operation that foxhounds are subjected to, and generally takes place as soon as the puppy has quite recovered from the distemper; it consists in cutting off the ends of the ears so that they may not be torn in going through cover. When about ten or twelve weeks old puppies are sent out to walk, and are not again received at the kennel till the beginning of the following April, soon after which date the distemper may be looked for. At this crisis the great aim should be to keep the body in a healthy condition, and not to feed hounds too highly, whey and porridge only being given. After the return from walks, the huntsman and whips should give the young entry plenty of gentle exercise, at first in the couples; and nothing more need be done in the way of training until about eight or nine weeks before cubbing begins, when the young hounds, who should hitherto have been exercised by themselves, should be put into the company of some older ones, and the exercise should be gradually extended until they can keep up for 2 or 3 miles with a horse going at half speed. The first day or two of cub-hunting is certain to be a somewhat unsatisfactory performance; the young entry are sure to run riot; it cannot be helped at first, but they will soon learn better manners under the watchful eyes of the huntsman and whips, and in company of the old hounds, about a dozen of the latter being taken out with twice that number of young ones. The sooner the puppies taste blood the better; it will help to teach them to stick to their proper game. Huntsmen therefore make every effort to bring a brace of cubs to hand the first day they go out, but this thirst after blood should not be indulged to any great extent afterwards, or the stock of foxes in the country may be much impaired, and sport thereby diminished. There is perhaps nothing connected with hunting of more importance, and, it may be added, of greater interest, than good kennel management. First of all it is shown in the formation of a level pack; for where things are done properly it is not enough to get together a lot of hounds that are good in themselves, they must also be, as nearly as possible, of one size. Then again, they must all be equally fast—to use a common expression, a sheet should cover them when running. Lastly, they must be free from certain faults, such as muteness, babbling, and skirting. A mute hound is a terrible nuisance. A fox is found and goes away unperceived; some time afterwards news is brought to the huntsman that a single hound has been seen running hard a mile from cover. This is our mute friend, which got on to the line by himself and gave no notice to anybody. But a young hound that is reticent with his tongue should not be too hastily set down as mute; he may have been flogged for proclaiming a scent, under the mistaken idea that he was running riot, and if so it would have the effect of checking his music. "Babbling" consists in a hound being too free with his tongue: after a fox has been found, the babbler announces the fact for the next ten minutes, and repeats his refrain whenever the least opportunity presents itself. A hound may give tongue too much without being an absolute babbler, but a noisy hound is pretty sure to become a babbler, and when he is so he should be drafted at once. A "skirter" is a hound that will not run with the pack, but is always taking a line of his own; like the babbler he should have every chance, but, if gentle as well as severe measures fail in effecting a reclamation, he too must be sent away. It goes without saying that where good kennel management exists, the hounds will be well disciplined, both in and out of the kennel. To the uninitiated, a visit to the kennel at feeding time is an interesting sight, notwithstanding the somewhat pungent smell of pudding and boiled horse. The hounds, as hungry as the proverbial hunter, stand anxiously awaiting the order to fall to, yet not daring to move until the order is given; and when the huntsman thinks a hound has eaten sufficient, the mere calling out of his name is sufficient to make him return to the benches, in spite of a desire for a more prolonged stay at the trough. An extraordinary instance of discipline in the field is related by Colonel Cook in his work *Observations on Fox-hunting*, p. 202. With hounds as with horses, control over them will be best obtained by kindness: the popular idea is that huntsmen, whips, and feeders never set about their respective duties unless armed with a formidable whip to be used on all possible occasions; but happily this is an entire mistake.

Feeding of hounds. The feeding of a pack of hounds is a matter calling for the exercise of great care and judgment, and cannot be properly carried out unless the establishment enjoy the services of a thoroughly trustworthy feeder. His duty is to cook the food, and to keep the utensils clean and the kennel sweet and wholesome. Hounds' food comprises both animal and vegetable substances. Objections have sometimes been made to admitting the former into the kennel fare at all, on the ground that it is likely to impair the powers of scent, but the exception does not seem to be well-founded, because wild dogs, as also wolves and foxes, are carnivorous animals and live by the use of their scenting powers; in moderation flesh is a necessity. Wheatmeal and barleymeal are eschewed, coarse oatmeal a twelvemonth old being the only thing fit to feed hounds with. The meal is boiled in a large iron boiler (a smaller one of the same metal being reserved for boiling the flesh), and during the cooking the feeder must be on the watch lest any of it stick to the bottom of the boiler. When sufficiently cooked it is turned out into coolers. On meat being given it is cut into small pieces and stirred into the pudding. In the summer young cabbages, given once every four days, form a wholesome food, and are vastly superior to potatoes, swedes, or any other root. With proper diet, an occasional alterative, and plenty of exercise, hounds should seldom or never require to be plastered over with ointment in consequence of skin irritations. The benches should be littered with good dry wheat-straw, which should be taken out of the kennel and shaken up every morning when the hounds are at exercise. Great cleanliness is indispensable; the natural odour of a kennel is none of the sweetest, and if hounds are kept in the midst of dirt their powers of scent will speedily deteriorate.

Harriers. The harrier like the foxhound is a very different animal from what he was one hundred years ago. Then there were several sorts used in hare-hunting; first came the old southern hound, used principally in heavy countries; the second variety was a somewhat faster dog, with a sharp nose and pointed ears, and was best adapted for an open country; thirdly, a rougher-coated hound; and lastly, the old fashioned blue mottled harrier, found in the Weald of Sussex and some parts of Kent. The first and last of the above list are said to have been endowed with wonderful scenting powers, and we are told that when these hounds were in use a run of six hours after a hare was no uncommon occurrence; but they were so slow that the same authority tells us that they fatigued "the healthy foot-man very little." It is probable that the Sussex blue mottled hound was the result of the first attempt to improve the old southern hound, and to obtain a species particularly suitable for hare-hunting, but since then almost all the traces of the old harrier have disappeared, until at the present time the modern harrier is little more than a dwarf foxhound. When pursued by the old-fashioned harrier, the hare had time to indulge in all those wiles in which our forefathers delighted, and of which they wrote at length in the hunting treatises of their time; but with the taste of the day in favour of pace, and with the modern harrier, the "curious and lasting sport" of old has been put an end to, and now the hare must, if the scent be moderately good, simply get away as far and as fast as possible. The late Sir John Dashwood King, of West Wycombe Park, Bucks, is said to have been the breeder to whom the sportsman is indebted for the present race of harriers. His pack did not exceed 18 inches in height. The parent stock was a small foxhound from the duke of Grafton's kennel, named Tyrant, whose blood, form, and character were apparent throughout; and so highly was the pack thought of that Lord Sondes, of Rockingham Castle, gave 700 guineas for it.

Beagle. The beagle (see Dog) is used in hunting the hare, but from its diminutive size it is not possessed of great pace; it is therefore generally followed on foot, but it is a good plan to have one person on horseback, in order that the pack may be stopped if they get away from the field and make for a cover.

Otter hound. The real otter hound bears a strong resemblance to the old southern hound. The head is heavier than that of the foxhound, and the eyes are deeply set as in a blood hound. The coat is rough and somewhat wiry, but it should be thick. The otter hound is not very common, foxhounds being often used for otter hunting; but the Carlisle pack is of the true breed.

The remarks already made on kennel management apply, for the most part, in the cases of hounds other than foxhounds; all varieties need the same cleanliness and attention. The different game for which the hounds are entered of course necessitate some trivial adaptation from the course pursued in foxhound kennels, but speaking generally the management is the same. (E. D. B.)

HOUNSLOW, a township, formerly a market-town, in the parishes of Isleworth and Heston, county of Middlesex, England, is situated on the great western coach road, and on a branch of the London and South-Western Railway, 9 miles from Hyde Park Corner. In the Domesday survey Hounslow is mentioned as *Honeslowe* and *Hundeslawe*. It consists chiefly of one street about a mile in length. In the 17th century it numbered about 120 houses, principally alehouses and inns. Previous to the opening of the railway nearly 500 coaches passed through the town daily. Of late years it has considerably recovered from the depression caused by the opening of the railway, and a number of fine villas have been erected in the neighbourhood. A priory of friars of the Holy Trinity was founded at Hounslow in 1296, and existed till the dissolution of the monasteries. The priory chapel was used as a church till 1830, when it was demolished, and the present church in the later style of English architecture erected. Another church in the Early English style was erected in 1874, and a town-hall in 1857. The surrounding country is flat and uninteresting, and to the west of the town there was at one time an extensive heath, which, according to the survey of 1546, had an area of 4293 acres. It is the site of Roman and old British camps, and in later history was the scene of several important military rendezvous. For many years the heath was a favourite resort of highwaymen, the carcases of whom used to be exposed on gibbets along the road. According to an Act passed in the 53d of George III., the heath has been enclosed, and it is now nearly all cultivated. In 1793 large cavalry barracks were erected upon it, and it also affords a site of extensive powder-mills. The population of the township in 1861 was 5760, and in 1871 it had increased to 9294.

HOUSE-FLY. Although extremely abundant in individual representatives, by habit specially attached to mankind, of widely extended range (North American and Abyssinian exponents are absolutely identical with European), familiar from the earliest times, engrafted upon the literature of all nations by proverbial and poetical allusions, and of later years affording material for much scientific microscopical investigation,—the dipterous species known to naturalists as *Musca domestica* apparently has two peculiarities opposed to these premises:—one, that its lack of salient external features would puzzle any but a profound dipterologist to define its specific attributes with absolute certainty; the other, that its earlier life history and transformations remained practically unknown (at all events to ordinary readers) up to the year 1873. It is scarcely within the province of this work to diagnose species; the instincts of the majority of readers will probably direct them at once to the right insect, which may be roughly described as a quarter of an inch long, black, hairy, with a reddish oval vertical spot and golden orbits, three grey longitudinal bands on the thorax, an interrupted yellowish band at the base of the abdomen, which has lateral and apical golden spots, and the base of the wings yellowish-white. But not only allied species are liable to be confused with the house-fly; representatives of other genera, such as *Anthomyia*, *Tachina*, and *Stomoxys*, are often mistaken for it, and a puncture from the sharp beak of the latter fly has often caused a wrong charge of blood-sucking to be brought against the subject of this notice, which has a short fleshy bilobed tongue incapable of penetrating the skin, though provided with a terminal framework of tracheal tubes, acting like a rasp, by using which it often annoys us in the heat of summer. As regards the second point, Linnæus, who first named the fly, left its transformations undescribed; De Geer in 1776, and Bouché in 1834, described the larva and pupa, and correctly defined their habitat; but it has been reserved for Dr A. S. Packard, jun., the well-known American entomologist and biologist, to make a thorough investigation of their whole economy, which he has published in the *Proceedings of the Boston Society of Natural History*, vol. xvi. (for 1873–74), pp. 136–150, pl. iii.

The minute dull chalky white eggs (usually about 120 in number), elongate oval and cylindrical in shape, are laid by the parent fly in crevices of fresh manure in or about stables,—heat, and especially moisture, being required for their development. The larvæ are hatched in twenty-four hours, and pass through three stages, averaging from five to seven days in all; in the second of its stages, the larva has been observed to increase by one-third of its length in twenty-four hours. They resemble those of the well-known meat fly, *Calliphora vomitoria*, but are smaller, longer, more slender, transparent, smooth, and shining, and regularly conical. The prop-leg at the apex is also much smaller, and cannot be seen from above when the larva is in motion. They eat the decaying parts of the manure, leaving the bits of hay and straw. The puparium, or pupa-case, is a quarter of an inch long, cylindrical, and dark brown, closely resembling that of *Stomoxys calcitrans*, from which it chiefly differs in the larger and squarer anal spiracles and the smoother apex. The enclosed pupa is of the usual type of the cyclorhaphous *Diptera*, and is readily distinguishable from that of *Stomoxys* by its broad spatulate labium and curved maxillary palpi; it rests in the case with the hard framework of the jaws of the old larva skin next the ventral side; and when the fly pushes its way out, after remaining from five to seven days as a pupa, the upper end of the case splits off just behind the suture between the thorax and abdomen. The term "pupa" is here used in a general sense, since intermediate stages of development (variously called "pseudo-nymph" or "semi-pupa") in that condition occur in the *Muscidæ*, as in *Hymenoptera*, *Coleoptera*, &c.

On leaving the pupa-case, the fly runs about with its wings soft, small, and baggy, pressed to the side of the body, much as in the pupa. It is pale, with the colours not set, and the membranous portion of its forehead constantly distends with air as the fly moves, being connected with the tracheæ. From Mr Lowne's observations on the anatomy of the blow-fly, this organ is evidently employed for pushing away the end of the puparium when the pupa slips out of its case.

The whole period of evolution being thus from ten to fourteen days only, and the number of eggs laid by each female fly so numerous, it will be readily seen that any slight personal inconvenience to man, as produced by the habits of the perfect insect, are much more than compensated for by the unceasing labours of its larvæ as scavengers; the benefit being the more direct as the work is invariably done close to human habitations. The workings of the law of nature, by which an excess of increase in any one species is checked, are conspicuously shown in the case of this insect. Not only do the ordinary parasites of its own class (some Hymenopterous, and in one recorded instance Coleopterous) attack it in its earlier stages, but certain common birds are particularly addicted to it in the perfect state (in which also a *Chelifer*, a minute European representative of the scorpions, has also been found parasitically attached to it). The vegetable world also supplies some lethal agents in the shape of fungi (notably *Empusa muscæ*), individuals destroyed by which are constantly to be seen in autumn unable to move, and distended or ruptured by the expansion of the internal growth, the white spores of which are finally to be observed scattered round their victim.

Trivial as the house-fly may appear even to entomologists, it is to be noted that recent observations by the German biologist Weissman on its development have resulted in his discovery of its possessing "imaginal discs" in the early larval state—a structure deemed of sufficient value to suggest a new division of the whole *Insecta* into "Discota" and "Adiscota."

HOUSELEEK, *Sempervivum*, a genus of ornamental evergreen plants belonging to the natural order *Crassulaceæ*. About 30 species are known in gardens, some of which are hardy perennial herbs, and grow well in dry or rocky situations; the others are evergreen shrubs or undershrubs, fit only for cultivation in the greenhouse or conservatory. The genus *Sempervivum* is distinguished from the nearly allied *Sedum* by having about 12 petals, and by the glands at the base of the ovary being laciniated if present. The common houseleek, *S. tectorum*, L. (Germ. *Hauswurzel*; Fr. *Joubarbe*), is often met with in Britain on roofs of outhouses and wall tops, but is not a native. Originally it was indigenous in the Alps, but it is now widely dispersed in Europe, and has been introduced into America. The leaves are thick, fleshy, and succulent, and are arranged in the form of a rosette lying close to the soil. The plant propagates itself by offsets on all sides, so that it forms after a time a dense cushion or aggregation of rosettes. The flowering stem, which is of rather rare occurrence, is about a foot high, reddish, cylindrical, and succulent, and terminates in a level-topped cyme, reflexed at the circumference, of reddish flowers, which bloom from June to September. The houseleek has been known variously as the Houselick, Homewort, Great Houseleek, *Sedum majus*, and *Crassula major altera*, *Sedum acre*, L., being styled the Least Houseleek. In Germany it is sometimes called *Donnerkraut*, from being supposed to protect the house on which it grows from thunder. The leaves are said to contain malic acid in considerable quantity, and are reckoned by herbalists to possess cooling and astringent properties. The leaves, freshly bruised, are applied to hæmorrhoids, boils, wens, and corns, and the expressed juice is used as a remedy for inflammation of the eyes and freckles, and especially for thrush (aphthæ) in children, also for stings and burns, erysipelas and herpes. Internally houseleek is used as a cooling remedy in dysentery and fluxes. The young leaves have also been eaten as salad, like *Portulacca*. *S. glutinosum*, Ait., and *S. balsamiferum*, Webb, natives respectively of Madeira and the Canary Islands, contain a very viscous substance in large quantity, and are used for the preparation of bird-lime; fishermen in Madeira, after dipping their nets in an alkaline solution, rub them with this substance, rendering them as tough as leather. *S. montanum*, L., indigenous in Central Europe, according to Gmelin, causes violent purging; *S. arboreum*, L., τὸ μέγα ἀείζωον of Dioscorides, is employed in Cyprus, the East, and northern Africa as an external remedy for malignant ulcers, inflammations, and burns, and internally for mucous discharges.

See Britten and Holland, *Dictionary of Plant Names*, pp. 265–271; Fristedt, *Joannis Franckenii Botanologia*, p. 60; Rosenthal, *Plantarum Diaphoricarum*, p. 576.

HOUSSA, Housa, Haussa, or Hausa, an important people of the western Soudan, forming a main element in the population of the country between 12° and 13° N. lat., from the Niger in the south-west to Bornu in the east. By Barth they are identified with the Atarantians of Herodotus; and it is certain that at a comparatively early date they attained great political power. The seven original states of Biram, Daura, Gobir, Kano, Rano, Katsena, and Zegzeg, formed a great confederation or empire, which extended its authority over many of the neighbouring countries, and retained its pre-eminence till the beginning of the 19th century, when the Pullo (Fellata or Fulbe) rose upon its ruins. Physically the Houssa may be considered as the most typical of all the negro peoples: they are strongly and somewhat heavily built, and even where there has been a considerable intermixture of Barber or Pullo blood, their racial persistence is very marked. In intellectual qualities they hold the very foremost rank among the negroes; they are excellent agriculturists, and, almost unaided by foreign influence, they have developed a variety of industries, such as the making of cloth, mats, leather, and glass, as well as a very extensive trade. In Sierra Leone and the Gold Coast territory the Houssa form the backbone of the military police, and under Captain Glover, who was the first to enrol them under the British flag, they did good service in the Ashantee campaigns.

The Houssa or Afnu language ranks as one of the richest and most cultivated in Africa; and it is not only the dominant vernacular throughout a large part of the Soudan, but serves as the means of communication in a great many places throughout the region to the south and west of the Lower Niger. At Idda, says Bishop Crowther (*Proc. Roy. Geog. Soc.*, 1877), we found Houssa becoming more generally spoken by the inhabitants, and at Igbegbi it is one of the prevailing languages of the mixed population of that town. From Lagos, Badagry, and Porto Novo, and upwards to the Niger, wherever Mahometans are found, Houssa is spoken by them; through it the Koran is explained in the mosques throughout Yoruba. According to Dr Baikie (*Observations on the Hausa and Fulfulde*, printed for private circulation, Lond. 1861) there are two master dialects—the Daura or eastern, and the Gobir or western. Of these the latter is the more original, the other the more refined. The Katsena form is very pure, and closely resembles the Gobir; that of Kano is extremely corrupt, though not so much so as that of Zariya or Zozari. As an example of the richness of the vocabulary, Dr Crowther mentions that there are eight names for different parts of the day from cockcrow till after sunset.

See El Hage Abd Salam Shabeeny, *Account of Timbuctoo and Haussa Territories*, 1820; Norris, *Dialogues and part of the New Testament in the English, Arabic, Haussa, and Bornu languages*, 1853; Koelle, *Polyglotta Africana*, 1854; Barth, *Travels in North and Central Africa*, vol. ii., London, 1857, and *Central-Afrikanische Vokabularien*, Gotha, 1862 and 1866; Schön, *Grammar of the Hausa Language*, London, 1862; Id., *Hausa Reading Book*, 1877; and Id., *A Dictionary of the Hausa Language*, 1877. Schön has also produced Houssa translations of Gen. (1858), Matt. (1857), and Luke (1858).

HOUSTON, a city of the United States, capital of Harris county, Texas, and the next city in the State to Galveston as regards both population and commercial enterprise, is situated on the left bank of Buffalo bayou at the head of navigation, and at the junction of several railways, 50 miles north-west of Galveston. The bayou is crossed at Houston by several bridges. Most of the streets are shaded by fine avenues of trees, and the principal of them are traversed by tramway cars. The chief buildings are the city-hall and market-house, completed in 1874, at a cost of 400,000 dollars, the masonic temple of the grand lodge of Texas, and the hotels, the largest of which is the finest in the State. The city is well supplied with schools and churches, and has two large public libraries. It is the principal railway centre of the State, and the depôt of an extensive and rich agricultural region, besides being the seat of important and varied manufactures. The recent deepening of the bayou so as to make it navigable for vessels drawing 9 feet of water has considerably increased the shipping trade, which is chiefly in lumber. The town possesses iron and brass founderies, railway machine shops, planing-mills, factories for cars, waggons, and agricultural implements, sheet-iron and tin works, a large flour-mill, beef-packing establishments, and manufactures of cotton, soap, Portland cement, and bone dust. In the neighbourhood there are extensive nurseries. The annual fair of the State of Texas is held at Houston. The city, which was named after Samuel Houston, noticed below, was settled in 1836, and in 1837 it was for a short time the capital of the State. In 1870 the population was 9382, and in 1880 it had increased to 17,000.

HOUSTON, Samuel (1793–1863), an American general and statesman, was born near Lexington, Virginia, 2d March 1793. On the death of his father, a soldier of the revolution, in 1807, he removed with his mother to the frontier, and settling in Blount county, Tennessee, was soon on familiar terms with the Cherokee Indians. For a while he acted as clerk to a trader, and then as village schoolmaster; but in 1813, after a residence of nearly three years among the Indians, he joined the United States army. He served with Jackson in the war against Great Britain, and at the peace of 1815 had risen from the ranks to a lieutenancy. Although conscious of his success, and proud of having won Jackson's friendship by his bravery, he then resigned his commission and turned to the study and practice of law at Nashville. In 1823 Tennessee returned him to congress, and four years later he was elected governor of the State. He married in January 1829, and in the April following, without assigning any reason, he suddenly abandoned his home and his office, and took up his residence among the Cherokees, by whom he was formally adopted as a member of their nation. Returning to Washington, he successfully pleaded their cause against the Government agents who had wronged them. In 1832 he settled in Texas, and was soon after elected a member of the convention called for the purpose of framing a constitution for that State, then in difficulties with the Mexican Government. On March 2, 1836, Texas declared its independence, and, on the 2d of April following, won it on the field of San Jacinto, where Houston, who had been appointed commander-in-chief of the Texas forces, with a body of 783 raw troops, defeated 1600 Mexican veterans led by Santa Anna. On the recognition of the independence of Texas, Houston was elected president of the new republic, and re-elected in 1841; and, when Texas was admitted to the Union in 1845, he was returned as one of its two representatives to the senate. There he distinguished himself as a zealous friend of the Indians, opposing the Kansas and Nebraska bill in a memorable speech (3d March 1854), and voting against the Lecompton constitution of Kansas. His decided opposition to secession obliged him in 1861 to retire from the office of governor of Texas, which he had held from 1859. He died at Huntersville, Texas, 25th July 1863. The hero of San Jacinto was above all things an able soldier, wary, intrepid, and resolute; but he also possessed as a legislator the qualities of rare foresight, cool discrimination, and fearless candour.

See his *Life* (New York, 1855), his *Letters to the People* (1856), and S. L. Knapp's *History of America* (New York, 1875).

HOUWAERT, JEAN BAPTISTA (1533-1599), Flemish poet, was the most prominent of the rhetoricians of his day. He held the title of "Counsellor and Master in Ordinary of the Exchequer to the Dukedom of Brabant." As a patriot and a friend of the prince of Orange he played a prominent part in the revolution of the Low Countries against Spain, and when the prince entered Brussels victoriously, September 23, 1577, Houwaert met him in pomp at the head of the two chambers of rhetoric, the "Book" and the "Garland of Mary." He died at Brussels, March 11, 1599.

His existing works are of an allegorical and highly fantastic order, and prove him to have been a disciple of Matthys de Castelyn. He wrote the *Commerce of Amorosity* (Den Handel der Amourenskeyt), consisting of four plays or moralities in verse, namely, *Æneas and Dido*, *Narcissus and Echo*, *Mars and Venus*, and *Leander and Hero*. His other principal poem is a didactic epic on the vanity of human love, *Pegasides Pleyn, of den Lusthof der Maechden*. These and other laborious and exemplary pieces gained him the title of the "Homer of Brabant" from his contemporaries. Houwaert prided himself on the introduction of classical and mythological names into his poems, but he had little or nothing of the antique spirit.

HOVEDON, ROGER OF, an old English chronicler, was in all probability born at Howden, in the East Riding of Yorkshire, and was possibly a member of a family which had taken its name from the place. The date neither of his birth nor his death is known, and the first notice we have of him is as being sent in 1174 by Henry II., on whom he was in attendance in France, to endeavour to induce the lords of Galloway to withdraw from their allegiance to the king of Scotland. He appears to have been recommended to the notice of Henry from his knowledge of law, and to have occupied a place in his household. It has been conjectured, but without much evidence, that he was a student of Oxford; and the ascription to him of a volume of lectures is also without ground to support it. From the interest manifested in his history regarding the dispute between Archbishop Roger of York and Bishop Hugh of Durham in regard to synodal fees, it has been supposed that he himself held for some time the living of Howden, but this is likewise wholly devoid of direct corroboration. In 1175 he was employed by Henry in the delicate mission of inducing the monastic houses to send deputations to Woodstock for the purpose of choosing their rulers. In 1189, the last year of Henry's reign, he was appointed a justice itinerant for the forests in Northumberland, Cumberland, and Yorkshire; and it is probable that after Henry's death he retired to Howden, since from the number of his references to Yorkshire disputes it is evident that he must have been living in that county during the time that he compiled the latter portion of his Chronicle. As the Chronicle closes abruptly in 1201, it is probable that he did not live long beyond that date.

The work of Roger of Hovedon, which commences with the close of the Chronicle of Bede in 732, is divided by Professor Stubbs into four parts:—the 1st ending with 1148, and consisting chiefly of the *Historia post Bedam*, with a few alterations and additions; the 2d ending with 1169, based principally on the *Melrose Chronicle*, and from 1163 composed mainly of the A Beckett letters contained in the collection made by John of Salisbury and Alan of Tewkesbury; the 3d ending with 1192, and virtually a condensation of Benedict's Chronicle, with the occasional addition of unimportant details and several variations, many of which are inaccurate and of such a kind as to show that he wrote from memory; the 4th ending in 1201, and evidently a narrative of contemporary events. The work of Roger of Hovedon was cited in 1291 by Edward I., when claiming the lordship of Scotland, as one of the authorities in regard to the homage done by the earlier kings to his ancestors. The independent value of the work belongs almost wholly to the last portion, although various documents of interest to be found nowhere else are incorporated in the 2d and 3d portions.

The Chronicle was first printed in 1596 in Sir Henry Saville's collection of the *Scriptores post Bedam*, and was reprinted at Frankfort in 1601. A translation of it by H. F. Riley, B.A., appeared in 1852, and forms part of Bohn's Antiquarian Library; and it has been published in 4 vols., 1868-71, in the series of the Master of the Rolls, under the editorship of Professor Stubbs, whose preface contains an elaborate criticism of the work and a full account of the various MSS.

HOWARD, HENRY. See SURREY, EARL OF.

HOWARD, JOHN (1726-1790), "the philanthropist," was born in 1726, most probably on September 2, and at Enfield, where his father, a moderately wealthy retired London merchant, had a country house. His childhood was spent at Cardington near Woburn, Bedfordshire, where his father had a small estate; for seven years he was under the tuition of the Rev. John Worsley of Hertford (author of a Latin grammar and of a new translation of the New Testament); and he was afterwards placed for a short time at a private academy in London under Mr John Eames, F.R.S. At the close of a very imperfect school education he was apprenticed by his father at a considerable premium to a firm of grocers in the city; but on the death of the elder Howard in September 1742, by which he inherited considerable property, he bought up his indenture and devoted more than a year to foreign travel, during which he acquired some knowledge of French. Never constitutionally strong, he on his return to England settled in lodgings at Stoke Newington as a confirmed valetudinarian, his days being spent for the most part in hypochondriac idleness (for little importance can be attached to what have sometimes been called his studies in medicine and meteorology). Having been nursed through an acute illness by an attentive landlady, a widow of some fifty-three years of age, he felt that he could offer no adequate return short of marriage for her motherly kindness, and they were united accordingly in 1752. Left a widower in less than three years, Howard broke up his establishment at Stoke Newington in 1755, and resolved to go abroad, the recent occurrence of the earthquake at Lisbon attracting him to Portugal. The ship, however, in which he sailed was so unfortunate as to be taken by a French privateer, by whom both crew and passengers were carried to Brest, where they were treated with great harshness and almost starved. At Morlaix and at Carhaix Howard had further opportunities of observing the treatment to which prisoners of war were usually at that time subjected; and when permitted on parole to return to England to negotiate an exchange for himself, he not only accomplished his personal object, but also successfully represented the case of those who had been his fellow-captives. Abandoning for the time his Lisbon scheme, he now retired to his property at Cardington, where he continued to interest himself in meteorological observation, for some slight notes on which he obtained publication in the *Transactions* of the Royal Society, of which he had been admitted a member in 1756. After his marriage (April 1758) to Henrietta, eldest daughter of Edward Leeds of Croxton, Cambridgeshire, he continued to live a secluded life, partly at Cardington and partly on another property which he had purchased at Watcombe, Hampshire. In both places he distinguished himself as a kind landlord, and at Cardington especially he displayed a highly enlightened philanthropy in his efforts to raise the condition of the poor by the construction of model cottages and by the erection of schools. In March 1765 his home was again desolated by the sudden and unexpected death of his wife, a few days after she had given birth to a son, her first and only child; and soon Howard's drooping health and spirits imperatively demanded a change of air and scene. After visiting Bath and London, he in the spring of 1768 crossed to Holland; and another brief stay at Cardington was followed by a prolonged tour in France, Switzerland, and Italy as far as to Naples, whence he returned in 1770 by Germany and the Rhine. Having resumed his former course of life at Cardington, he was in 1773 named high sheriff of Bedford, an office which, although as a nonconformist he was unable to take the usual tests, he resolved to accept. The characteristic work of his life may be said to have now begun. When the assizes were held he did not content himself with sitting out the trials in open court; his inquisitiveness and his benevolence alike impelled him to visit the jail to which the prisoners had been condemned. Howard found it, like all the prisons of the time, wretchedly defective in all its arrangements; but what chiefly astonished and shocked him was an almost incredible abuse arising out of the circumstance that neither the jailer nor his subordinates were salaried officers, but were dependent for their livelihood on fees which they rigorously exacted from the prisoners themselves. He found it to be a fact that some whom the juries had declared not guilty, others in whom the grand jury had not found even such appearance of guilt as would warrant a trial, others whose prosecutors had failed to appear, were frequently detained in prison for months after they had ceased to be in the position of accused parties, until they should have paid the fees of jail delivery. (See Introduction to *The State of the Prisons in England and Wales.*) His prompt application to the justices of the county for a salary to the jailer in lieu of his fees was met by a demand for a precedent for charging the county with such an expense. This he undertook to find if such a thing existed. He went accordingly from county to county until his journey had extended to every town in England which contained a prison, but the object of his search eluded inquiry. He could find no precedent for charging the county with the wages of its servants, but he did find so many abuses in prison management which imagination had never conceived, and so many sufferings of which the general public knew nothing, and of which the law took no account, that he determined to devote to the exposure of those wrongs and the reform of those abuses whatever time and money might be needful. The task cost him a fortune, and the best remaining years of his life. The subject of prison reform, indeed, had not previously been wholly absent from the public mind. As early as the year 1728 the House of Commons had appointed a committee to inquire into the state of Newgate, the Marshalsea, and other London prisons, where abuses had come to light which had caused the house to order the arrest of several governors of jails, who were tried for high misdemeanours (see *Reports of the Committee Appointed to Inquire into the State of the Gaols*, 1729). Much more recently Popham, member for Taunton, had forced the unwilling legislature at least to discuss the propriety of paying fixed salaries to jailers out of the county rates; but in February 1773 the bill after passing the second reading had been withdrawn with a view to its being again brought forward in an amended form. The way had thus been prepared for a friendly reception to anything Howard might have to say as the result of his investigations; and at the close of his first rapid survey of the English prisons he was, through the influence of the supporters of Popham's bill, cited to appear before a committee of the whole house in March 1774. After his report had been received and he himself examined upon it, it was moved and carried, on the house resuming, "that John Howard, Esq., be called to the bar, and that Mr Speaker do acquaint him that the House are very sensible of the humanity and zeal which have led him to visit the several jails of this kingdom, and to communicate to the house the interesting observations which he has made on that subject." Almost immediately an Act was passed which provided for the liberation, free of all charges, of every prisoner against whom the grand jury failed to find a true bill, giving the jailer a sum from the county rate in lieu of the abolished fees. This was followed in June by another requiring justices of the peace to see that the walls and ceilings of all prisons within their jurisdiction were scraped and whitewashed once a year at least; that the rooms were regularly cleaned and ventilated; that infirmaries were provided for the sick, and proper care taken to get them medical advice; that the naked should be clothed; that underground dungeons should be used as little as could be; and generally that such courses should be taken as would tend to restore and preserve the health of the prisoners. It was highly characteristic of the man that, having caused the provisions of the new legislation to be printed at his own private cost in large type, he sent a copy to every jailer and warder in the kingdom, determined that no one should be able to plead ignorance of the law if detected in the violation of its provisions. He then set out upon a new tour of inspection, from which, however, he was brought home by the approach of a general election in September 1774. Siding with those who objected to the American policy of the Government, he had consented to stand as one of the anti-ministerial candidates for Bedford; although, however, he was returned by a narrow majority along with his friend Whitbread, he was unseated after a scrutiny on account of the alleged disqualification of some of those voters who had supported him. He was thus left entirely free for the vigorous prosecution of the special task which he had assigned himself; and he began to have thoughts of publishing the immense mass of facts which he had so industriously collected, and which was still so rapidly accumulating. But after a tour which had extended to Scotland and Ireland, it occurred to him before going into print that his notes would be much enhanced in utility if supplemented with the regulations and arrangements of the more important Continental prisons. In April 1775, accordingly, he set out upon an extended tour through France, the Low Countries, and Germany. At Paris he was at first denied access to the prisons; but by recourse to an old and almost obsolete law of 1717, according to which any person wishing to distribute alms to the prisoners was to be admitted and allowed to dispense his charity with his own hand, he succeeded in inspecting the Bicêtre, the Force l'Évêque, and most of the other places of confinement, the only important exception being the Bastille. With regard to this last, however, he succeeded in obtaining possession of a suppressed pamphlet, which he afterwards translated and published in English, to the unconcealed chagrin of the French authorities. At Ghent he examined with special interest the great Maison de Force, then recently erected; its distinctive features—useful labour, in the profits of which the prisoners had a share, and complete separation of the inmates by night—drew from him the exclamation that it was a "noble institution." At Amsterdam, as in Holland generally, he was much struck with the comparative absence of crime, a phenomenon which he attributed to the industrial and reformatory treatment there adopted. In Germany he found little that was useful and much that was repulsive; in Hanover and Osnabrück, under the rule of a British sovereign, he even found traces of torture. Returning to England in autumn with his copious notes, he determined, before finally reducing them to order and sending them to press, to undertake another tour of England. This lasted for seven months (November 1775 to May 1776), and yielded results so important by way of correction and supplement that he resolved to give his Continental experience the benefit of a similar revision. On this occasion he extended his tour to several of the Swiss cantons. At last in 1777 appeared *The State of the Prisons in England and Wales, with Preliminary Observations, and an Account of some Foreign Prisons* (Warrington). It met with a very favourable reception, although its author was fully justified in his statement in the preface that as the journeys were not undertaken for the traveller's amusement, so the results of them were not published for general entertainment. It consists principally of a mass of minute statistical details, somewhat pedantically accumulated and very unmethodically arranged; its most important section

—that relating to "proposed improvements in the structure and management of prisons"—constituting less than a tenth part of the whole. One portion of his subject, indeed,—that relating to the ships used for transportation of convicts,—had been to some extent taken out of his hand by the passing in 1776 of the Act authorizing the hulk system; but even in this connexion the appearance of his work was highly opportune. Following within a few years the publication of Beccaria's work *On Crimes and Punishments*, it called public attention to the practical question of the treatment of criminals in a manner which compelled the adoption of remedial or at least of palliative measures, although the full difficulty and delicacy of the problem had not as yet been thoroughly appreciated. One of the most immediate results was that Sir W. Blackstone and Mr Eden were requested to draft a bill for the establishment of penitentiary houses, where by means of solitary imprisonment, accompanied by well-regulated labour and religious instruction, the object of reforming the criminal and inuring him to habits of industry might be successfully pursued. New buildings were manifestly necessary in order that the provisions of such an Act might be carried into effect; and as no one seemed to know how to set about their construction, Howard volunteered to go abroad again and collect plans and other information. On this errand (April 1778) he first went to Amsterdam, and carefully examined the "spin-houses" and "rasp-houses" for which that city was famous; next he traversed Prussia, Saxony, Bohemia, Austria, and Italy, everywhere inspecting prisons, hospitals, and work-houses, and carefully recording the merits and defects of each. In the course of this tour he was received with marked consideration and respect at more than one court; but the personal incident of greatest consequence was one which befel him on a voyage along the Tuscan coast. A sudden and violent storm had compelled the master of the small vessel in which he had taken a passage for Leghorn to seek the shelter of land; cold, wet, and exhausted, passengers and crew reached a little island harbour, but only to find that through fear of the plague (they having sailed from a port supposed to be infected) a landing was refused them. Driven back again upon the storm, they were carried by its violence to the coast of Algeria, where a similar experience was encountered, permission to enter the harbours there also being peremptorily denied. It was this occurrence which first directed Howard's attention to the subject which engrossed his attention in after years, and in the investigation of which he ultimately lost his life. Leghorn at last reached, he hastened northwards through Lombardy, France, and Flanders, arriving in England in 1779. The information he had obtained having been placed at the service of the House of Commons, a bill was introduced and passed for building two penitentiary houses in Middlesex, Surrey, Kent, or Essex (as might be afterwards determined), and Howard was appointed first supervisor (19 Geo. III. cap. 74). The scheme, however, did not proceed without friction too trying for his patience; and after much time had been lost in interminable discussions with his colleagues as to the sites of the proposed buildings, he in January 1781 wrote to Lord Bathurst resigning his post before anything practical had been achieved. In 1780 he had published a quarto volume of 220 pages as an appendix (the first) to his *State of Prisons*; about the same time also he caused to be printed his translation of the suppressed French pamphlet on the Bastille; but on obtaining release from his employments at home his passion for accumulating statistics urged him to new and more extended Continental tours, as far as to Denmark, Sweden, and Russia in 1781, and to Spain and Portugal in 1783. The results of these journeys (which were full of curious and romantic incidents) were embodied in 1784 in a second appendix, with the publication of which his direct labours in connexion with the subject of prison reform may be said to have ceased. The five remaining years of his life were chiefly devoted to researches on a different though cognate subject, that of the means which ought to be used for prevention of the plague, and for guarding against the propagation of contagious distempers in general. Having at the suggestion of his medical friends provided himself with a list of queries to be put to the physicians in attendance at the lazarettos he proposed to visit, he in November 1785 sailed for Holland, and thence travelling through France inspected the great lazaretto at Marseilles, though with considerable difficulty, owing to the unfriendliness of the authorities. He next passed through Florence, Rome, and Naples to Malta, whence he sailed by Zante to Smyrna, where his reputed medical skill opened all the prisons and hospitals to his inspection, and where he had ample opportunities of studying the plague in its most fatal form. He then went to Constantinople, where the fame of his skill had preceded him, and where some further fortunate practice greatly added to his prestige. Declining the hospitalities of the British ambassador, however, he devoted himself entirely to the care of the neglected poor, and persistently forced his way into infected caravanserais and pest-houses whither physician and dragoman alike declined to follow him. At length his researches seemed to be complete; and with a great accumulation of papers and memoranda, he was preparing to return homewards by Vienna, when it occurred to his scrupulous mind that he still lacked one essential qualification for practically dealing with the matter which he had taken in hand; he had not as yet had any personal experience of quarantine discipline. Altering his plans accordingly, he returned to Smyrna, and, deliberately choosing a foul ship, took a passage to Venice that he might there undergo the usual confinement. A protracted voyage of sixty days, during which an attack by pirates gave Howard an opportunity of manifesting in a new form that personal bravery which was one of his characteristics, was followed by a weary term of confinement which enabled him to gain, though at the cost of considerable hardship and suffering, the experience he had desired. While imprisoned in the Venetian lazaretto he received two pieces of intelligence which from very opposite causes gave him acute pain. One was the announcement of a proposal that a statue should be erected commemorative of his services in the cause of humanity; to Howard as "a private man with some peculiarities," desirous to retire into obscurity and silence, it presented itself as a "hasty and disagreeable measure," "a distressing affair." The other was the information that his only son, a youth of twenty-two years of age, after a course of flagrant misconduct, had lost his reason and had been put under restraint. Returning hastily by Trieste and Vienna (where he had a long and singular interview with the emperor Joseph II.), he reached England in February 1787. His first care related to his domestic concerns; after these had been put into such order as they admitted, he set out upon another journey of inspection of the prisons of the United Kingdom, at the same time busying himself in preparing for the press the results of his recent tour. The somewhat rambling work containing them was published in February 1789 at Warrington, under the title *An Account of the Principal Lazarettos in Europe: with various Papers relative to the Plague, together with further Observations on some Foreign Prisons and Hospitals, and additional Remarks on the present state of those in Great Britain and Ireland.* In the conclusion (p. 235) he committed with some solemnity the result of his past labours to his country, and announced his intention of again visiting Russia, Turkey, and some other countries, and of extending his tour in the East, adding these words, "I am not insensible of the dangers that must attend such a journey. Trusting, however, in the protection of that kind providence which has hitherto preserved me, I calmly and cheerfully commit myself to the disposal of unerring wisdom. Should it please God to cut off my life in the prosecution of this design, let not my conduct be uncandidly imputed to rashness or enthusiasm, but to a serious, deliberate conviction that I am pursuing the path of duty, and to a sincere desire of being made an instrument of more extensive usefulness to my fellow-creatures than could be expected in the narrower circle of a retired life." The execution of the purpose he had thus expressed was delayed for some time by the necessity for making special arrangements with regard to his private affairs in consequence of the confirmed insanity of his son; but early in July 1789 he finally embarked in what proved to be his last journey. Travelling overland from Amsterdam by Hanover, Berlin, Königsberg, and Riga to St Petersburg and Moscow, and so southwards, and visiting in passing the military hospitals that lay on his route, he reached Cherson in November. In the hospitals of this place and of the immediate neighbourhood he found more than enough to occupy his attention while he awaited the means of transit to Constantinople. Towards the end of the year his medical advice was asked in the case of a young lady who was suffering under the camp fever then prevalent, and in attending her he himself took the disease, which terminated fatally on January 20, 1790. "Give me no monument," he had said, "but lay me quietly in the earth; place a sundial over my grave, and let me be forgotten;" but a life like his had made such a burial even in a foreign land impossible, and his remains were followed, respectfully and sorrowfully, by many thousands to the grave, where they now lie near the village of Dauphigny on the road to St Nicolas. A statue by Bacon with a suitable inscription was afterwards erected to his memory in St Paul's, London.

In personal appearance Howard is described as having been short, thin, and sallow,—unprepossessing apart from the attraction of a penetrating eye and a benevolent smile. "There was an animation in his manner and a quickness in his gait which corresponded with the activity of his mental powers. In his address he was dignified, kind, and condescending, always adapting himself to the persons with whom he conversed; as free from a cringing servility amongst his superiors in station as he was from arrogancy towards those of lower rank" (Field). In point of intellectual ability he cannot be said to have been possessed of more than the ordinary endowments; nor had education done all that was possible for the development of those which he had. That he was of a deeply religious temperament is abundantly shown by the meagre remains we have of his letters and diaries; while the greater part of his life shows that his enthusiasm of humanity was the unusual yet normal outcome of the sincerest piety. His benevolent impulses were sustained by a rare degree of energy and determination, while they were guided by a remarkable delicacy of tact and an equally remarkable vigour of practical common sense. It would be idle to speculate how far Howard's work could have been done when it was, and as it was, by a man differently endowed. Doubtless the reforms which he inaugurated were reforms urgently called for by the spirit and enlightenment of his age; but this fact rather enhances than diminishes the imperishable glory which belongs to him of having been the foremost to give an articulate voice to that demand. "In the scale of moral desert the labours of the legislator and the writer are as far below his as earth is below heaven. His kingdom was of a better world; he died a martyr after living an apostle" (Bentham).

See *Anecdotes of the Life and Character of John Howard, written by a Gentleman* (1790); Aikin, *View of the Character and Public Services of the late John Howard*; *Memoirs*, by Baldwin Brown (1818), Taylor (1836), Hepworth Dixon (1849), Field (1850), and Stoughton (1853); and *Correspondence of John Howard, with brief Memoir and Anecdotes* (1855).

HOWE, JOHN (1630–1706), one of the greatest of the later Puritan divines, was born May 17, 1630, at Loughborough, Leicestershire, of which parish his father was minister. When hardly five years old he was removed to Ireland by his father, who, unable to support the ecclesiastical policy of Archbishop Laud, had been ejected from his living. On the outbreak of the Irish rebellion in 1641, the exiles returned to England; and, fixing his abode in Lancashire, the elder Howe conducted in person the studies of his son, who in his seventeenth year (May 19, 1647) entered Christ's College, Cambridge, as a sizar, and in the following year took his degree of B.A. During his residence in this university he made the acquaintance of Cudworth, More, and Smith, from intercourse with whom, doubtless, as Calamy suggests, as well as from direct acquaintance with the *Dialogues* themselves, his mind received that "Platonic tinge" which is so perceptible in his writings. Immediately after graduation at Cambridge, he removed to Oxford, where he took the same degree in the following year, and, after becoming a fellow of Magdalen College, proceeded M.A. in 1652. On leaving Oxford in that year he returned to his father's retreat in Lancashire, and received ordination at Winwick from the hands of Mr Herle, the minister of the parish, who was assisted by the ministers of the neighbouring chapelries. Sometime afterwards "an unexpected conduct of divine providence" bore him to Great Torrington in Devonshire, where he spent some years as pastor. It was there that he preached those discourses which at a later period took shape in his treatises on *The Blessedness of the Righteous* and on *Delighting in God*. There also it was that he married the daughter of "his inner friend" Mr George Hughes. In the beginning of 1657 a journey to London accidentally brought Howe under the notice of Cromwell, who, struck by his appearance and preaching, made him his domestic chaplain. In this prominent position, which he had accepted with very great reluctance, his conduct as the almoner and confidential adviser of the Protector was such as to win the praises of even the bitterest enemies of his party. Without overlooking the due claims of the Puritans, he omitted no opportunity of helping pious and learned men of other denominations, Ward (afterwards bishop of Exeter) and Thomas Fuller having been among the number of those who profited by Howe's kindness, and who were not ashamed subsequently to express their gratitude for it. On the deposition of Richard Cromwell, Howe returned to Great Torrington, where, like all who had played a conspicuous part under the Commonwealth, he soon after the Restoration found himself an object of suspicion and hatred; in 1662 the passing of the Act of Uniformity drove him from his parish. For several years he now led a wandering and uncertain life, preaching in secret as occasion offered to handfuls of trusted hearers. More than once his liberty was in imminent peril; and it is alleged by Calamy, though on doubtful grounds, that for two months in 1665 he was imprisoned in the Isle of St Nicholas in Plymouth Sound. Impelled by the demands of pressing want, he in 1668 published the treatise entitled *The Blessedness of the Righteous*; the reputation which he had acquired by it procured for him in 1669 an invitation from Lord Massarene of Antrim Castle, Ireland, to become his domestic chaplain. At Antrim, where he was soon joined by his family, he accordingly spent six years of quiet, during which he frequently preached in public, with the approval of the bishop of the diocese, and also found time to produce the most eloquent of his shorter treatises, *The Vanity of Man as Mortal*, and *On Delighting in God*; there too he planned the largest (and also in some respect the greatest) of his works, *The Living Temple*. In the beginning of 1676 he accepted an invitation to become pastor of a nonconformist congregation in Silver Street, London; and in the same year he published the first part of *The Living Temple*, entitled *Concerning God's Existence and His Conversableness with Man: Against Atheism or the Epicurean Deism*. In 1677 appeared his tractate *On the Reconcileableness of God's Prescience of the Sins of Men with the Wisdom and Sincerity of His Counsels, Exhortations, and whatsoever means He uses to prevent them*, which was attacked from various quarters, and had Andrew Marvel for one of its defenders. His work *On Thoughtfulness for the Morrow* followed in 1681; those on *Self-Dedication* and *Union among Protestants* in 1682; and that on *The Redeemer's Tears wept over Lost Souls* in 1684. During the earlier years that followed his settlement in London Howe had enjoyed comparative freedom from annoyance on the ground of his nonconformity, and had been on intimate terms with many who already were or who afterwards became eminent in the Established Church, such as Stillingfleet, Tillotson, Sharp, and Kidder; but the greater severity which began to be manifested in 1681, and which continued to be shown during the following years, so interfered with his liberty that in 1685 he gladly accepted the invitation of Philip Lord Wharton to travel abroad with him. The tour extended over the greater part of a year. In 1686, matters still seeming hopeless in England, he determined to settle for a time at Utrecht, where he officiated along with Mead and others in the English chapel, and also read privately with English students at the university. Among his friends there was Burnet, the future bishop of Salisbury, by whose influence he obtained several confidential interviews with the prince of Orange. In 1687 Howe availed himself of the publication by James II. of the declaration for liberty of conscience to return to England, and in the following year he headed the procession of nonconformist ministers who went to congratulate William on his accession to the English throne. The remainder of his life, so far as recorded, was extremely uneventful. In 1693 he published three admirable discourses *On the Carnality of Religious Contention*, suggested by the disputes and divisions that had so abundantly occurred among the nonconformists as soon as liberty of doctrine and worship had been granted. In 1694 and 1695 he published various treatises on the subject of the Trinity, the principal being *A Calm and Solemn Inquiry concerning the Possibility of a Trinity in the Godhead*. The second part of *The Living Temple*, entitled *Animadversions on Spinosa and a French Writer pretending to confute him, with a recapitulation of the former part and an account of the destitution and restitution of God's Temple among Men*, appeared in 1702. About this time he appears to have fallen into shattered health, but he was able in 1705 to give to the world a discourse *On Patience in the Expectation of Future Blessedness*, which proved to be his last work. He died in London on April 2, 1706.

Though excelled by Baxter as a pulpit orator, and by Owen in exegetical ingenuity and in almost every department of theological learning, Howe compares favourably with either as a sagacious and profound thinker, while he was much more successful in combining religious earnestness and fervour of conviction with large-hearted tolerance and cultured breadth of view. His style, moreover, though not altogether free from the literary faults which may almost be called characteristic of Puritanism, has often a stately yet graceful flow which the modern reader will look for in vain in most of Howe's theological contemporaries. The works published in his life-time, including a number of sermons and other occasional pieces besides those specified above, were collected into 2 vols. fol. in 1724, and again reprinted in 3 vols. 8vo. in 1848. A complete edition of the *Whole Works*, including much posthumous and additional matter, appeared with a Memoir in 8 vols. in 1822; this was reprinted in 1 vol. in 1838. The *Memoirs* of Howe by Calamy, originally published in 1724, have been more than once reprinted, and form the basis of *The Life and Character of Howe, with an Analysis of his Writings*, by Henry Rogers (1836; new ed., 1863).

HOWE, Richard Howe, Earl (1725-1799), English admiral, was born in 1725. By his father Emanuel Scrope Howe, second Viscount Howe in the Irish peerage, he was descended from an old family, several members of which attained distinction in war or in politics; and his mother was the daughter of Baron Kielmansegge, master of the horse to George I. when elector of Hanover. Leaving Eton at the age of fourteen, Howe entered the navy as midshipman on board the "Severn," which then formed one of a squadron under Anson destined for an expedition against Spain in the Pacific. Nothing is recorded as to the manner in which he conducted himself in the actions in which the squadron engaged, but he at any rate succeeded in winning the approval of his commander, and in his twentieth year was made lieutenant. Shortly after this he was appointed to the command of a sloop-of-war, the "Baltimore," in which with the aid of the "Greyhound" frigate, commanded by Captain Noel, he signalized himself by defeating off the coast of Scotland two French vessels, of greatly superior metal to his own, which were carrying supplies and reinforcements to the Pretender. On his arrival in England he found that previous to this action he had been raised to the rank of post-captain, and he served in this capacity on the coast of Guinea and on the Jamaica station. In 1748 he returned to England, and after spending three years chiefly in the study of naval tactics, he was in 1751 appointed to the "Glory," of 44 guns, and employed on the coast of Africa. In May 1752 he was commissioned to the "Dolphin" frigate, in which he was employed for some years in protecting the trade in the vicinity of Gibraltar. Shortly after his return to England he was appointed in 1755 to the "Dunkirk," and joined the squadron of Admiral Boscawen, bound for America. In the course of the voyage thither Howe took a prominent part in capturing two French men-of-war, the "Alcide" and the "Lys." This action was virtually the commencement of the seven years' war with France, in the course of which Howe in command of a small squadron succeeded in capturing from the French the island of Chaussé, and, after obtaining a commission to the "Magnanime," distinguished himself in the attacks made on the Isle of Aix, St Malo, and Cherbourg, manifested conspicuous courage and readiness of resource at the disaster of St Cas, and in the action with the French fleet under De Conflans disabled two of the enemy's ships. Shortly before the close of the war Howe had married, and by the death of his brother Viscount Howe had inherited the family titles and estates. From 1758 till 1782 he represented Dartmouth in parliament; in the latter year he was raised to the British peerage as Viscount Howe. In 1763 he received a seat at the board of admiralty, and in June 1765 he was appointed to the important office of treasurer of the navy, which he retained till August 1770. In October of this latter year he was made rear-admiral of the blue, and nominated commander in chief of the fleet intended to be employed in the Mediterranean in view of a probable rupture with Spain, which, however, did not take place. In 1775 he was promoted rear-admiral of the white, and in the following year he received the command of the squadron despatched to America, but owing to the insufficiency of his force he achieved no exploit of importance. After his return to England he was in September 1782 appointed to the command of the Channel fleet, and ordered to proceed to the relief of Gibraltar, then besieged by the combined land and sea forces of France and Spain, when after succeeding in supplying the garrison with stores and provisions he engaged at long ranges the united fleet which numbered 44 sail to his 34, and caused them to retreat to Cadiz. In January 1783 Howe succeeded Keppel as first lord of the admiralty, an office which he resigned in the following April, but again accepted under the Pitt ministry, holding it till July 1788. In July 1787 he was made admiral of the white, and shortly afterwards was raised to an earldom. In 1790 he was appointed to the command of a fleet intended to operate against the Spaniards, but peace was concluded before any action took place. On the commencement of the war with France after the Revolution he obtained the chief command in the Channel, and on the 1st of June 1794 gained a great victory over the French fleet off Ushant, dismasting ten of the enemy's ships and taking seven, one of which, the "Vengeur," sank as she was being towed away. On the 9th August of the same year he resumed the command of the Channel fleet, but in none of his cruises was he fortunate enough to meet any of the enemy's vessels; and during the greater part of 1795 and 1796 ill health compelled him to remain on shore. In May 1797 he resigned his command. In the same year he was appointed with full powers to treat with the mutineers in the British fleet at Portsmouth and Spithead, and completely succeeded, through the confidence they had in the friendliness of his intentions, and by the firm and judicious measures he adopted, in eradicating the causes of discontent. During the latter years of his life Lord Howe suffered much from ill health; and he died under a violent attack of gout, August 5, 1799. A splendid monument was erected to Howe in St Paul's Cathedral.

Lord Howe is entitled to the exceptional praise of never having failed to bear himself with credit and success in any of his enterprises. The qualities in which he excelled were coolness, firmness, seamanship, and caution—an excess of the latter virtue, however, tending perhaps on some occasions to diminish the lustre and completeness of his victories. He introduced a new and thorough system of naval tactics, evolutions, and signals, and bestowed careful and minute attention on all the details of the service. In person he was tall and well-proportioned. His countenance was strongly marked, somewhat harsh in expression except when softened by his genial smile, and dark in complexion—although the *sobriquet* of Black Dick by which he was known in the navy was not due to this circumstance, but to a mezzotinto portrait of himself which hung in his cabin. The benevolent friendliness of his disposition secured him the strong affection and confidence as well as respect of his seamen, while no professional jealousy prevented him from doing full justice to the achievements of his officers.

HOWELL, James (1594-1666), a voluminous English author, best known by his collection of letters (*Epistolæ Ho-Elianæ*) and his *Instructions for Forreine Travell*, which, in Mr Arber's phrase, form our first handbook for the Continent. Howell, as he was proud to acknowledge, was a Welshman; he was born probably at Abernant in Carmarthenshire, where his father was minister. From the free grammar school at Hereford he proceeded to Jesus College, Oxford, in 1610, and there he took his degree of B.A. in 1613. About 1617 we find him holding the post of steward in Sir Robert Mansell's glass-works in Broad Street, and in the following year he was commissioned to go abroad to procure the services of some high-class workmen. It was not till 1622 that he returned home, having visited Holland, France, Spain, and Italy; and these three or four years of foreign experience made a lasting impression on his character and his career. Not long after his return he was despatched to Spain in company with Lord Digby's embassy to try and settle a dispute about the unlawful seizure of an English vessel; but though he remained till the end of 1624 he was obliged to return without success: the Spaniards, irritated at the breaking off of the famous match, were in no mood for concessions. For some time Howell had no stable employment, but at length, in 1626, he went to York as secretary to Lord Scroop, lord president of the north, and for a season he appears to have been wonderfully fortunate. In 1627 he was elected M.P. for Richmond; in 1632 he was sent as orator with the embassy of the earl of Leicester to Denmark; and in 1642 the king appointed him one of the clerks of the privy council. On suspicion of royalist leanings he was committed to the Fleet prison by the Parliament in 1643, and, though he professed himself most humbly submissive to its authority, he was allowed to languish in confinement till 1648. He had acquired considerable fame by his allegorical Δενδρολογία, published in 1640, and his *Instructions for Forreine Travell*, 1642; and now he was driven to maintain himself by his pen. He edited and supplemented Cotgrave's French and English dictionary, compiled *Lexicon Tetraglotton, or an English, French, Italian, and Spanish Dictionary* (London, 1660), translated various works from Italian and Spanish, and wrote a life of Louis XIII. In 1660 he presented a petition for confirmation in the place of clerk of the privy council; and, though this was not granted him, the post of historiographer royal was created for his benefit. In 1661 he made application for the office of tutor in foreign languages to the infanta Catherine of Braganza, and in the following year published an *English Grammar translated into Spanish*. He died in 1666, having realized to the last his favourite motto, "*Senesco non segnesco.*" Howell had no small ability and learning; and all his writings are imbued with a certain simplicity and quaintness. His elaborate allegories, *Discourses of Trees* and the like, are now dead to the root; his linguistic labours, though of worth in their time, are a hundred times superseded; but his *Letters* (10th ed., 1737) are still almost models of their kind, and his *Instructions*, with their subtle observations and pithy parallels, are well worthy of their place in Mr Arber's series (London, 1869).

HOWITT, William (1795–1879), a popular writer and poet, was born in 1795 at Heanor, Derbyshire, where the Howitts had long been settled. His mother and father being members of the Society of Friends, William was brought up, with his brothers, in the faith of that sect, and educated at the local schools of the society. What he thus learned was supplemented by studies in natural science and modern literature and languages; and his leisure, spent in the woods and by the brook, fostered that love of nature which brightened every page he wrote and won his readers' sympathy. A poem, published in 1814, on the *Influence of Nature and Poetry on National Spirit*, was, so far as we know, his first printed work. He married in 1823 a Quaker lady, Mary Botham of Uttoxeter, who as poetess and prose-writer occupies a place in literature no less distinguished than her husband's. The first joint book appeared in the year of their marriage under the title, *The Forest Minstrel, and other Poems*. After a pedestrian excursion to Scotland, they took up their residence at Nottingham, Howitt engaging in the business of an apothecary. In 1824 he printed *A Poet's Thoughts at the Interment of Lord Byron*. We now find that both he and his wife had become known by their contributions, chiefly in rustic verse, to *The Literary Souvenir*, *The Amulet*, and other serial volumes of the day; these were collectively issued with additions in 1827 as *The Desolation of Eyam* (founded on the plague), *The Emigrant, and other Poems*. In 1831 Howitt produced a work of the class specially his own, *The Book of the Seasons, or the Calendar of Nature*, in which he drew a picture, from his own observations, of the appearances of mother earth in the garden, in the field, and by the stream during each of the twelve months. Of quite a different character was *A Popular History of Priestcraft* (1833), which ran through several editions, and gained him the favour of the active Liberals of his time, and the office of alderman of Nottingham. It was followed, in 1835, by a cognate work in 2 vols., entitled, *Pantika, or Traditions of the most Ancient*

Times. Having removed in 1837 to Esher, to be near the literary circles of the metropolis, Howitt there wrote in succession *The Rural Life of England*, 2 vols., 1838; *Colonization and Christianity*, 1838; *The Boy's Country Book*, 1839; and the first series (afterwards extended) of *Visits to Remarkable Places, Old Halls, Battlefields, and Scenes illustrative of striking passages in English History and Poetry*, 1840–42, in which he recorded impressions derived on the spot, and pictured each place with its inhabitants—freed, as he says, from the heaviness of the antiquarian rubbish piled upon them. Visiting Heidelberg in 1840, primarily for the education of their children, the Howitts remained in Germany two years, studying their neighbours, and busying their pens in descriptions of their new surroundings. In 1841 Howitt produced *The Student Life of Germany*, under the pseudonym of "Dr Cornelius," including translations of some of the most popular German songs. The next year he published *The Rural and Domestic Life of Germany, with characteristic Sketches of its Cities and Scenery*; in the year following a translation of Chamisso's *Wonderful History of Peter Schlemihl*; and in 1844 *The Life of Jack of the Mill*, a version of Holthaus's *Wanderings of a Journeyman Tailor*, and *German Experiences, addressed to the English*, a satire on the social life of Germany. In 1845 appeared *Life in Dalecarlia*, translated from the Swedish of Miss Bremer, *The Renounced Treasure*, and *Johnny Darbyshire. The Aristocracy of England, a History of the English People*, a political sketch, appeared in 1846, at the beginning of which year Howitt became connected with the management and proprietorship of *The People's Journal*, a weekly paper. A disagreement leading to his withdrawal he started in 1847 a rival called *Howitt's Journal*, but this was continued through three or four volumes only, though *The People's Journal* was merged in it. In 1847 Howitt had translated Ennemoser's *History of Magic*, and written an original work entitled *Homes and Haunts of the most eminent British Poets*, 2 vols., which was succeeded by *The Hall and the Hamlet, or Scenes and Characters of Country Life*, and very speedily by *Stories of English and Foreign Life* (Bohn's Illustrated Library), in which Mrs Howitt assisted. Then appeared *The Year-Book of the Country, or the Field, the Forest, and the Fireside*, and in 1851 a three-volume novel called *Madam Dorrington of the Dene.*

Under the associated names of husband and wife an interesting work was brought out in 1852, *The Literature and Romance of Northern Europe: constituting a complete History of the Literature of Sweden, Denmark, Norway, and Iceland*, in 2 vols. In June of that year Howitt, with two sons and some friends, set sail for Australia, where he spent two of the most trying years of his life, working in the gold diggings, and visiting Melbourne, Sydney, and other towns. Some account of the novel situations in which he was himself placed is given in *A Boy's Adventures in the Wilds of Australia* (1854). Shortly afterwards he returned to the suburbs of London, on this occasion to Highgate, and narrated more elaborately his experiences in *Land, Labour, and Gold; or Two Years in Victoria, with Visits to Sydney and Van Diemen's Land*, 2 vols., 1855, a work which speedily became popular, the condition of the Australian colonies being then almost totally unknown in England. A further account of Australian life was given in 1857 in *Tallangetta, the Squatter's Home*, 3 vols. The year before Howitt had commenced *The Illustrated History of England* for Messrs Cassell, the sixth and last volume of which appeared in 1861. While this work was in progress he wrote in 1859 *A Country Book of Amusements*, and, in connexion with Mrs Hall and others, *The Boy's Birthday Book*, and in 1860 *The Man of the People*, 3 vols. From 1861 to 1864 Mr and Mrs Howitt were occupied on *The Ruined Abbeys and Castles of Great Britain*, issuing, before its completion, *The Wye, its Ruined Abbeys and Castles* (1863); and the same year Howitt printed a series of *Letters on Transportation, and the Cruelties Practised under the Game Laws*, and a work of great research, *The History of the Supernatural in all Ages and Nations, and in all Churches, Christian and Pagan, demonstrating a Universal Faith*, 2 vols. To a man with the mental development of Howitt the miraculous became at all times an absorbing speculation; and he adds to these pages "his own conclusions from a practical examination of the higher phenomena through a course of seven years." "If," he reasons, "you crush the supernatural you must crush the universe." Other works from Howitt's prolific pen were *Sargent's Peculiar* (1864); *The History of Discovery in Australia*, &c., 2 vols., 1865; *The Ruined Abbeys of the Border* (1865), *and of Yorkshire* (1865), jointly with his wife; *Woodburn Grange*, a story of English country life, 3 vols., 1867; *The Northern Heights of London*, an antiquarian and topographical description of Hampstead, Highgate, &c., 1869; *The Mad War-Planet, and other Poems*, 1871; *The Religion of Rome*, 1873. Suffering from bronchitis, Howitt had now made Rome his winter residence, passing the summer in Tyrol. He died at Rome on the 3d of March 1879.

HOWRAH, the largest and most important town in the district of Hooghly, Bengal, and the headquarters of the magisterial district of Howrah, is situated on the right bank of the Hooghly river, opposite Calcutta, and forms a suburb of that city. Since 1785 it has risen from a small village to a town, with a magistrate, subordinate judge, &c., of its own. The total area of Howrah and suburbs within municipal limits is 11·05 square miles; the population in 1872 numbered 97,784, of whom 54,098 were males and 43,686 females (Hindus, 79,335; Mahometans, 16,611; Christians, 1484; others, 354). The municipal income in 1871–72 was £13,994. The town is lighted with gas; it contains several large and important dockyards, and is also the Bengal terminus of the East Indian Railway. Mills and manufactories of various sorts are rapidly developing. Communication with Calcutta is carried on by means of ferry steamers, and by a massive pontoon bridge, which was opened for traffic in 1874. Howrah is a suburban residence for many people who have their places of business in Calcutta. Sibpur, one of the suburbs of Howrah, situated opposite Fort-William, a small village at the commencement of the century, is now a flourishing little town. To the south of Sibpur are the Royal Botanical Gardens and the Bishop's College.

HÖXTER (Latin, *Huxaria*), a town of Prussia, capital of a circle in the government district of Minden, province of Westphalia, is situated on the Weser at its confluence with the Grube and the Schelpe, and on a branch line of the Westphalian Railway, 2½ miles S.W. of Holzminden. It is the seat of a provincial office and of a circle court, and possesses an Evangelical and a Catholic church, a synagogue, a gymnasium, a building-school, and a hospital. The Weser is crossed by a stone bridge about 500 feet in length, erected in 1833. On the Brunsberg adjoining the town there is an old watch-tower said to be the remains of a fortress built by Bruno, brother of Wittekind. Near Höxter is the castle, formerly the Benedictine monastery, of Corvey (see CORVEY). The principal manufactures of the town are linen, cotton, cement, and gum, and there is also a considerable shipping trade. The population in 1875 was 5645.

Höxter in the time of Charlemagne was a *villa regia*, and was the scene of a battle between him and the Saxons. Under the protection of the monastery of Corvey, founded in 816, it gradually increased in prosperity. Ultimately it asserted its independence and joined the Hansa League. It suffered severely during the

Thirty Years' War, being captured four several times. After the peace of Westphalia it was united to Brunswick; in 1802 it was transferred to Orange-Nassau, and in 1807 to Westphalia, after the dismemberment of which in 1814 it came into the possession of Prussia.

HOYLE, EDMUND or EDMOND (1672–1769), the first systematizer of the laws of whist, and author of a book on games, was born in 1672. His parentage and place of birth are unknown, and few details of his life are recorded. For some time he was resident in London, and partially supported himself by giving instruction in the game of whist. For the use of his pupils he drew up a *Short Treatise* on the game, which after circulating for some time in manuscript was printed by him and entered at Stationers' Hall in November 1742. The laws of Hoyle continued to be regarded as authoritative until 1864, since which time they have been gradually superseded by the new rules adopted by the Arlington and Portland clubs in that year. He also published rules for various other games, and his book on games, which includes the *Short Treatise*, has passed into many editions. The weight of his authority is indicated by the phrase "according to Hoyle," which, doubtless first applied with reference to whist, has gained currency as a general proverb. Hoyle died at Cavendish Square, London, August 29, 1769.

HRABANUS MAURUS MAGNENTIUS (776–856), archbishop of Mainz, and one of the most prominent teachers and writers of the Carolingian age, was born of noble parents at Mainz about the year 776. Less correct forms of his name are Rabanus and Rhabanus. At a very early age he was sent to Fulda, where he continued until, on attaining the canonical age, he received deacon's orders (801); in the following year, at the instance of Ratgar his superior, he went along with Haimon (afterwards of Halberstadt) to complete his studies at Tours under Alcuin, who in recognition of his diligence and purity gave him the surname of Maurus, after St Maur the favourite disciple of Benedict. Returning after the lapse of two years to Fulda, he was entrusted with the principal charge of the school, which under his direction rose into a state of great efficiency for that age, and sent forth such pupils as Walafrid Strabo, Servatus Lupus of Ferrières, and Otfrid of Weissenburg. At this period it is most probable that his *Excerptio* from the grammar of Priscian, long so popular as a textbook during the Middle Ages, was compiled. In 814 he was ordained a priest; but shortly afterwards, apparently on account of disagreement with Ratgar, he was compelled to withdraw for a time from Fulda. This "banishment" is understood to have occasioned the pilgrimage to Palestine to which he alludes in his commentary on Joshua. Returning to Fulda on the election of a new abbot (Eigil) in 817, he himself five years afterwards (822) became superior. The duties of this office he discharged with efficiency and success until 842, when, in order to secure greater leisure for literature and for devotion, he resigned and retired to the neighbouring cloister of St Peter's. In 847 he was again constrained to enter public life by his election to succeed Otgar in the archbishopric of Mainz, which see he occupied for upwards of eight years. The principal incidents of historical interest belonging to this period of his life were those which arose out of his relations to Gottschalk; they may be regarded as thoroughly typical of that cruel intolerance which he shared with all his contemporaries, and also of that ardent zeal which was peculiar to himself; but they hardly do justice to the spirit of kindly benevolence which in less trying circumstances he was ever ready to display. He died at Winkel on the Rhine, February 4, 856. He is frequently referred to as St Rabanus, but incorrectly.

His voluminous works, many of which remain unpublished, comprize commentaries on a considerable number of the books both of canonical and of apocryphal Scripture (Genesis to Judges, Ruth, Kings, Chronicles, Judith, Esther, Canticles, Proverbs, Wisdom, Ecclesiasticus, Jeremiah, Lamentations, Ezekiel, Maccabees, Matthew, the Epistles of St Paul, including Hebrews); and various treatises relating to doctrinal and practical subjects, including more than one series of Homilies. Perhaps the most important is that *De Institutione Clericorum*, in three books, by which he did much to bring into prominence the views of Augustine and Gregory the Great as to the training which was requisite for a right discharge of the clerical function; the most popular has been a comparatively worthless tract *De Laudibus Sanctæ Crucis*. Among the others may be mentioned that *De Universo Libri xxii., sive Etymologiarum Opus*, a kind of dictionary or encyclopædia, designed as a help towards the historical and mystical interpretation of Scripture, the *De Sacris Ordinibus*, the *De Disciplina Ecclesiastica*, and the *Martyrologium*. All of them are characterized by erudition (he knew even some Greek and Hebrew) rather than by originality of thought. The poems are of singularly little interest or value, except as including one form of the "Veni Creator." In the annals of German philology a special interest attaches to the *Glossaria Latino-Theodisca*. A commentary, *Super Porphyrium*, printed by Cousin in 1836 among the *Ouvrages inédits d'Abélard*, and assigned both by that editor and by Hauréau to Hrabanus Maurus is now generally believed to have been the work of a disciple.

The first nominally complete edition of the works of Hrabanus Maurus was that of Colvener (Cologne, 6 vols. fol., 1627). The *Opera Omnia* form vols cvii–cxii. of Migne's *Patrologiæ Cursus Completus*. The *De Universo* is the subject of *Compendium der Naturwissenschaften an der Schule zu Fulda im IX. Jahrhundert* (Berlin, 1880). Maurus is the subject of monographs by Schwarz (*De Rhabano Mauro primo Germaniæ præceptore*, 1811), Kunstmann (*Historische Monographie über Hrabanus Magnentius Maurus*, 1841), Spengler (*Leben des heil. Rhabanus Maurus*, 1856), and Köhler (*Rhabanus Maurus u. die Schule zu Fulda*, 1870). *Lives* by his disciple Rudolphus and by Joannes Trithemius are printed in the Cologne edition of the *Opera*. See also Pertz, *Monum. Germ. Hist.*, vols. i. and ii.; and Bähr, *Gesch. d. römischen Literatur im Karoling. Zeitalter*, 1840.

HROSVITHA (frequently ROSWITHA, and properly HROTSUIT), early mediæval dramatist and chronicler, occupies a very notable position in the history of modern European literature. Her endeavours formed part of the literary activity by which the age of the emperor Otto the Great sought to emulate that of Charles the Great. The famous nun of Gandersheim has occasionally been confounded with her namesake, a learned abbess of the same convent, who must have died at least half a century earlier. The younger Hrosvitha was born in all probability about the year 935; and, if the statement be correct that she sang the praises of the three Ottos, she must have lived to near the close of the century. Some time before the year 959 she entered the Benedictine nunnery of Gandersheim, a foundation which was confined to ladies of German birth, and was highly favoured by the Saxon dynasty. In 959 Gerberga, daughter of Duke Henry of Bavaria, and therefore niece of the emperor Otto I., was consecrated abbess of Gandersheim, and the earlier literary efforts of the youthful Hrosvitha (whose own connexion with the royal family appears to be an unauthenticated tradition) were encouraged by the still more youthful abbess, and by a nun of the name of Richarda.

The literary works of Hrosvitha, all of which were as a matter of course in Latin, divide themselves into three groups. Of these the first and least important comprises eight narrative religious poems, in leonine hexameters or distichs. Their subjects are the Nativity of the Virgin (from the apocryphal gospel of St James, the brother of our Lord), the Ascension, and a series of legends of saints (Gandolph, Pelagius, Theophilus, Basil, Denis, Agnes). Like these narrative poems, the dramas to which above all Hrosvitha owes her fame seem to have been designed for reading aloud or recitation by sisters of the convent. For though there are indications that the idea of their representation was at least present to the mind of the authoress, the fact of such a representation appears to be an unwarrantable assumption. The comedies of Hrosvitha are six in number, being doubtless in this respect also intended to recall their nominal model, the comedies of Terence. They were devised on the simple principle that the world, the flesh, and the devil should not have all the good plays to themselves. The experiment upon which the young Christian dramatist ventured was accordingly, although not absolutely novel, audacious enough. In form the dramas of "the strong voice of Gandersheim," as Hrosvitha (possibly alluding to a supposed etymology of her name) calls herself, are by no means Terentian. They are written in prose, with an element of something like rhythm, and an occasional admixture of rhyme. In their themes, and in the treatment of these, they are what they were intended to be, the direct opposites of the lightsome adapter of Menander. They are founded upon legends of the saints, selected with a view to a glorification of religion in its supremest efforts and most transcendental aspects. The emperor Constantine's daughter, for example, Constantia, gives her hand in marriage to *Gallicanus*, just before he starts on a Scythian campaign, though she has already taken a vow of perpetual maidenhood. In the hour of battle he is himself converted, and, having on his return like his virgin bride chosen the more blessed unmarried state, dies as a Christian martyr in exile. The three holy maidens Agape, Chionia, and Irene are preserved by a humorous miracle from the evil designs of *Dulcitius*, to offer up their pure lives as a sacrifice under Diocletian's persecutions. *Callimachus*, who has Romeo-like carried his earthly passion for the saintly Drusiana into her tomb, and among its horrors has met with his own death, is by the mediation of St John raised with her from the dead to a Christian life. All these themes are treated with both spirit and skill, often with instinctive knowledge of dramatic effect—often with genuine touches of pathos and undeniable felicities of expression. In *Dulcitius* there is also an element of comedy, or rather of farce. How far Hrosvitha's comedies were an isolated phenomenon of their age in Germany must remain undecided; in the general history of the drama they form the visible bridge between the few earlier attempts at utilizing the forms of the classical drama for Christian purposes and the miracle plays. They are in any case the productions of genius; nor has Hrosvitha missed the usual tribute of the supposition that Shakespeare has borrowed from her writings.

The third and last group of the writings of Hrosvitha is that of her versified historical chronicles. At the request of the abbess Gerberga she composed her *Carmen de Gestis Oddonis*, an epic attempting in some degree to follow the great Roman model. It was completed by the year 968, and presented by the authoress to both the old emperor and his son (then already crowned as) Otto II. This poem so closely adheres to the materials supplied to the authoress by members of the imperial family that, notwithstanding its courtly omissions, it is regarded as an historical authority. Unfortunately only half of it remains; the part treating of the period from 953 to 962 is lost with the exception of a few fragments, and the period from 962 to 967 is summarized only. Subsequently, in a poem (of 837 hexameters) *De Primordiis Cœnobii Gandersheimensis*, Hrosvitha narrated the beginnings of her own convent, and its history up to the year 919.

The Munich MS., which contains all the works enumerated above except the *Chronicle of Gandersheim*, was edited by the great Vienna humanist Celtes in 1501, and re-edited by the learned H. L. Schurzfleisch in 1707. The comedies have been translated into German by Bendixen (Lübeck, 1858), and into French by A. Magnin (Paris, 1845), whose introduction gives a full account of the authoress and her works. A copious analysis of these plays will be found in Klein, *Geschichte des Dramas*, iii. 665–754. Gustav Freytag is the author of a treatise *De Rosuitha poetria* (Breslau, 1839); and at the beginning of Cohn's *Shakspeare in Germany*, Shakespearean parallels are suggested to certain passages in Hrosvitha's dramas. Her two historical chronicles were edited by Pertz among the *Monumenta Germaniæ* (vol. iv.); for an appreciation of them see Wattenbach, *Geschichtsquellen*, 214–216, and Giesebrecht, *Deutsche Kaiserzeit*, i. 780, who mentions a German translation by Pfund. There is a complete edition of the works of Hrosvitha by K. A. Barack (Nuremberg, 1858). J. Aschbach (1867) attempted to prove that Celtes had forged the productions which he published under the name of Hrosvitha, but he was refuted by R. Köpke (Berlin, 1869). (A. W. W.)

HUANCAVELICA, or GUANCABELICA, the chief town of a department of same name, Peru, is situated in a deep ravine, of an average width of one mile, at about 12,400 feet above sea level, and 160 miles south-east of Lima. It is well and regularly built, the houses being of stone, while several stone bridges span the stream that flows through the town. Huancavelica was founded in 1572 as a mining town by the viceroy Francisco de Toledo, and mining has continued to be the principal employment of the inhabitants. Close by is the famous quicksilver mine of Santa Barbara, with its subterranean San Rosario church, cut out of the cinnabar. Population in 1876, 3937.

HUANUCO, or GUANUCO, the chief town of the Peruvian department of the same name, is situated on the left bank of the river Huallaga near its junction with the Higueras, in a beautiful valley nearly 6000 feet above sea-level, and 180 miles north-west of Lima. The streets are laid out regularly, but the houses are mean-looking. As nearly every house is surrounded by a garden the limits of the town embrace a large area. Sweetmeats for the Lima market are almost the only manufacture, most of the inhabitants being engaged in mining and farming. Huanuco was founded in 1539 by Gomez Alvarado, and was shortly afterwards raised to a bishopric. In 1812 during an insurrection of the Indians of Panao it was plundered. The population in 1876 was 5263.

HUARAZ, chief town of the Peruvian department of Ancachs, and of a district to which it gives its name, is situated on the left bank of the river Santa, in a fertile valley of the Andes, about 190 miles N.N.W. of Lima. There is some export trade in cattle, wheat, sugar, and fruit; and in the vicinity considerable quantities of gold, silver, and copper are mined. A state railway 172 miles long, of which 82 miles are completed, is designed to connect Huaraz with Chimbote on the coast. Near the town there are ruins in the second or Cyclopean style of Inca architecture, sufficiently like the remains at Tiahuanca to allow us to assign Huaraz as the northern limit of the prehistoric Incarial empire, of which Tiahuanca was the southern boundary. Population in 1876, 4851.

HUBER, FRANÇOIS (1750–1831), an eminent Swiss naturalist, especially distinguished by the originality and reach of his researches into the life history of the honey-bee, was born at Geneva, July 2, 1750. He belonged to a family which had already made its mark in the literary and scientific world; his great-aunt, Marie Huber (1695–1753), was known as a voluminous writer on religious and theological subjects, and as the translator and epitomizer of *The Spectator* (*Redaction du Spectateur Anglais à ce qu'il renferme de meilleur*, Amst., 3 vols. 1753); and his father Jean Huber (1721–1786), who had served for many years as a soldier, was a prominent member of the coterie at Ferney, distinguishing himself both by the rare skill with which he could reproduce the likeness of Voltaire by clipping paper and by other unpromising devices, and by the publication of a valuable series of *Observations sur le vol des oiseaux* (Geneva, 1784). From an early age François Huber displayed a dangerous ardour for study; and he was only fifteen years old when he began, in consequence of his ill-judged assiduity, to suffer from an affection of the eyes which gradually resulted in total blindness. Happily at once for his comfort and his fame he had secured the affection of Marie Aimée Lullin. Having patiently waited till she was legally of age, she married the husband of her choice, and ministered to his wants till her death with such unceasing devotion that it was only, he said, when he lost her that he really felt he was blind. For many years her efforts were seconded by François Burnens, a servant, whom Huber had inspired with something of his own love of nature. The results of the investigations which were conducted by this happily assorted trio, at once surprised and delighted the world. So skilfully did the blind man devise his experiments, and so carefully did his assistants conduct and register their observations, that the work *Nouvelles Observations sur les abeilles* (Geneva, 1792; Paris, 1796; new ed., Paris, 1814; English translation, Edinburgh, 1806 and 1821) laid the foundation of all our scientific knowledge of the subject. Huber assisted Senebier in his *Mém. sur l'influence de l'air, &c., dans la germination* (Geneva, 1800); and we also have from his pen "Mém. sur l'origine de la cire" (*Bibliothèque Britannique*, tome xxv.), a "Lettre à M. Pictet sur certains dangers que courent les abeilles" (*Bib. Brit.*, xxvii.), and "Nouvelles observ. rel. au sphinx *Atropos*" (*Bib. Brit.*, xxvii.). He died at the age of eighty-one, December 22, 1831. De Candolle gave his name to a genus of Brazilian trees—*Huberia laurina*. Pierre Huber (1777–1840) followed in his father's footsteps. His best known work is *Recherches sur les mœurs des fourmis indigènes* (Geneva and Paris, 1810; new ed., Geneva, 1861), but he also contributed papers on various entomological subjects to several scientific periodicals.

See the account of François Huber by De Candolle in *Bibl. Universelle*, 1832; and the notice of Pierre in *Bibl. Univ.*, 1866; also Haag, *La France Protestante*.

HUBER, Johann (1830–1879), a philosophical and theological writer whose name is intimately connected in Germany, and indeed throughout Europe, with the Old Catholic and other recent movements towards freedom and enlightenment, was born in very humble circumstances, on August 18, 1830, at Munich, where, originally destined for the priesthood, he early began the study of theology. By the writings of Spinoza and Oken, however, he was strongly drawn to philosophical pursuits, and it was in philosophy that he "habilitated" (1854), and ultimately became professor (extraordinarius in 1859 and ordinarius in 1864). Along with Döllinger and others he attracted a large amount of public attention in 1869 by the challenge to the Ultramontane promoters of the Vatican council in the treatise *Der Papst u. der Koncil*, which appeared under the pseudonym of "Janus," and also in 1870 by a series of letters ("Römische Briefe"), which were published in the *Allgemeine Zeitung*. The nature of the numerous controversies in which he became involved both before and after this main episode of his life may be gathered from the subjoined list of his published writings. He died suddenly of heart disease at Munich on March 20, 1879.

His treatise *Ueber die Willensfreiheit* (1858) was followed in 1859 by *Die Philosophie der Kirchenväter*, which was promptly placed by the Roman authorities upon the *Index*, and which led to the prohibition of all Catholic students from attending his lectures; *Johannes Scotus Erigena*, 1861; *Idee der Unsterblichkeit*, 1864; *Studien*, 1865; *Der Proletarier: zur Orientirung in der socialen Frage*, 1865; *Der Jesuitenorden nach Verfassung u. Doktrin, Wissenschaft u. Geschichte*, 1873; *Der Pessimismus*, 1876; *Die Forschung nach der Materie*, 1877; *Zur Philosophie der Astronomie*, 1878; *Das Gedächtniss*, 1878. He also published adverse criticisms on Darwin, Strauss, Hartmann, and Haeckel; pamphlets on *Das Papstthum u. der Staat*, 1870, and on *Die Freiheiten der französischen Kirche*, 1871; and a volume of *Kleine Schriften*, 1871.

HUBERT (Hugubert or Hugubrecht, "the Bright-witted"), St, bishop of Liége, was son of Bertrand, duke of Guienne, and held a prominent place in the court of the Frankish king Theodoric, and afterwards in that of Pippin of Heristal. He was passionately fond of the chase, but with the death of his wife Floribane all his taste for mundane enjoyments disappeared, and following the counsels of his friend and teacher, Bishop Lambert of Maestricht, he retired to the monastery of Stavelot, whence he afterwards undertook a pilgrimage to Rome, on occasion of which he was by pope Sergius I. appointed bishop of Tongern. In 708 he succeeded Lambert in the see of Maestricht and Liége, to whose memory he erected a cathedral in the latter city. His death occurred in 727, and in 825 his remains (which, it is alleged, suffered no decay for many years) were removed to a Benedictine cloister in the Ardennes, which thenceforth bore his name, and ultimately became a considerable resort of pilgrims. St Hubert's day is November 3, but the date and circumstances of his canonization are not stated. His conversion, represented as having been brought about, while he was hunting on Good Friday, by a miraculous appearance of a stag bearing between his horns a beaming cross or crucifix, has frequently been made the subject of artistic treatment. He is the patron of hunters, and is also invoked in cases of hydrophobia and demoniac possession. Several orders of knighthood have been under his protection; among these may be mentioned the Bavarian, the Bohemian, and that of the electorate of Cologne.

See Jameson, *Sacred and Legendary Art*; Fétis, *Légende de Saint Hubert, précédée d'une préface bibliographique et d'une introduction historique*, 1846; Des Granges, *Vie de Saint Hubert*, 1872; Heggen, *Des heiligen Hubertus Leben u. Wirken*, 1875.

HUBLI, a town in Dhárwár district, Bombay, 15° 20′ N. lat., 75° 12′ E. long., situated 13 miles south-east of Dhárwár, on the main road from Poona to Harihar; it is 230 miles south-east from Poona, 142 miles from Bellári (Bellary), 90 miles from Kárwár, and 97 miles from Kumpta (Coompta). Population (1872) 37,961. Situated on the main lines of communication to Harihar, Kárwár, and Kumpta, the town has become the centre of the cotton trade of the southern Marhattá country. Besides raw cotton and silk fabrics, a general trade in copper vessels, grain, salt, and other commodities is conducted on a large scale. Hubli was formerly the seat of an English factory, which in 1673, with the rest of the town, was plundered by Sivají, the Marhattá leader.

HUC, Évariste Régis (1813–1860), a celebrated French missionary-traveller, was born at Toulouse, 1st August 1813. In his twenty-fourth year he entered the congregation of the Lazarists at Paris, and shortly after receiving holy orders in 1839 set forth fired by missionary zeal for China. At Macao he spent some eighteen months in the Lazarist seminary preparing himself under the instruction of Perboyre for the regular work of a missionary in the interior. Having at last acquired a sufficient command of the Chinese tongue, and modified his personal appearance in accordance with Chinese taste, he started from Canton clad in the flowing costume of the natives, with his skin dyed yellow, and wearing the inevitable queue. He at first superintended a Christian mission in the southern provinces, and then passing to Peking, where he perfected his knowledge of the language, eventually settled in the Valley of Black Waters or He Shuy, a little to the north of the capital, and just within the borders of Mongolia. There, beyond the Great Wall, a large but scattered population of native Christians had found a refuge from the persecutions of Kia-King, to be united half a century later in a vast but vague apostolic vicariate. The assiduity with which Huc devoted himself to the study of the dialects and customs of the Tartars, for whom at the cost of much labour he translated various religious works, was an admirable preparation for undertaking in 1844, at the instigation of the vicar apostolic of Mongolia, an expedition whose object was to dissipate the obscurity which hung over the country and habits of the Tibetans. September of that year found the missionary at Tolon-noor occupied with the final arrangements for his journey, and shortly afterwards, accompanied by his fellow-Lazarist, Joseph Gabet, and a young Tibetan priest who had embraced Christianity, he set out. To escape attention the little party assumed the dress of lamas or priests. Crossing the Hoang-ho at Shagan-Kooren, they advanced into the terrible sandy tract known as the steppes of the Ortoos. After suffering dreadfully from want of water and fuel they entered Kansu, having recrossed the flooded Hoang-ho, but it was not till January 1845 that they reached Tang-Kiuul on the boundary. Rather than encounter alone the horrors of a four months' journey to Lhassa they resolved to wait for eight months till the arrival of a Tibetan embassy on its return from Peking. Under an intelligent teacher they meanwhile studied the Tibetan language and Buddhist literature, and during three months of their stay they resided in the famous Kounboum Lamasery, which was reported to accommodate 4000 persons. Towards the end of September they joined the returning embassy, which comprised 2000 men and 3700 animals. Crossing the deserts of Koko-nur, they passed the great lake of that name, with its island of contemplative lamas, and, ascending with difficulty and hardship the tortuous snow-covered mountains of Chuga and Baylen-Bharat, they at last entered Lhassa on the 29th January 1846. Favourably received by the regent, they opened a little chapel, and were in a fair way to establish an important mission, when the Chinese ambassador interfered and had the two missionaries conveyed back to Canton, where they arrived in October of the same year. For nearly three years Huc remained at Canton, but M. Gabet, returning to Europe, proceeded thence to Rio de Janeiro, and died there shortly afterwards. Huc returned to Europe in shattered health in 1852, visiting India, Egypt, and Palestine on his way, and, after a prolonged residence in Paris, died 31st March 1860. His writings comprise, besides numerous letters and memoirs in the *Annales de la Propagation de la Foi*, the famous *Souvenirs d'un Voyage dans la Tartarie, le Thibet, et la Chine pendant les années* 1844-46 (2 vols., Par., 1850; Eng. transl. by W. Hazlitt, 1851, abbreviated by M. Jones, Lond., 1867); its supplement, crowned by the Academy, entitled *L'Empire Chinois* (2 vols., Par., 1854; Eng. transl., Lond., 1859); and an elaborate historical work, *Le Christianisme en Chine*, &c. (4 vols., Par., 1857-58; Eng. transl., Lond., 1857-58). These works are written in a lucid, racy, picturesque style, which has secured for them an unusual degree of popularity. The narrative of one of the most remarkable feats of modern travel, the *Souvenirs* contain passages of so singular a character as in the absence of corroborative testimony to stir up a feeling of incredulity. That Huc was suspected unjustly has been amply proved by the later research of Bushnell, David, Prejevalski, Richthofen, and Colonel Montgomerie's "Pundits." But although his credibility has been firmly established, and although in his heroic enterprise he gathered a vast amount of novel and curious information, the fact remains that Huc was by no means a practical geographer, and that the record of his travels loses greatly in value from the want of precise scientific data.

See, for information specially relating to the whole subject, the Abbé Desgodin's *Mission du Thibet de 1855 à 1870*, Verdun, 1872; and "Account of the Pundit's Journey in Great Tibet," in the *Royal Geographical Society's Journal* for 1877.

HUCBALD (also called HUGBALDUS and HUBALDUS) was born in or about 840, if we may believe the statement of his biographers to the effect that he died in 930, aged 90. Of his life little is known; not even the place of his birth can be ascertained, but he was no doubt a Frenchman or a Belgian. It is certain that he studied at the convent of St Amand in French Flanders, where his uncle Milo occupied an important position. Hucbald made rapid progress in the acquirement of various sciences and arts, including that of music, and at an early age composed a hymn in honour of St Andrew, which met with such success as to excite the jealousy of his uncle. It is said that Hucbald in consequence was compelled to leave St Amand, and started an independent school of music and other arts at Nevers. In 860, however, we find him at St Germain d'Auxerre, bent upon completing his studies, and in 872 he is back again at St Amand as the successor in the head-mastership of the convent school of his uncle, to whom he had been reconciled in the meantime. Between 883 and 900 Hucbald went on several missions of reforming and reconstructing various schools of music, including that of Rheims, but in the latter year he returned to St Amand, where he remained to the day of his death (June 25, 930, or, according to other chroniclers, June 20, 932), and where his most important works on music were written. Of the character of these works and of the reforms and improvements advocated by them it is not easy to give a correct idea; not even their number is sufficiently certain, for some treatises have been attributed to Hucbald which are obviously not his, and others of which the authorship is at least doubtful. His largest and most authentic work is the *Enchiridion Musicæ*, published with other writings of minor importance in the first volume of Gerber's *Scriptores ecclesiastici*, and containing a complete system of musical science as well as instructions regarding notation. Hucbald as a musical theorist may be called a precursor of Guido d'Arezzo, to whose hexachord system his tetrachord, that is, the use of four instead of seven letters, forms a kind of basis. His scales are founded on strictly Greek principles, and cannot be said to mark a decided step in advance; neither is his system of notation much superior to the earlier ones, although here also he seems in a manner to foreshadow Guido's use of the lines and spaces of the staff from which the modern method took its rise. Of great importance is the 13th chapter of the *Enchiridion*, which treats of the diaphony or organum,—in other words, of singing in parts. Amongst other prescriptions it is curious to find the rule which recommends the use of parallel fifths and fourths, so strictly prohibited by later theorists, while, on the other hand, consecutive thirds, particularly euphonious to the modern ear, are excluded by Hucbald.

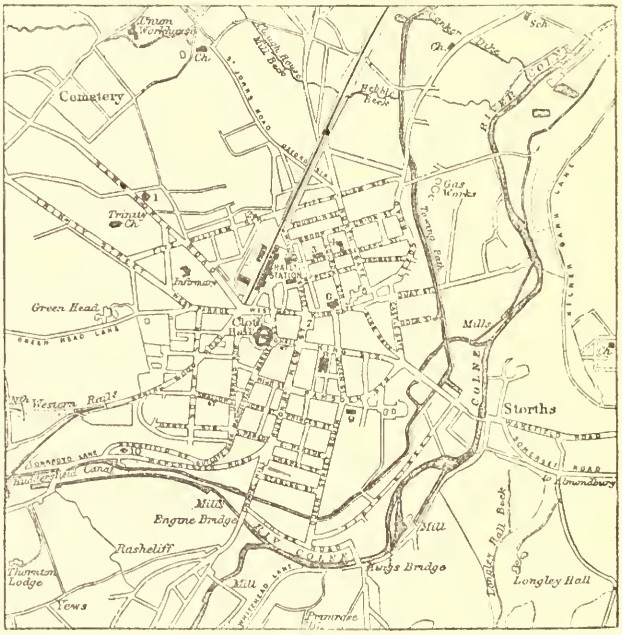
A good account of the monk of St Amand and his system will be found in Coussemaker's *Mémoire sur Hucbald*, Paris, 1841; Hawkins (*History*, vol. i. p. 153) also gives a short notice of Hucbald, and mentions two epitaphs written in his honour by contemporaries.

HUCHTENBURG. Two brothers of this name practised the art of painting in the second half of the 17th century. Both were natives of Haarlem. Jacob, the elder, of whom very little is known, studied under Berghem, and went early to Italy, where he died young about 1667. His pictures are probably confounded with those of his brother. In Copenhagen, where alone they are catalogued, they illustrate the style of a Dutchman who transfers Berghem's cattle and flocks to Italian landscapes and market-places.

John van Huchtenburg (1646-1733), born at Haarlem it is said in 1646, was first taught by Thomas Wyk, and afterwards induced to visit the chief cities of Italy, where, penetrating as far as Rome, he met and dwelt with his brother Jacob. After the death of the latter he wandered homewards, taking Paris on his way, and served under Van der Meulen, then employed in illustrating for Louis XIV. the campaign of 1667-68 in the Low Countries. In 1670 he settled at Haarlem, where he married, practised, and kept a dealer's shop. His style had now merged into an imitation of Philip Wouvermans and Van der Meulen, which could not fail to produce pretty pictures of hunts and robber camps, the faculty of painting horses and men in action and varied dress being the chief point of attraction. Later on Huchtenburg ventured on cavalry skirmishes and engagements of regular troops generally, and these were admired by Prince Eugene and William III., who gave the painter sittings, and commissioned him to throw upon canvas the chief incidents of the battles they fought upon the continent of Europe. When he died at Amsterdam in 1733, Huchtenburg had done much by his pictures and prints to make Prince Eugene, King William, and Marlborough popular. Though clever in depicting a *mêlée* or a skirmish of dragoons, he remained second to Philip Wouvermans in accuracy of drawing, and inferior to Van der Meulen in the production of landscapes. But nevertheless he was a clever and spirited master, with great facility of hand and considerable natural powers of observation.

The earliest date on his pictures is 1674, when he executed the Stag-Hunt in the Museum of Berlin, and the Fight with Robbers in the Lichtenstein collection at Vienna. A Skirmish at Fleurus (1690) in the Brussels gallery seems but the precursor of larger and more powerful works, such as the Siege of Namur (1695) in the Belvedere at Vienna, where William III. is seen in the foreground accompanied by Max Emmanuel, the Bavarian elector. Three years before, Huchtenburg had had sittings from Prince Eugene (Hague museum) and William III. (Amsterdam Trippenhuis). After 1696 he regularly served as court painter to Prince Eugene, and we have at Turin (gallery) a series of eleven canvases all of the same size depicting the various battles of the great hero, commencing with the fight of Zentha against the Turks in 1697, and concluding with the capture of Belgrade in 1717. Had the duke of Marlborough been fond of art he would doubtless have possessed many works of our artist. All that remains at Blenheim, however, is a couple of sketches of battles, which were probably sent to Churchill by his great contemporary. The pictures of Huchtenburg are not very numerous now in public galleries. There is one in the National Gallery, London, another at the Louvre. But Copenhagen has four, Dresden six, Gotha two, and Munich has the well-known composition of Tallart taken Prisoner at Blenheim in 1704.

HUDDERSFIELD, a municipal and parliamentary borough and market-town of England, in the West Riding of Yorkshire, is beautifully situated on the slope of a hill in the valley of the Colne, a tributary of the Calder, 15 miles south of Bradford, and 16½ south-west of Leeds. It is surrounded by a network of railways, and is connected with the extensive canal system of Lancashire and Yorkshire. The town is built principally of stone, and has undergone within late years very extensive improvements, in regard to both its external appearance and its sanitary arrangements. The older portions of the town, where the streets were mean-looking and narrow, have almost disappeared, making way for handsome, spacious, and well-paved thoroughfares, whilst many of the business premises possess considerable architectural merit. Among the churches deserving special mention are St Peter's, the parish church, in the Perpendicular style, rebuilt in 1837 at a cost of £10,000, possessing chancel, nave, aisles, transept, and tower with peal of ten bells; Trinity Church, erected in 1819 at a cost of £12,000, in the Pointed style, with an embattled tower at the west end; St Paul's, built by the parliamentary commissioners in 1831, in the Early English style, with a tower surmounted by a light spire; St Thomas's, in the Transition Early English style, completed in 1859 at a cost of £10,000. Of the numerous Nonconformist places of worship, Ramsden Street (Congregational), Queen Street and Buxton Road (Wesleyan), and Brunswick Street (Free Methodist) chapels are remarkable for their capacity, whilst High Street (New Connexion Methodist), New North Road (Baptist), and Highfield and Hillhouse (Congregational) have considerable architectural beauty. The principal other buildings, in addition to the many fine warehouses, are the Cloth-Hall, erected by Sir Thomas Ramsden in 1768, and extended in 1780,—a circular two-storied brick building, having a diameter of 80 yards, now fallen almost into disuse; the Armoury, erected as a riding-school, but now the headquarters of the rifle volunteers, and also used for concerts and large public meetings; the Victoria Hall, a capacious building recently erected by the Huddersfield Temperance Society; the Philosophical Hall, in the Grecian style, originally used for lectures and public meetings, afterwards converted into a theatre, and burnt almost to the ground February 15, 1880; the Gymnasium Hall, erected in 1847, capable of accommodating 1000 persons, and transformed into public baths in 1879; the Infirmary, erected in 1831, a large and elegant stone edifice of the Doric order with wings and a portico, the latter supported by four fluted columns, a large ward and medicated baths being added later; the General Railway Station, in the Grecian style, erected in 1848, having in front a handsome statue of Sir Robert Peel; the Huddersfield College, in the Baronial style, established in 1838 for sons of gentlemen and tradesmen; the Collegiate School, in the Gothic style, erected in 1839; the Huddersfield Club; the Borough Club; the Masonic Hall (1838); the Corporation offices, in the Classic style (1877); the Town-Hall, also in the Classic style, but much richer (1880); the Guardians' offices (1880); the Ramsden Estate buildings, a handsome and extensive block of the mixed Italian order; the Chamber of Commerce; and a remarkably fine new market-hall, in the Gothic style, with a clock-tower and spire 106 feet in height, founded in 1878, and opened in 1880.



Plan of Huddersfield.

The cost of the building was £28,000, and the sum paid by the corporation to Sir J. W. Ramsden, Bart., for the market-rights and site, was £25,790, in addition to £15,273 for the site and rights of the cattle-market. A public cemetery, off New North Road, the property of the corporation, with mortuary chapels for Churchmen and Nonconformists, was completed in 1855; and the cemetery at Almondbury was taken over by the corporation in 1868. The extensive gas-works are the property of the corporation, as are also the water-works, which afford an ample supply of excellent water, the reservoirs being capable of storing 900,000,000 gallons. The cost has been over £750,000. A public park of 21 acres, called the Beaumont Park, is the gift of Mr H. F. Beaumont; the first sod was cut on May 29, 1880. There are fourteen handsome board schools, erected at a cost of about £120,000, twenty-one national schools, and one Roman Catholic school. The principal public societies are the mechanics' institution, the building for which, a large edifice in the Italian style, was opened in 1861, and the mechanics' institutes at Lindley and Lockwood, each possessing handsome buildings. Huddersfield is a place of considerable antiquity, being mentioned in Domesday, and is supposed by some to derive its name from

Oder or Hudard, a Saxon chief; but its importance dates from the establishment of the woollen manufacture within the last century. It is the principal seat of the fancy woollen trade in England; and it exceeds every other place in the variety of its manufacture of this class of textile fabrics, which includes doeskins, angolas, tweeds, worsted coatings and trouserings, Ulster cloths, mohairs, cashmeres, sealskins, fancy dress skirtings, kerseys, woollen cords, quiltings, a few broad cloths, and a large number of union materials. It also possesses silk and cotton spinning mills, iron foundries, engineering works for steam-engines, steam-engine boilers, and the machinery used in the various manufactures, chemical works, dye-houses, lead-piping and sanitary tube manufactories, and three organ factories. Handloom weaving is carried on in the surrounding villages, but to a much less extent than formerly. A market for woollen goods is held weekly. Coal is abundant in the vicinity. There is a sulphurous spa in the Lockwood ward, with warm, cold, vapour, and shower baths. At Almondbury, 2 miles distant from the centre of the town, there was at one time a Saxon fortress, and by some writers the Roman station *Cambodunum*, mentioned by Antonine, is believed to have been situated there; recent excavations, however, have proved almost conclusively that at Slack, just outside the opposite boundary of the borough, was the real *Cambodunum*. Kirklees park, 3 miles from Huddersfield, is popularly supposed to have been the burial-place of Robin Hood. Since 1832 Huddersfield has returned one member to parliament, and it became a municipal borough in 1868, with 12 wards, and a town council of 56 members. The area of the town was greatly increased at the time of its incorporation. The area of the parliamentary borough is 10,998 acres, and that of the municipal borough 10,498 acres. The population of the parliamentary borough in 1861 was 34,877; and in 1871, owing chiefly to the increased area, it was 74,358. The population of the municipal borough in 1880 was estimated at 81,780.

HUDSON, a city of the United States of America, capital of Columbia county, New York, is situated on the left bank of the Hudson river at the head of navigation, and on the Hudson and Boston and Hudson River Railways, 114 miles north of New York city. It stands on the ridge of a picturesque elevation called Prospect Hill, which after rising abruptly 60 feet from the river, slopes gradually to an elevation of 500 feet. The high river bank projects into the river in the form of a bold promontory, affording a delightful promenade, and having on either side a fine bay with depth of water sufficient for the largest ships. The wharves are situated at the foot of the promontory and along the margin of these bays. The city is for the most part regularly built, with streets crossing each other at right angles, and a public square situated immediately above the wharves. Works to supply the city with water have lately been constructed at a cost of 250,000 dollars. The principal buildings are the court-house, constructed of marble and limestone and surmounted by a dome, the city hall and post-office, and the academy. The city is also well supplied with other schools, and possesses three public libraries. Hudson at one time vied as a trading port with New York, and, although both its West India trade and its whale fishing have now been abandoned, it still carries on an important river trade, and has regular steam communication with New York and Albany. It also possesses large iron smelting works, a stove-foundry, a tannery, a flour-mill, breweries, iron-foundries, and factories for pianos, carriages, paper, car wheels, and steam fire-engines. Hudson was settled in 1784, being then known as Claverack Landing. It became a city in 1785. The population, which in 1870 was 8615, was 8669 in 1880.

HUDSON RIVER, or NORTH RIVER, one of the largest and noblest rivers of the United States, and the principal river of the State of New York, is formed by the confluence of two small streams which rise in the Adirondack mountains in Essex county. About the middle of Warren county the river is joined by another of nearly equal size, the Schroon, which also has its rise in Essex county. After receiving the Sacondaga river 10 miles further south, the Hudson flows irregularly in an easterly direction to Sandy Hill, after which it keeps a very straight course almost due south until it falls into New York Bay. At Troy it receives the Mohawk, whose volume of water is greater than its own, and at Kingston the Wallkill, but its other tributaries, though numerous, are unimportant. Its total length is about 300 miles, and the length of its course from Sandy Hill 190 miles. At Glen's Falls, near Sandy Hill, it makes a precipitous descent of 50 feet, whence there are various rapids of different velocities until it reaches Troy. It is tidal nearly up to Troy, and the fall from Albany, 6 miles below Troy, to the mouth of the river, a distance of 145 miles, is only 5 feet. By means of a lock and dam it is navigable to Waterford, a short distance above Troy, but large steamers do not proceed further up than Hudson, 29 miles below Albany, and 116 from the mouth of the river. A short distance below Albany the navigation has been obstructed by shifting sands, the point at which the difficulties are most formidable being the "overslaugh" at Castleton, but extensive operations have been for some time carried on in order to effect a permanent remedy for the obstructions. The breadth of the river at Albany is about 300 yards, and thence to Haverstraw, distant 34 miles from New York, it varies from 300 yards to 900 yards. From Haverstraw to Piermont it expands into Tappan Bay, with a length of 12 miles and a breadth of from 4 to 5, after which it narrows to a breadth of between 1 and 2 miles. The scenery of the river is for the most part varied and beautiful, generally picturesque, and in many places in the highest degree striking and magnificent. In the upper part the views though not tame are a little monotonous, the gently sloping hills, with the variegated colours of wood and cultivated land and the occasional occurrence of a town or village, repeating one another without any marked feature to break their regularity. Below Troy, for a considerable distance, the number of islands renders much care in navigation necessary. Thirty miles from Troy noble views begin to be obtained of the Catskill mountains, towering up on the west bank, the nearest eminence at the distance of about 7 miles. Forty-six miles below Catskill is the large and flourishing city of Poughkeepsie, and 14 miles further down the prosperous city of Newburgh, a short distance below which, at the favourite summer resort of Cornwall Landing, the river enters the Highlands, passing between a series of hills whose frequently precipitous sides rise often abruptly from the water's edge. The views in this part of the river are of a character in some respects unparalleled, and at several points they have an impressiveness and surprising grandeur rarely equalled. The distance through which the river traverses this mountain scenery is about 16 miles, and about 10 miles after it is entered West Point is reached, a favourite landing place of tourists, the seat of the United States military academy, and historically interesting on account of Fort Putnam, now in ruins, built during the war of American independence, at which time a chain was stretched across the river to prevent the passage of British ships. After passing the pretty town of Peekskill the river widens into Haverstraw Bay, at the extremity of which is the headland of Croton Point. Below is the wider expanse of Tappan Bay, upon which stands Tarrytown, famous both historically and from its connexion with Washington Irving, whose cottage of Sunnyside is in the vicinity. At Piermont, where the bay ends, the range named the Palisades rises picturesquely from the water to the height of between 300 and 500 feet, extending along the west bank for about 20 miles, the left bank being level and dotted with hamlets and villas. At the mouth of the river on the west bank are Hoboken and Jersey city, and on the east bank New York city.

By the Erie canal the river is connected with Lake Erie, by the Champlain canal with Lake Champlain, and by the Delaware canal with the Delaware river; and its commercial importance as a means of traffic is not excelled by that of any other river in the world. It was on the Hudson that Fulton, the inventor of steam navigation, made his first successful experiment. The Hudson River Railway skirts the east bank of the river from New York to Troy, whence it bends eastward on its way to Lake Champlain. On the west bank a railway is to run from Jersey City to Newburg, and branch lines from various centres touch both banks at several points. The Hudson has some valuable fisheries, the principal fish being bass, shad, and sturgeon. The attempts to stock it with salmon have not been very successful. Though Verrazzani in 1524 proceeded up the river Hudson a short distance in a boat, the first to demonstrate its extent and importance was Henry Hudson, from whom it derives its name. He sailed above the mouth of the Mohawk in September 1609.

HUDSON, GEORGE (1800–1871), the "railway king," was born in York in 1800, was a successful linen draper in that city, and subsequently became the leading representative of the railway mania of 1845–46. Elected chairman of the North Midland Company, he was for three years the ruling spirit of speculation and as the arbiter of capital held the key of untold treasures. All classes delighted to honour him, and, as if a colossal fortune were an insufficient reward for his public services, the richest men in England presented him with a tribute of £20,000. Deputy-lieutenant for Durham, and thrice lord mayor of York, he was returned in the Conservative interest for Sunderland in 1845, the event being judged of such public interest that the news was conveyed to London by a special train, which travelled part of the way at the rate of 75 miles an hour. Full of rewards and honours, he was suddenly ruined by the disclosure of the Eastern Railway frauds. Sunderland clung to her generous representative till 1859, but on the bursting of the bubble he had lost influence and fortune at a single stroke. His later life was chiefly spent on the Continent, where he benefited little by a display of unabated energy and enterprise. Some friends gave him a small annuity a short time before his death, which took place in London, 14th December 1871. His name has long been used to point the moral of vaunting ambition and unstable fortune. The "big swollen gambler," as Carlyle calls him in one of the *Latter Day Pamphlets*, was savagely and excessively reprobated by the world which had blindly believed in his golden prophecies. He certainly ruined scrip-holders, and disturbed the great centres of industry; but he had an honest faith in his own schemes, and, while he beggared himself in their promotion, he succeeded in overcoming the powerful landed interest which delayed the adoption of railways in England long after the date of their regular introduction into America.

HUDSON, HENRY, a distinguished English navigator, of whose personal history before April 19, 1607, or after June 21, 1611, absolutely nothing is known, and whose well-earned fame rests entirely on four voyages which were all unsuccessful as regarded their immediate object, the discovery of a commercial passage to China other and shorter than that by the Cape of Good Hope. The first of these, in quest of new trade and the passage to China by the North Pole, was made for the Muscovy Company, with ten men and a boy, in the little "Hopewell" of 60 tons that had so successfully braved the dangers of Frobisher's last voyage twenty-nine years before. Sailing from the Thames on April 19, 1607, Hudson first coasted the east side of Greenland, and thence hugging the Arctic ice-barrier, proceeded to the "north-east of Newland" to near 82° N. lat. He then turned back to seek, according to his chart, the passage round the north of Greenland into Davis Straits to make trial of Lumley's Inlet, or "the furious overfall"; but, having traced the ice-barrier from 78½° to 80°, he on July 27 became convinced that by this way there is no passage, and on August 15 he returned to the Thames. Molineux's chart, published by Hakluyt about 1600, was Hudson's blind guide in this voyage, and the polar map of 1611 by Pontanus illustrates well what he attempted, and the valuable results both negative and positive which he reached. He investigated the trade prospects at Cherrie Island, and recommended his patrons to seek higher game in Newland; hence he may be called the father of the English whale-fisheries at Spitzbergen.

Next year Hudson was a second time sent by the Muscovy Company "to open the passage to China by the north-east between Newland and Nova Zemla;" this voyage lasted from April 22 to August 26, 1608. From June 12 to June 29, he raked the Barrentz Sea between 75° 30′ N.W. and 71° 15′ S.E. on the Goose coast of Nova Zemla, meeting with much ice and no great encouragement for trade, and deleting Willoughby Island from his chart. On July 6, "voide of hope of a north-east passage (except by the Waygats, for which I was not fitted to try or prove), I therefore resolved to use all means I could to sayle to the north-west" (still harping on Lumley's Inlet and "the furious overfall"). The failure of this second attempt satisfied the Muscovy Company, which thenceforward directed all its energies to the profitable Spitzbergen trade.

In the Autumn of 1608 Hudson "had a call" to Amsterdam, where he saw Plancius, who gave him Waymouth's journals, and Hondius, who supplied him with translations of certain Dutch papers. After some vacillating negotiations he finally undertook for the Dutch East India Company his important third voyage to find the passage to China "by the east or the west." With a mixed crew of eighteen or twenty men he left the Texel in the "Half-Moon" on April 5, and by May 5 was in the Barrentz Sea, and soon afterwards among the ice near Costin Sarch in Nova Zemla, where he had been the year before. Some of his men becoming disheartened and mutinous (it is now supposed that he had arrived two or three months too early), he soon lost hope of effecting anything by that route, and submitted to his men, as alternative proposals, either to go to Lumley's Inlet and follow up Waymouth's light, or to make for North Virginia and seek the passage in about 40° lat., according to the letter and map sent him by his friend Captain John Smith. The latter plan was adopted, and on May 14 Hudson set his face towards the Chesapeake and China. He touched at Stromo for water, and on June 15 off Newfoundland in about 48° lat. the "Half-Moon" "spent overboord her foremast." This accident compelled him to put into Sagadahoc (44° 1′ lat.), where on July 18 a mast was procured, some communication with the Indians was had, and an unnecessary battle fought, in which the ship's two "stone murderers" were employed. Sailing again on July 25, he was off Cape Cod on August 6, and on the 9th (38° 39′ lat.) "went with low sail because we were in an unknown sea." On August 18 they made Smith's Islands, 6 or 7 miles north of the entrance to the Chesapeake. On August 28, beginning the survey where Smith left off at 37° 36′ according to his map, he coasted north to Sandy Hook, passing the "overfall" of the Delaware with scarcely any notice, probably because a western inlet there would have taken him in amid Smith's surveys. On September 3, in 40° 30′, he entered the fine bay now known by the name of New York. After having gone 150 miles up what is now the Hudson river, treating with the Indians, surveying the country, and trying the stream above tide-water, he became satisfied that this course did not lead to the South Sea or China, a conclusion in harmony with that of Champlain, who the same summer had been making his way south through Lake Champlain and Lake St Sacrement to the South Sea. The two explorers by opposite routes approached within 20 leagues of each other. On October 4 the "Half-Moon" weighed for the Texel, and on November 7 put in to Dartmouth, where she was seized by the English Government and the crew detained. The voyage had fallen short of Hudson's expectations, but it served many purposes perhaps as important to the world. Among other results it exploded Hakluyt's myth, which from the publication of Lok's map in 1582 to the 3d charter of Virginia in May 1609 he had lost no opportunity of promulgating, that near 40° lat. there was a narrow isthmus, formed by the sea of Verrazano, like that of Tehuantepec or Panama.

Hudson's three failures served only to increase men's confidence in the existence of a passage by the north-west, for the discovery of which a new and strong joint-stock company was accordingly formed. The command was given to Hudson, who on April 10, 1610, sailed in the "Discoverie" of 70 tons, the ship that took Waymouth in 1602 in the same direction. How he penetrated through the long straits, discovered the great bay that bears his name, at once his monument and his grave, how he and his men wintered in its southern extremity, how in coming north in the next summer, near the east coast, half way back to the straits, he, his son, and seven of his men, in a mutiny, were put into a shallop and cut adrift on Midsummer day 1611, is told in many books. The ringleaders and half the crew perished miserably, but the "Discoverie" was finally brought home to London. No more tidings were received of Hudson, but no one doubted the complete success of his voyage. A grander company was incorporated in 1612, under Prince Henry, to complete the exploration of the passage, and to find the lost discoverer and his companions. Sir Thomas Butler was the commander in 1612, and the "Discoverie" was again the chosen ship. In 1613 the voyage was repeated by Gibbons, and once more in 1614 by Baffin; and the bay was thoroughly explored with the results which have long been universally familiar.

See *Henry Hudson, the Navigator* (Hakluyt Society, 1860)

HUDSON'S BAY COMPANY is a joint-stock association formed for the purpose of importing into Great Britain the furs and skins which it obtains, chiefly by barter, from the Indians of British North America. The trading forts of the company are dotted over the immense region (excluding Canada Proper and Alaska) which is bounded E. and W. by the Atlantic and Pacific Oceans, and N. and S. by the Arctic Ocean and the United States. From these forts the furs are despatched by boat or canoe to York Fort on Hudson's Bay, whence they are shipped to England to be sold by auction.

In the year 1670 Charles II. granted a charter to Prince Rupert and seventeen other noblemen and gentlemen, incorporating them as the "Governor and Company of Adventurers of England trading into Hudson's Bay," and securing to them "the sole trade and commerce of all those seas, straits, bays, rivers, lakes, creeks, and sounds, in whatsoever latitude they shall be, that lie within the entrance of the straits commonly called Hudson's Straits, together with all the lands and territories upon the countries, coasts, and confines of the seas, bays, &c., aforesaid, that are not already actually possessed by or granted to any of our subjects, or possessed by the subjects of any other Christian prince or state." Besides the complete lordship and entire legislative, judicial, and executive power within these vague limits (which the company finally agreed to accept as meaning all lands watered by streams flowing into Hudson's Bay), the corporation received also the right to "the whole and entire trade and traffic to and from all havens, bays, creeks, rivers, lakes, and seas into which they shall find entrance or passage by water or land out of the territories, limits, or places aforesaid." The first settlements in the country thus granted, which was to be known as Rupert's Land, were made on James's Bay and at Churchhill and Hayes rivers; but it was long before there was any advance into the interior, for in 1749, when an unsuccessful attempt was made in parliament to deprive the company of its charter on the plea of "non-user," it had only some four or five forts on the coast, with about 120 regular employés. Although the commercial success of the enterprise was from the first immense, great losses, amounting before 1700 to £215,514, were inflicted on the company by the French, who sent several military expeditions against the forts. After the cession of Canada to Great Britain in 1763, numbers of fur-traders spread over that country, and into the north-western parts of the continent, and began even to encroach on the Hudson's Bay Company's territories. These individual speculators finally combined into the North-West Fur Company of Montreal, of which Washington Irving has given an interesting description in his *Astoria*. The fierce competition which at once sprang up between the companies was marked by features which sufficiently demonstrate the advantages of a monopoly in commercial dealings with savages, even although it is the manifest interest of the monopolists to retard the advance of civilization towards their hunting grounds. The Indians were demoralized, body and soul, by the abundance of ardent spirits with which the rival traders sought to attract them to themselves; the supply of furs threatened soon to be exhausted by the indiscriminate slaughter, even during the breeding season, of both male and female animals; the worst passions of both whites and Indians were inflamed to their fiercest, and costly destruction of human life and property was the result (see RED RIVER SETTLEMENT). At last, in 1821, the companies, mutually exhausted, amalgamated, obtaining a licence to hold for 21 years the monopoly of trade in the vast regions lying to the west and north-west of the older company's grant. In 1838 Hudson's Bay Company acquired the sole rights for itself, and obtained a new licence, also for 21 years. On the expiry of this, it was not renewed, and since 1859 the district has been open to all, the Hudson's Bay Company having no special advantages beyond its tried and splendid organization. The licences to trade did not of course affect the original possessions of the company. These it retained till 1869, when they were transferred to the British Government for £300,000; in 1870 they were incorporated with the Dominion of Canada. The company, which now trades entirely as a private corporation, still retains one-twentieth of the entire grant, together with valuable blocks of land round the various forts; and these possessions will doubtless, as the country becomes opened up and colonized, yield a considerable revenue at some future time.

For further information see the *Report* of the Select Parliamentary Committee in 1857; *The Hudson's Bay Territories and Vancouver's Island*, by R. M. Martin, 1849; *An Examination of the Charter and Proceedings of the Hudson's Bay Company, &c.*, by J. E. Fitzgerald, 1849; *Notes of a Twenty-five Years' Service in the Hudson's Bay Territory*, by J. Maclean, 2 vols., 1849; *The Great Lone Land*, 1872, and *The Wild North Land*, 1873, both by Captain W. F. Butler.

HUÉ, or HUE-FOO (variously called QUANG-DUK, PHU-THUA-THIEN, and SAN HUÉ), the capital of the kingdom of Anam, is situated in a province of its own name, on the left bank of the Truòng-Tiên or Hué river, which falls into the Chinese Sea about 8 miles further down in 16° 34′ 28″ N. lat. and 107° 38′ 39″ E. long. The surrounding country is a flat alluvial plain, traversed by streams and canals, and largely occupied by extensive rice-fields; to the south-west, at a distance of about 3 or 4 miles, rise the Ai-van hills, of which Hondun has a height of 1445 feet. The centre of Hué is formed by the citadel, which was built in the reign of Gialong (d. 1820) after the plans of the French colonel Olivier. It is 7323 feet square, has six equal bastions on each side, and is surrounded by ditches about 120 feet in width, but not more than 5 or 6 feet in depth. Within are the royal residence, the houses of the ministers, the treasury, the arsenal, the barracks, &c.,—the royal residence, or Thanh Noi, having a special encincture of its own, measuring about 2290 feet each way. The inner town or citadel has a population of 30,000, inclusive of the garrison, and there are nearly as many in the suburbs and market-villages within a radius of 2½ miles. The suburb of Mang-Sa (*i.e.*, Fish Mouth) at the north-east corner of the citadel is the centre of the local traffic, and the neighbouring part of the river serves as an inner harbour. At the village Thanh Phuoc, about 2 miles below the town, are the winter quarters for the Anamese fleet, and in its vicinity is a ship-building yard and docks. On the landward slope of the sand-dune which lies between the sea and the lagoon at the river mouth stretches the village of Thuân, with about 1400 inhabitants, and serving as a sort of port to the capital. During the rainy season, October to January, the level of the Truòng-Tiên rises about 3 feet, and all the plain is laid under water. No European residents are permitted at Hué, except the members of the French legation, who have been allowed to erect consular buildings on the right bank of the river, there 1180 feet wide, directly opposite the citadel.

See *J. Roy. Geogr. Soc.*, 1849; M. Dutreuil de Rhins, "Notice géog. sur la rivière de Hué," in *Bull. Soc. Géogr. de Paris*, 1878.

HUELVA, one of the eight provinces into which Andalucia has since 1833 been divided, is bounded on the N. by Badajoz, on the E. by Seville, on the S. and S.W. by the Atlantic, and on the W. by Portugal, and has an area of 4122 square miles. With the exception of its south-east angle, where the province merges into the flat waste lands known as Las Marismas of the Guadalquivir, Huelva presents throughout its entire extent an agreeably varied surface, being traversed in a south-westerly direction by the western spurs of the Sierra Morena. The principal streams are the Odiel and the Tinto, which both fall into the Atlantic by navigable rias or estuaries; the Malagon, the Chanza, the Murtiga, which belong to the Guadiana system, and the Huelva, belonging to that of the Guadalquivir, also take their rise in this province. Iron pyrites and manganese occur in the Sierra in considerable quantities; among many important mines, which are at present inactive, may be mentioned Lagunazo, Carpio, Lapilla, San Miguel, Monterubio, Sotiel, Coronada, San Telmo, Cueva de la Mora, and Toya. Those of Rio Tinto, situated to the north-east of Valverde del Camino, and near the source of the river Tinto, are ascertained to have been known to the Phœnicians and Romans. They are at present wrought by an Anglo-German company; in 1876 the output amounted to 329,305 tons; the number of men employed approached 5000. The mines of Tharsis and Calañas, and of Buitron and Poderosa, are of corresponding importance. Saline and other mineral springs are also of frequent occurrence in the province. The soil possesses great fertility, and produces excellent pasturage; among the exports are included, besides corkwood and esparto, oranges, grapes, figs, oil, and wine. The only railways at present in the province are those constructed for mineral traffic between Rio Tinto mines and Huelva (52 miles), between Tharsis and Huelva (30 miles), and between Buitron and Poderosa and San Juan del Puerto at the head of the Tinto estuary (44 miles); but a line from Huelva to Seville is at present in course of construction. The towns of chief interest and importance in the province are, besides Huelva the capital, Ayamonte, Aracena, Valverde, La Palma, Niebla, and Moguer, with Palos its harbour. The population in 1877 was 210,641.

Huelva, the capital of the above province, is situated on the western shore of the triangular peninsula formed by the estuaries of the Odiel and Tinto, 53 miles west by south of Seville. Its streets are wide and well built, and among the public edifices may be mentioned two parish churches, an Academia Onubense, two hospitals, and a theatre. The town has a considerable coasting trade in the produce of the province, and there is a limited manufacture of esparto floor mattings; others of the inhabitants find employment in the sardine, tunny, and bonito fisheries of the neighbourhood. The chief source of the growing prosperity of Huelva, however, is in connexion with the extensive exportation of ore from the Tharsis and Rio Tinto mines. The total quantity of pyrites shipped amounted in 1872 to 261,373 tons, and in 1876 had risen to 442,201 tons (value £552,506). The exportation of manganese, however, which in 1868 amounted to 41,000 tons, did not in 1876 exceed 6972 tons (value £41,813); 7178 tons of precipitate of copper were valued at £279,956. For the accommodation of the Rio Tinto mineral traffic there is a fine pier 2682 feet long, 65½ feet wide, and 43½ feet above the level of the river at high-water, at which vessels of 2000 tons can be moored and loaded with ease. In 1876 the total number of vessels entering the port was 1409, with a tonnage of 278,594; of these 512 were British, with a tonnage of 237,610. The total imports amounted to £315,856; from Great Britain, £149,939. Total exports £918,506; to Great Britain, £833.968. Population 13,174 (1877).

Huelva is usually identified with the Onuba Æstuaria of Ptolemy, the Onoba or Onuba of Strabo, Mela, and the numismatists, described in the *Antonine Itinerary* as situated on the estuary of the river Luxia, on the road from the mouth of the Anas to Augusta Emerita. There still exist vestiges of a Roman aqueduct, which, however, are fast disappearing. The town is alleged to have been founded by the Phœnicians; the name Welba or Wuelba is due to the Moors.

HUESCA, one of the three provinces into which the old northern Spanish kingdom of Aragon was divided in 1833, is bounded on the N. by France, E. by Lerida, S. and S.W. by Saragossa, and W. and N.W. by Navarre. The total area is 7530 square miles. The surface is mountainous, especially in the north, which is occupied by the lofty offshoots of the Pyrenees, which there reach in Monte Perdido (Mont Perdu) the height of 11,430 feet. The chief river is the Cinca; but the want of natural streams has in some measure been made up for by a system of irrigation. Mineral springs are numerous throughout the province. The climate varies much according to the region; in the north cold winds from the snow-capped Pyrenees prevail, while in the south the warm summers are often unhealthy from the humidity of the atmosphere. The leading industry of Huesca is agriculture, although only a limited proportion of the soil is under cultivation. There is good summer pasturage on the mountains, where cattle, sheep, and swine are reared. The mountains are richly clothed with forests of pine, beech, oak, and fir, and the southern regions produce abundant crops of cereals, vines, mulberries, and numerous kinds of fruits and vegetables. The mineral resources include argentiferous lead, copper, iron, and cobalt, with limestone, millstone, gypsum, granite, and slate. The mining industry was formerly much more important, but the difficulties of transport caused by the absence of good roads have much hindered the development of this and other resources of the province. Huesca exports timber, cereals, wine, oil, and some cattle, and imports iron, flax, and colonial and foreign goods. The manufactures, which are unimportant, include brandy, wine, soap, linen, woollens, baize, and common crockery. The population in 1877 was 252,165.

Huesca, chief town of the above province, and the seat of a bishop, is pleasantly situated on an eminence commanding an extensive view over the surrounding fertile plain. It stands near the right bank of the Isuela, 35 miles north-east of Saragossa. The town bears many traces of its antiquity. The streets in the older part are narrow and crooked, though clean, and many of the houses witness by their size and style to the former magnificence, and by their neglected and ruined aspect to the present decay of the place. The newer streets are wide, and the houses have some claims to regularity. There are several squares and plazas, in one of which rises the imposing Gothic cathedral, begun in 1400 and finished in 1515, and enriched with fine carving. In the same plaza is the old palace of the kings of Aragon, formerly given up for the use of the now closed *Sertorio* (the university), so named in memory of a school for the sons of nativo chiefs, founded at Huesca by Sertorius in 77 B.C. (Plut., *Sert.* 15). Among the other prominent buildings are the interesting parish churches (San Pedro, San Martin, and San Juan), the archiepiscopal palace, the town-house, and various benevolent and religious houses. Huesca manufactures cloth, pottery, bricks, and leather. Its chief trade is in exporting fruit and cereals, and in importing linen, cloth, silk, hardware, and colonial produce. The population in 1877 was 7760.

Huesca is a very ancient town. Strabo (iii. 161, where some editors read *Ileosca*) describes it as a town of the Ilergetes, and the scene of Sertorius's death; while Pliny places the Oscenses in *regio Vescitania*. Plutarch (*loc. cit.*) calls it a large city. Julius Cæsar names it *Venecdora*; and the name by which Augustus knew it, *Urbs victrix Osca*, was stamped on its coins, and is still preserved on its arms. It fell under Saracen rule; but in 1096 Pedro I. of Aragon regained it, after winning the decisive battle of Alcoraz, as the termination of the two years' siege.

HUESCAR, chief town of a judicial district in the Spanish province of Almeria, is situated in a plain, surrounded by mountains on three sides, about 91 miles north-east of Granada. The town occupies a large area in proportion to the number of its houses, and although the older streets are narrow and tortuous, the newer quarters have wide and regular streets. Among the chief buildings are the court-house and the adjoining prison, the hospital, the foundling hospital, and three schools. There are two parish churches, dating respectively from 1498 and 1504. About three miles to the east are the ruins of Huescar la Vieja, a Carthaginian foundation. Pottery, woollen and hempen cloth, linen, and baize are manufactured at Huescar. There are also oil and flour mills. The export trade is not extensive. The population in 1870 was 5106.

HUET, PIERRE DANIEL (1630–1721), bishop of Avranches, is the last of those encyclopædic and massive scholars of whom France produced so many. He left no successor to his omnivorous learning, prodigious memory, and indomitable energy. He was born at Caen of a family formerly Huguenot. He lost both father and mother while still a child, and was brought up by his aunt, wife of the mathematician Gilles Macé, to whom he owed his respect for science. He says himself that the ardour of study did not possess him in earnest until in early manhood he was reading the *Géographie Sacrée* of Bochart, and suddenly became intoxicated with the desire of becoming a scholar. It may be remarked that a youth who was not already studious would hardly be reading such a book. However, the statement means that he began about that time to study not in earnest only but with passion and fury. In Hebrew alone so great was his industry that he read through the Old Testament in the original no less than four-and-twenty times during his life. At the age of twenty he had already achieved a reputation as one of the most promising scholars of the time. He went at the age of twenty-one to Paris, where he formed a friendship with Gabriel Naudé, conservator of the Mazarin library. In the following year Bochart, being invited by Queen Christina to her court at Stockholm, took his friend Huet with him. This journey, in which he saw Leyden, Amsterdam, and Copenhagen, as well as Stockholm, resulted chiefly in the discovery of some fragments of Origen's *Commentary on St Matthew*, which gave Huet the idea of editing Origen. On his return to France he assisted at the foundation of the academy of Caen, and shortly afterwards quarrelled with his friend Bochart, who accused him of having suppressed a line in Origen in the Eucharistic controversy. Shortly afterwards he removed to Paris, where he entered into close relations with Chapelain. At this time arose the famous dispute of Ancients and Moderns. Huet took the side of the Ancients against Charles Perrault and Desmarets. Among his friends at this period were Corrart and Pellisson. His taste for mathematics led him to the study of astronomy, and in 1672 he founded the Academy of Science at Caen. He next turned his attention to anatomy, and, being himself shortsighted, devoted his inquiries mainly to the question of vision and the formation of the eye. In this pursuit he made more than 800 dissections. He then learned all that was then to be learned in chemistry, and wrote a Latin poem on salt. All this time he was no mere book-worm or recluse, but was haunting the salons of Mlle. de Scudéry and the studios of painters; nor did his scientific researches interfere with his classical studies, for during this time he was discussing with Bochart the origin of certain medals, and was learning Syriac and Arabic under the Jesuit Parvilliers. Nor did he neglect the lighter walks of letters. He translated the pastorals of Longus, wrote a tale called *Diane de Castro*, and defended in a treatise on the origin of romance the reading of fiction. Then, being appointed assistant tutor to the Dauphin, he edited with the assistance of Anne Lefèvre, afterwards Madame Dacier, the well-known edition of the classics *ad usum Delphini*. He also continued to work upon his edition of Origen, and issued one of his greatest works, the *Demonstration Évangelique*. It was at the age of forty-six that he took orders, a step which he had contemplated for some years. Two years later the king gave him the abbey of Aunay, where he wrote his *Questions d'Aunay, sur l'accord de la Foi et de la Raison*, his *Critique de la Philosophie de Descartes*, his *Memoires pour servir à l'Histoire du Cartésianisme*, his dissertation on the site of the terrestrial paradise, and his discussion with Boileau on the Sublime. In 1685 he was made bishop of Soissons, but after waiting for installation for four years he took the bishopric of Avranches instead. He exchanged the cares of his bishopric for what he thought would be the easier chair of the Abbey of Fontenay, but there he was vexed with continual law suits. At length he retired to the Jesuits' House in the Rue Saint Antoine at Paris, where he ended his days, in 1721, amidst incessant labours maintained to the end, at the age of ninety-one. His great library and manuscripts, after being bequeathed to the Jesuits, were bought by the king for the royal library.

It is impossible here to enter upon an estimate of the place in philosophy, literature, and scholarship now occupied by this remarkable and omnivorous student. It has been disputed whether a writer who could so strenuously advocate the claim of philosophy could have been at the same time an orthodox believer. Perhaps like many other men Huet separated his creed from his philosophy, and while he argued on Descartes forgot that he was a bishop. In the *Huetiana* will be found the most ready materials for arriving at an idea of his prodigious labours, exact memory, and wide scholarship. His own autobiography, found in his *Commentarius de rebus ad eum pertinentibus*, was translated into English by Dr Aiken in 1726. It remains to be said that he owed the preservation of his faculties to extreme old age, and perhaps the prolongation of his life, to the rigid observance of a spare diet which he began at the age of forty, dining moderately, and taking no other supper than a little bouillon.

HUFELAND, CHRISTOPH WILHELM (1762–1836), a distinguished physician and writer on medical subjects, was born at Langensalza, 12th August 1762. His early education was carried on at Weimar, where his father held the office of court physician to the grand duchess. In 1780 he entered the university at Jena, and in the following year proceeded to Göttingen, where in 1783 he graduated in the faculty of medicine. After assisting his father for some years at Weimar, he was called in 1793 to the chair of medicine at Jena, receiving at the same time the dignities of court physician and councillor at Weimar. In 1793 he was placed at the head of the medical college and generally of state medical affairs in Berlin, with the title of privy councillor. He filled the chair of pathology and therapeutics in the university of Berlin, founded in 1809, and in 1810 became councillor of state. He died at Berlin in 1836.

Hufeland is celebrated as the most eminent practical physician of his time in Germany, and as the author of numerous works displaying extensive reading and cultivated and critical faculty. The most widely known of his many writings is the treatise entitled *Makrobiotik, oder die Kunst das menschliche Leben zu verlängern*, 1796. Of his practical works, all of the kind which cannot long retain their place in the literature of special science, the *System of Practical Medicine* ("System der praktischen Heilkunde," 3 vols., 1828) is the most elaborate. By medical writers Hufeland's services in promoting and elevating the study of the art of medicine are highly extolled. His autobiography was published in 1863. Sketches of his life and labours appeared shortly after his death by Augustin and Stourdza, 1837.

HUFELAND, Gottlieb (1760–1817), a distinguished writer on political economy and law, was born at Dantzic on 19th October 1760. He was educated at the gymnasium of his native town, and completed his university studies at Leipsic and Göttingen. He graduated at Jena, and in 1788 was there appointed to an extraordinary professorship. Five years later he was made ordinary professor. His lectures on natural law, in which he developed with great acuteness and skill the formal principles of the Kantian theory of legislation, attracted a large audience, and contributed to raise to its height the fame of the university of Jena, then unusually rich in able teachers. In 1803, after the secession of many of his colleagues from Jena, Hufeland accepted a call to Würzburg, from which, after but a brief tenure of a professorial chair, he proceeded to Landshut. From 1808 to 1812 he acted as burgomaster in his native town of Dantzic. Returning to Landshut, he lived there till 1816, when he was invited to Halle, where he died in February 1817.

Hufeland's works on the theory of legislation—*Essay upon the Fundamental Theorem of Natural Law* ("Versuch über die Grundsatz Naturrechts," 1785), *Handbook of Natural Law* ("Lehrbuch des Naturrechts," 1790), *Institutes of Positive Law* ("Institutionen des gesammten positiven Rechts," 1798), and *History and System of German Positive Law* ("Lehrbuch der Geschichte und Encyclopädie aller in Deutschland geltenden positiven Rechte," 1790)—are distinguished by precision of statement and clearness of deduction. They form on the whole the best commentary upon Kant's *Rechtslehre*, the principles of which they carry out in detail, and apply to the discussion of positive laws. In political economy Hufeland's chief work is the *New Foundation of National Economy* ("Neue Grundlegung der Staatswirthschaftskunst," 2 vols., 1807 and 1813), the second volume of which has the special title, *Theory of Money and Circulation* ("Lehre vom Gelde und Geldumlaufe"). The principles of this work are for the most part those of the *Wealth of Nations*, which were then beginning to be accepted and developed in Germany; but both in his treatment of fundamental notions, such as economic good and value, and in details, such as the theory of money, Hufeland's treatment has a certain originality. Two points in particular seem deserving of notice. Hufeland was the first among German economists to point out the profit of the *entrepreneur* as a distinct species of revenue with laws peculiar to itself. He also tends towards, though he does not explicitly state, the view that rent is a general term applicable to all payments resulting from differences of degree among productive forces of the same order. Thus the superior gain of a specially gifted workman or specially skilled employer is in time assimilated to the payment for a natural agency of more than the minimum efficiency. See Roscher, *Geschichte der Nationalökonomik in Deutschland*, pp. 654–662.

HUG, Johann Leonhard (1765–1846), Roman Catholic theologian and Biblical critic, was born at Constance, where his father was a locksmith, on June 1, 1765. After passing through the gymnasium of his native town, he proceeded in 1783 to the university of Freiburg, where he became a pupil in the seminary for the training of priests, and very early distinguished himself in the departments of classical and Oriental philology as well as of Biblical exegesis and criticism. In 1787 he became superintendent of studies in the seminary, and he continued to hold this appointment until the breaking up of the establishment in 1790. In the following year he was called to the Freiburg chair of Oriental languages and Old Testament exegesis; to the duties of this post were added in 1793 those of the professorship of New Testament exegesis. Steadily declining calls to Breslau, Tübingen, and (repeatedly) to Bonn, Hug continued to labour at his post in Freiburg for upwards of thirty years, varying the monotony of his work only by an occasional literary tour to Munich, Paris, or Italy. In 1827 he resigned some of his professorial work, but continued in active duty until in the autumn of 1845 he was seized with a painful illness, which proved fatal on March 11 of the following year.

Hug's earliest publication was the first instalment or "heft" of his *Einleitung*; in it he argued with much acuteness against Eichhorn in favour of the "borrowing hypothesis" of the origin of the synoptical gospels, maintaining the priority of Matthew, the present Greek text having been the original. His subsequent works were dissertations on the origin of alphabetical writing (*Die Erfindung der Buchstabenschrift*, 1801), on the antiquity of the *Codex Vaticanus* (1810), and on ancient mythology (*Ueber den Mythos der alten Völker*, 1812); a new interpretation of the Song of Solomon (*Das hohe Lied in einer noch unversuchten Deutung*, 1813), to the effect that the lover represents King Hezekiah, while by his beloved is intended the remnant left in Israel after the deportation of the ten tribes; and treatises on the indissoluble character of the matrimonial bond (*De Conjugii Christiani vinculo indissolubili commentatio exegetica*, 1816) and on the Alexandrian version of the Pentateuch (1818). His *Einleitung in die Schriften des Neuen Testaments*, undoubtedly his most important work, was completed in 1808 (fourth German edition, 1847; English translations by Wait, London, 1827; and by Fosdick, New York; French partial translation by Cellerier, Geneva, 1823). It is specially valuable in the portion relating to the history of the text (which up to the middle of the 3d century he holds to have been current only in a κοινὴ ἔκδοσις, of which recensions were afterwards made by Hesychius, an Egyptian bishop, by Lucian of Antioch, and by Origen) and in its discussion of the ancient versions. The author's intelligence and acuteness are more completely hampered by doctrinal presuppositions when he comes to treat questions relating to the history of the individual books of the New Testament canon. From 1839 to his death Hug was a regular and important contributor to the *Freiburger Zeitschrift für Kathol. Theologie*.

HUGH, St, of Avalon (c. 1135–1200), bishop of Lincoln, was born of a noble family at Avalon, near Pontcharra in Burgundy, about 1135. At the age of eight he entered along with his widowed father the neighbouring priory of canons regular at Villarbenoit, where he was ordained deacon at nineteen. Appointed not long after prior of a dependent cell, Hugh was attracted from that position by the holy reputation of the monks of the Grande Chartreuse, whose house he finally entered despite an oath to the contrary which he had given his superior. There he remained about ten years, receiving priest's orders, and rising to the important office of procurator, which brought him into contact with the outer world. The wide reputation for energy and tact which Hugh speedily attained penetrated to the ears of Henry II. of England, and induced that monarch to request the procurator's assistance in establishing at Witham in Somersetshire the first English Carthusian monastery. Hugh reluctantly consented to go to England, where in a short time he succeeded in overcoming every obstacle, and in erecting and organizing the convent, of which he was appointed first prior. He speedily became prime favourite with Henry, who in 1186 procured his election to the see of Lincoln. Forced sorely against his will to accept this responsible post, Hugh nevertheless set himself actively and piously to discharge its important functions, although at least once a year he retired to live for a short period as a simple monk at Witham. He took little to do with political matters, maintaining as one of his chief principles that a churchman should hold no secular office. A sturdy upholder of what he believed to be right, he let neither royal nor ecclesiastical influence interfere with his conduct, but fearlessly resisted whatever seemed to him an infringement of the rights of his church or diocese. But with all his bluff firmness Hugh had a calm judgment and a ready tact, which almost invariably left him a better friend than before of those whom he opposed; and the astute Henry, the impetuous Richard, and the cunning John, so different in other points, agreed in respecting the bishop of Lincoln. St Hugh's manners were a little apt to be boisterous at times, and his early monastic discipline had left him rigid and harsh; but, though an ascetic to himself, "so that his whole life was a continued martyrdom," he was distinguished by a broad kindliness to others, so that even the Jews of Lincoln wept at his funeral. He had great skill in taming birds, and for some years had a pet swan, which occupies a prominent place in all histories and representations of the saint. In 1200 Bishop Hugh revisited his native country and his first convents, and on the return journey was seized with an illness, of which he died at London, on November 16, 1200. Twenty years later he was canonized.

The chief life of St Hugh is the *Magna Vita S. Hugonis* (MS. in the Bodleian Library), written by Adam, the saint's private chaplain, of which a number of abridgments have been made at various dates. A *Metrical Life of St Hugh of Avalon* is preserved in two MSS. in the British Museum and the Bodleian Library. Both these *Lives* have been edited by the Rev. J. E. Dimock. The best modern source for information as to St Hugh and his time is Canon Perry's *Life of St Hugh of Avalon*, &c., 1879.

HUGH OF ST CHER, Hugo (Ugo) de S. Caro or Carensis (*c.* 1200–1263), a learned compiler of the 13th century, was born at St Cher, a suburb of Vienne, Dauphiné, about the year 1200, became a student of theology and canon law in Paris, and in 1224 entered the Dominican cloister of St Jacob there (whence he is sometimes designated as Hugo de S. Jacobo). After having taught theology for upwards of twenty years, in the course of which his learning was frequently appealed to by those in authority for the solution of difficult questions, he was in 1245 created cardinal of St Sabina by Pope Innocent IV. He died at Orvieto in 1263.

His principal works are *Correctorium Bibliæ*, a revised text of the Vulgate, prepared about 1236, hitherto unprinted, but forming the basis of the *Correctorium Bibliæ Sorbonicum*; *Postilla in universa Biblia juxta quadruplicem sensum*, first printed in 1487 (Basel) and often since, as for example at Cologne in 1621 (8 vols. fol.); *Speculum Ecclesiæ*, a manual for the priesthood (ed. prin., Lyons, 1554); and *Sacrorum Bibliorum Concordantiæ*, in the preparation of which he was assisted by the members of the community to which he belonged, hence it is sometimes known as *Concordantiæ S. Jacobi* (Lyons, 1540; Basel, 1543). See *Hist. Litt. de la France*, vol. xix.

HUGH OF ST VICTOR, Hugo a S. Victore, sometimes also known as Hugh of Paris (*c.* 1097–1141), was born, probably in the neighbourhood of Ypres, about 1097, and is known to have received his early education in the cloister of Hamersleben near Halberstadt; in 1115 he removed for the further advancement of his studies to the abbey of St Victor, which had recently been founded by William of Champeaux, the preceptor of Abelard, in the neighbourhood of Paris. There the remainder of his life was spent in teaching or in studious retirement. He died in 1141.

The works of Hugh of St Victor, who was the intimate friend of St Bernard, share all the learning, acuteness, and mysticism of the theological school which then sought to neutralize the opinions and the influence of Abelard. Of chief importance are—*Institutiones Monasticæ*, including the treatises *De arca morali*, *De arca mystica*, and *De vanitate mundi*; *De Sacramentis Fidei*, on the mysteries of the faith, and thus a complete exposition of Catholic theology; and *De Eruditione Didascalica*, in six books, which earned for its compiler the title of magister or didascalus. It forms a sort of encyclopædia of the sciences as then understood, viewed of course merely in their subordination to theology. In his treatment of Biblical introduction, the sharpness with which he separates the apocryphal from the canonical books has been noticed; but in doing so it is important also to recollect that he seems to place on a par with the New Testament the canons, the decretals, and the writings of the fathers. An Augustinian in spirit and in language, so as to deserve the titles Alter Augustinus and Lingua Augustini, by which he is frequently designated, Hugo was still more eminently the disciple of Anselm and Abelard; he, however, had a strongly marked individuality of his own, which appears in his somewhat fully elaborated theory of knowing and being. All the knowable he assigns to one or other of three spheres, that of intelligence, that of science, and that of logic. That of intelligence embraces both theory and practice. Under theory fall to be classed theology, mathematics (arithmetic, music, geometry, astronomy), and physics; practice is equivalent to ethics. Science has to do with the practical arts and industries, while logic embraces grammar, rhetoric, and dialectic. In correspondence to the trichotomous division of man, as made up of body, soul, and spirit, he speaks of a threefold eye, that of the body, that of reason, and that of contemplation. The last of these, by which God is discerned, has been totally destroyed by sin; the second has been much impaired. Faith now takes the place of contemplation; but by oratio and operatio it can attain to real convictions and genuine love. The doctrine of the Trinity he illustrates by the analogy of the human personality as spirit, wisdom, and love. The collected works have been printed at Paris in 1528, at Venice in 1588, at Mainz and Cologne in 1617, and at Rouen in 1648. They occupy three volumes (175–177) in Migne's *Patrologiæ Cursus Completus*. See *Hist. Litt. de la France*, vol. xii.; Liebner, *H. v. S. Victor*, (1832); Görres, *Die christliche Mystik*; and other works bearing on this general subject.

HUGUENOTS, THE. The word Huguenot first appears in France about the middle of the 16th century, and there is historical proof that it was imported from Geneva, where it had existed for some time as a political nickname in a form which connects it directly with the German-Swiss *Eidgenossen*, oath-comrades, confederates. In France it was used as a term of reproach for those who aimed at a reform of religion according to the pattern displayed by Calvin in his famous *Institutio Christianæ Religionis*. The name attached itself to the Reformers when, having shaken off all connexion with Lutheranism, they were beginning to organize themselves both as a church and as a political body. The Lutheran ideas, which had early come into northern France by way of Metz and Meaux, had for a short time seemed likely to prevail at the court of Francis I., where the king's love of culture welcomed whatever came from the land of the learned; the genius of Erasmus, or the sharp satire of Hutten, or Luther's weighty tractates, all seemed to him at first to be so many protests against the darkness of a monkish past; the hymns of Marot, the bright poetry of Margaret of Valois, the king's sister, harmonized not ill with the desire for a humanist reform which prevailed at the French court. But when the destructive enthusiasm of the artisans who embraced the new opinions, breaking out in attacks on the art-treasures of the churches, alienated the royal moderates, the simpler and more marked theology of the "Sacramentarians" of Geneva quietly replaced the Lutheranism of the first Reformers; and by the middle of the 16th century the new Huguenots were an unpopular party, drawing their inspiration from Calvin, and bitterly disliked by the court and the bulk of the people of France. The persecutions, varied by protection, of the reign of Francis I. had given place to a vehement desire to crush the rising heresy; the character of Henry II. and his chief advisers led them towards a thorough persecution.

Influenced by these repressive measures, and taught by Calvin's book and his frequent letters, the French Reformers now began to organize their infant churches. Hitherto they had been content to meet in quiet, to sing Marot's psalms, to listen to earnest prayer and practical discourse in some lowly chamber, deferring questions as to church government; now their ecclesiastical system began to develop itself. In 1555 the first Protestant French church was established at Paris, and almost immediately there sprang up fifteen communities, the largest being at Meaux, Poitiers, and Angers, each having its pastor, elders, and deacons, each ruling itself, and recognizing no common bond of union save that of charity and suffering. These were the heroic days of the Huguenot movement in

France, each little church striving only to fulfil the simplest ideal of Christian faith and practice, happiest when least observed, purest when least developed. Three influences had hitherto acted on French religious feeling:—that of the Lutherans, that of the ancient Vaudois churches of south-eastern France, represented by Faber, and lastly that of Calvin of Noyon, the Picard exile settled at Geneva. Now a fourth element came in: resistance had elicited organization, organization demanded leadership; and, unhappily for France and the Huguenots, the movement fell too much into the hands of secular chiefs, great lords who used it for their own political and selfish purposes.

In 1559 the churches of the Huguenots met in a first synod at Paris, eleven sending representatives. This body drew up a confession of faith, which bears throughout the mark of Calvin's hand, in its scrupulous orthodoxy, strong statements as to God's election of some to eternal life, and careful definitions of the nature and structure of the church; the synod also issued a scheme of discipline to which the churches were all to conform. No church should take lordship over any other (a church being a single community under one pastor). Each "colloque" or synod should have a freely-elected president; every pastor should come to the colloque, bringing each at least one elder or deacon from his church; this body was to meet at least twice a year; new pastors were to be appointed by it to vacant churches, on presentation by the elders and deacons; minute rules were laid down for church discipline; it was ordered that provincial synods should be held in each province, and finally that there should be from time to time a general or national synod of representatives of the whole body.

Two years later the civil war broke out (see FRANCE, vol. ix. pp. 560–564), and lasted over thirty years. At the beginning of this period we have some data as to the Huguenot strength: Beza tells us that in 1558 there were 400,000 of them; a list presented by Condé to Catherine de' Medici is said to have contained the names of 2150 (some say 2500) churches; and it is probable that the number of their open adherents had increased rapidly. John Correro, Venetian envoy in 1569, says that only one-thirtieth of the common folk, but one-third of the nobles, were Huguenots, for the strength of the movement had undoubtedly come to lie in the noblesse. The list of the Huguenot churches given by Haag (*La France Protestante*, vol. i., "Pièces justificatives," No. xviii. p. 52) provides us with data as to their distribution in France. The two centres were Languedoc in the south, and the Orléanais in the middle of the country; and a line drawn north-west to south-east through a point halfway between Paris and Orleans would nearly give the northern limit of Huguenot success. Normandy, thanks to the Châtillon influence, had many churches; in Orleans and Burgundy they were well represented. In Guyenne and throughout western France they had numerous communities. The little independent principality of Béarn, through the influence of Jeanne d'Albret, Henry IV.'s mother, was entirely Huguenot. On the other hand, though there were some churches in the Île de France and Champagne, they had little hold there; and Picardy was from the first profoundly hostile to them, while Paris became the headquarters of the Catholic League. Their churches sprang up with wonderful quickness at this time; thus we see that all the 76 congregations in Languedoc named by Haag were established between 1558 and 1562. All were characterized by a like aptitude for organization; their constitution, simple and popular, is a proof that under better auspices the French people might have well exercised the privileges of constitutional liberty; the Huguenots had a popular representation and frequent deliberative assemblies. Between 1559 and 1598 they held fifteen general church synods, and from 1573 to 1622 many political assemblies, in which all questions bearing on the interests of the "cause" were debated and decided.

The subordination of the religious to the political interests of the Huguenots became inevitable after the massacre of St Bartholomew's day, 1572; while at the same time their organization assumed a more decidedly republican tone. The horror they felt at the violent action of Charles IX. seemed to free them from all allegiance to him; they looked to England and Germany for help, to Switzerland and the United Provinces for encouragement and political example. They at once drew up an independent constitution, democratic and federative, framed chiefly after the Swiss pattern. Like all other attempts at a republican form of government, it had an aristocratic and a democratic side, the latter for the time seeming to be the stronger. For the centre of their power was now passing from the aristocracy to the burghers, from country chateaux to provincial towns. In the towns the only distinction recognized was that of pastor and elders, and these might be, and mostly were, men of the people, chosen by the people. The great nobles who sided with them, the "Politique" princes, like Alençon or Damville-Montmorency, winked for a time at this new "state within the state," the germ of that Huguenot organization which later on hampered Richelieu's path. Their system was based on the towns in their hands. In each an independent government was elected by popular suffrage, and was composed of a mayor, a council of twenty-four, and an elective chamber of seventy-five citizens, making up in all a hundred rulers. This body was a court of justice, with some amount of sovereignty. Thus, the twenty-four with the mayor had control over war, police, and "things of highest importance," though without the seventy-five they could neither pass nor abrogate laws, as to coin, taxation, truces, or terms of peace. The mayors and privy councils of the confederate towns were charged with the election of a general, a kind of Roman dictator, who was to have both a council to advise him and also five lieutenants to help and succeed him, if need were. Lastly, provision was made for a strict moral discipline.

Soon after this the Huguenots established a system of "generalities" or districts, each with its own local estates, and over these provincial councils and a states-general, thus materially strengthening their independent organization. This system continued throughout the League-wars (1574–1589), during which the religious movement was controlled by a knot of selfish political leaders, and in the course of which their point of view completely changed: for, while in the beginning they had passionately called for popular institutions and the convocation of the states-general of France, in the end they became the followers of Henry of Navarre, as heir to the French crown, representative throughout of the anti-popular temper of the Bourbon house. Under him the discontented Huguenots again reorganized themselves into nine great circles, over each of which was a council of from five to seven members, elected by delegates from the churches, and having the duty of laying their independent taxation, of levying, commanding, and paying their own troops. There was also a general assembly for all the circles (after the pattern of the United Provinces) sitting in three estates—pastors, nobles, burghers; the whole polity being representative as an aristocratic republic. This general assembly sat frequently, sent embassies to foreign powers, sometimes acting as an independent body politic.

The discontent of the Huguenots at last extorted from Henry IV. the famous edict of Nantes (2d May 1598), a document which in the main only reproduced the more favourable of the earlier edicts. Its provisions were at least as helpful for Catholics as for Protestants; it was always being so modified as to show less and less favour to the Calvinists, who were little satisfied with it. They had dreamed of dominance, had hoped for equality, and were now put off with tolerance. For whatever Henry IV. might feel about their faith, he was determined, as he once told Sully, "to reduce to nothing the Huguenot faction," to destroy their political independence, and by closing up the civil strife to secure the solid establishment of the central monarchy. The edict allows public exercise of the Huguenot faith in the houses of nobles and gentry, and in a few named towns; it gave the sectaries full civil rights, and made them eligible to all civil offices; in several parliaments mixed chambers were established; the education of their children was left in their own hands.

We find that about 1590 the Huguenots had exercise of their worship in about 3500 chateaux, and in about 200 towns or bourgs, chiefly in the south and west. In most parts of the north, except Paris and round Rouen and Amiens, they had one place for worship in each bailliage or sénéchaussée. In 1598 we have a list of about 150 places granted by Henry IV. to the Huguenots for their safety, the chief groups being in the generalities of Bordeaux and Montpellier, and in Poitou; these were either free towns, like La Rochelle, Nîmes, Montauban, or towns belonging to private gentlemen, or towns belonging to the king, which had fallen into Huguenot hands during the wars.

Throughout the next quarter of a century we trace their history in a series of outbursts, indicating noble impatience and Calvinistic dissatisfaction. The siege and fall of La Rochelle (1627–1628) brought this period to an end. During this time their number seems to have increased; at the accession of Louis XIII. they had about 500 churches; in 1622 and 1628 we have lists of 688; in 1637 no less than 720 are enumerated, though of these 49 were either vacant or suspended. Richelieu and Mazarin treated them with statesman-like prudence; their synods were discouraged, their grumblings ceased; they grew in piety and purity as the political arena was closed to them, and the noble houses one by one deserted them. This was the time of their material prosperity, and of their important contribution to the welfare of France which Louis XIV. so rudely cast away.

As that king got hold of his power, the tranquillity of the Huguenots waned. In 1657 they were forbidden to hold colloquies, lest perchance they should take to politics; in 1659 they were practically told to hold no more synods. Soon the court went further: conversions were undertaken. Wherever a pastor could be bribed, won over, or got rid of, his "temple" was at once torn down; the Huguenot worship became almost impossible in towns, and lingered on in a few castles, whereby it fell still more under the royal displeasure. As his conscience grew morbid, under Madame de Maintenon's direction, Louis XIV. became more eager to expiate his own crimes by punishing the heretics. Between 1657 and 1685 520 churches were rooted up; Anquetil declares that 700 had been destroyed before 1685. All through this period, while thousands yielded to oppression or bribery, thousands also fled the land; the emigration began in 1666 and went on for fifty years. It is probable that in 1660 there were over two millions of Huguenots, the best and thriftiest citizens in the land; it is said, though no figures can be trusted, that in all fully a million of French subjects escaped from their inhospitable fatherland. At last in 1685, thinking that the Huguenots were as good as suppressed, Louis XIV. revoked the edict of Nantes (see FRANCE, vol. ix. p. 579). The revocation was the sentence of civil death on all Huguenots; it crushed more than half the commercial and manufacturing industry of the kingdom. It is said that at the time of it there were 1000 Huguenot pastors; of these over 600 escaped from France, 100 were slain or sent to the galleys, the remainder conformed or disappeared.

The war of 1689 called attention away from the persecuted remnant of the Huguenots, and they had a breathing space in Languedoc, the Cevennes, and Dauphiné; but directly the peace of Ryswick was signed, repression began again, and consequently, when the Spanish succession war commenced, the Huguenots of the "Desert," that is, of the country about Nîmes, broke out after endless provocations into open war, which lasted two years, and for a while defied all the efforts of the court. Marshal Villars was at last sent down, and by mingled gentleness and severity he both secured the submission of the gallant Cavalier, the chief leader of the Huguenots, and the defeat of the more determined of the mountaineers. Throughout the rest of the century the down-trodden Protestantism of France was kept alive chiefly by the exertions of Antoine Court, the apostle of the Desert, who never lost faith in the cause, and who reorganized the dying churches, breathing into them fresh life. Though under the influence of oppression and excitement, the Huguenot story is here and there disfigured by fanatical outbursts of the "prophets" and "prophetesses," still on the whole the account of their endurance is among the most remarkable and heroic records of religious history.

After the interference of Voltaire in behalf of Calas, their sufferings came almost to an end; the general change of opinion, the steady weakening of the Catholics, the indolence or good nature of the sovereign, forbade the scandals of the past, until at last in 1787, under Necker's influence, Louis XVI. signed a memorable edict which restored, after 102 years' deprivation, their civil status to the Huguenots. The Revolution of 1789 carried justice a stage further; among the many titles of the Revolution to the gratitude of posterity none is more marked than the complete restoration of the non-Catholic elements of French society to their rights. From that moment to the present time the descendants of the Huguenots have had peace.

There are now about half a million Calvinists in France; by the census of 1872 they numbered 467,531 souls, of whom about 100,000 were in the north, and the rest mostly in their old quarters in the south; in the Gard, the ancient Desert, nearly a quarter of the whole body still abide. Of late years the Protestant Church in France has shown a tendency to division into two parties, that of the more rigid Calvinistic opinions, and that of a more liberal and less orthodox theology. In either case they form a group of loyal citizens, on whom French politicians now look with favour. The old reproach that "the Huguenots are all republicans" has at last turned to their credit.

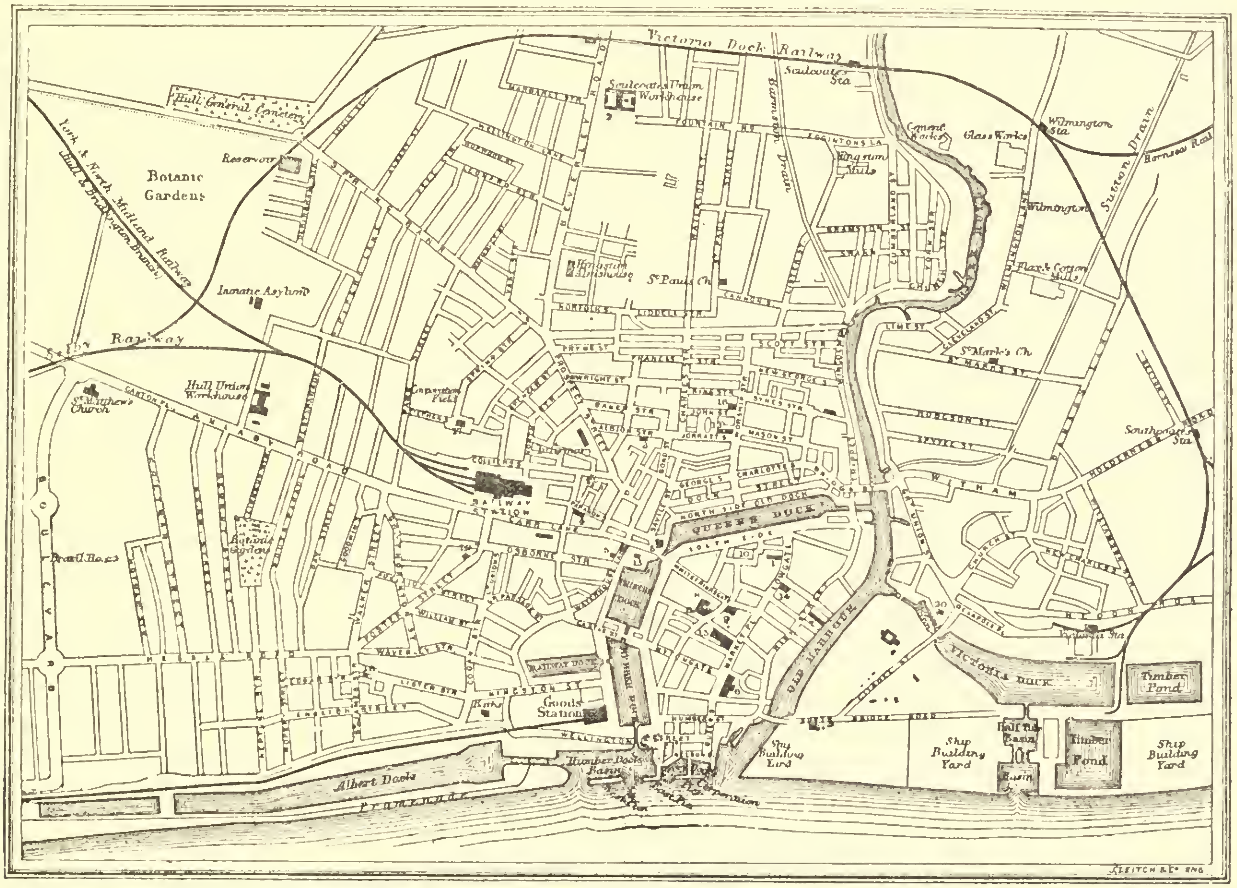
The persecutions which checked all wholesome developments at home, whether religious, literary, or commercial, were favourable to their growth abroad; and we consequently find that in literary and artistic excellence the Huguenots have taken their full share. Their first attention was naturally called to theology, in which the names of Calvin and Farel, Beza, Daillé, the Drélincourts, the learned S. Desmarets, Jortin, P. Jurieu, Labadie the mystic, the Leclercs, the great Hebraist Mercier, Mestrezat the preacher, the old hero Duplessis Mornay, Salmasius, J. Saurin, first of Protestant orators, and a crowd of lesser men testify to their activity in this branch. Add to these the dictionary of Bayle, the works of the Basnages, Morin the Orientalist, Pithou, the Daciers, Étienne Dolet, Ramus, Le Févre of Etaples, above all Scaliger, as leaders in learning; in history, Bénoît, Bongars, Palma Cayet, Hubert Languet, Béroalde, and Rapin-Thoyras; and with them the political writer Hotman. Of lawyers they claim Baudouin, Cujas, Coras, Doneau, Hérault, and Godefroy, famed as the most learned of jurisconsults. In science they have the Cuviers, Desmaizeaux, Dubois the chemist, Paré, father of modern surgery, Papin, herald of the steam-engine, the physician Joubert, L'Ecluse the botanist, and the Hubers. In art they lay claim to Crispin, J. Cousin, Pallissy, Simon the engraver, the Picarts, and Goujon the architect. Their poets are Marot and Margaret of Valois. The general effect of this activity is hard to gauge: from Amsterdam and Berlin, Geneva and London, issued sermon, political pamphlet, controversial polemic; but these efforts had no settled audience, they failed to win the ear of France. The same is true of their religious heroism; though it seemed to be exactly what was wanted to strengthen the national character, the confessors were scattered, like the Jews, among the nations, and ceased to affect the progress of their fatherland. In the Revolution we can see traces of their mental and moral activity; it may be that their day of influence is not yet over. For their history is a standing marvel, illustrating the abiding power of strong religious convictions, narrow in theory, pure in practice; they have stood as much ill-usage as has befallen any branch of Christ's church. It remains for their descendants to show to France that their creed goes well with freedom and advance,—that the religious instinct, so deeply implanted in man, is a true friend of orderly and rational national life. Religion which does not abuse its power, a freedom from divided allegiances, an aptitude for constitutional institutions, and an intelligent belief in the sovereignty of the people—these are the elements which the Huguenots of to-day can bring to the service of the republic under which they dwell safely, none making them afraid.

Authorities.—Calvin, *Institutio Christianæ Religionis*, and *Lettres*, ed. J. Bonnet, 1854; Haag, *France Protestante*, 1846; Meaux, *Luttes réligieuses au XVI. siècle*, 1879; Arquez, *Assemblées politiques des Réformés*, 1859; E. Hugues, *Restauration de Protestantisme en France*, 1875; Mignet, *Établissement . . . du Calvinisme à Genève*; G. de Félice, *Hist. des Protestants en France*; E. Bénoît, *Hist. de l'Édit de Nantes*; C. Coquerel, *Eglises du Désert*; A. Court, *Troubles des Cévennes*; Bonnemère, *Hist. des Camisards*; Guizot, *Hist. de France*, 1872; Merle d'Aubigné, *Réformation au XVI. siècle*; Professor H. M. Baird, *History of the Rise of the Huguenots*, 2 vols., 1880. (G. W. K.)

HULL, or KINGSTON-UPON-HULL, a municipal and parliamentary borough, and one of the principal seaport towns of England, is, though a county in itself, locally within the East Riding of Yorkshire, situated in 53° 44′ N. lat. and 0° 10′ W. long., on the west side of the Hull, where it discharges into the estuary of the Humber, 20 miles from the German Ocean at Spurn Head. By rail it is 41½ miles east-south-east of York. Branch lines of the North-Eastern Railway connect it with the principal towns in the East Riding; and by means of the steam ferry across the Humber to New Holland it has communication with the Great Northern and the Manchester, Sheffield, and Lincolnshire Railways. The town stands on a level plain so low as to render embankments necessary to protect it from inundation, and the flatness of the surrounding country as far as the eye can reach is unbroken by anything that can be properly termed an elevation. The older portion of the town, which is completely enclosed between the docks on the north and west and the Hull and Humber on the east and south, was originally very densely inhabited, and its streets were narrow and irregular, but in this respect it has lately undergone great improvements. The streets in the modern quarter are spacious and regular, and the villas of the wealthier classes occupy the suburbs. A pier fronting the Humber affords a pleasant promenade. To the north of the town there is a public park presented in 1860 by Z. C. Pearson, then mayor of Hull. It is 27 acres in extent, is tastefully laid out, and contains full-sized marble statues of her Majesty the Queen and of the late Prince Consort. A botanic garden about 40 acres in extent was opened in 1880. There is a large public cemetery, which possesses separate chapels for churchmen and dissenters. The town is supplied with water from springs about 4 miles distant, two condensing engines of 60 horse power each being employed in pumping it.

The principal public buildings are the town-hall in Lowgate, completed in 1866 in the Italian Renaissance style, having a very richly adorned façade, with a central dome 135 feet in height resting on eight arches, and containing a clock and bell; the exchange in the same street, completed also in 1866, in a less ornate form of the Italian style, containing a hall 70 feet long by 40 feet wide, and the offices of the Hull chamber of commerce and the Hull guardian society for the protection of trade; the corn exchange in High Street, a plain building with a great hall 157 feet long by 36 feet wide; the custom-house in Whitefriargate; Trinity House, a handsome brick building in the Tuscan style, erected in 1753 by the guild of Trinity House, originally established in 1369; Charterhouse, rebuilt in 1645, belonging to a foundation for the support "of the feeble and old," which was established by Sir Michael de la Pole in 1384; the dock offices, an elaborate building in the Italian style; the royal institution, a large and beautiful edifice in the Roman Corinthian style, opened by Prince Albert in 1854, possessing a museum, a library of 40,000 volumes, and accommodation for the meetings of the literary and philosophical society; the new general post-office, in the modern Italian style, opened in 1877; the prison, constructed on the new model principle, opened in 1869; the music-hall, in the Renaissance style; the theatre royal, opened in 1873, a stuccoed structure with a handsome Corinthian front; the public baths and washhouses, in the Tudor style, completed in 1850 at a cost of £12,000. The only church of special interest or architectural merit is that of Holy Trinity, on the west side of the market-place, a cruciform edifice in the floral Gothic style, originally founded at the end of the 13th century, but of various dates, and lately completely restored at a cost of over £30,000, having an extreme length of 272 feet, the breadth of the nave being 72 feet and that of the chancel 70 feet. It possesses a very fine west window, filled with stained glass in 1862 at a cost of £1000, and is surmounted at the intersection of the nave and transept by a noble tower, with finely decorated pinnacles, rising from the point of intersection to the height of 140 feet. St Mary's church in Lowgate, in the Perpendicular style, was originally founded in the beginning of the 14th century, but has been nearly all rebuilt since that period, the tower being erected in 1696, and the whole building restored in 1863–65 at a cost of £10,000. The principal educational establishments are the grammar school, founded in 1486; the Hull and East Riding college, a proprietary school for sons of gentlemen; the Trinity House marine school, founded in 1716; Cogan's charity school for girls, founded in 1763; national, British, Catholic, Wesleyan, and school board schools; a ragged and industrial school; and the Humber industrial school ship "Southampton." Among the other institutions for ministering to the intellectual wants of the community are the school of science and art, the literary and philosophical society, the royal institution, the mechanics' institution, the Hull church institute and library, the young people's Christian and literary institute, the Catholic institute, the Lyceum library and reading-room, and the literary club. The charities and benevolent foundations are numerous, and, in addition to Charterhouse and Trinity House, already mentioned, include the infirmary, founded in 1782, and extended by the addition of two wings in 1840, and of detached fever wards in 1874; the Hull and Sculcoates dispensary, founded in 1814; the hospital for sick children, opened in 1873; the homœopathic dispensary; the blind institute; the borough lunatic asylum, erected in 1849, with accommodation for 160 patients; the Hull workhouse, the Sculcoates union workhouse, the seamen's and general orphan asylum; the sailors' home, opened in 1860; the sailors' orphan home and school, erected in 1863; Gregg's hospital, founded in 1416, Lister's in 1641, and Crowle's in 1661.

Hull ranks as the third port of the United Kingdom, being surpassed in the value of its exports and imports by London and Liverpool only. The original harbour occupied that part of the river Hull which faced the old town, but in 1774 an Act was passed for forming a dock on the site of the old fortifications, having its entrance at the upper end of the old harbour. This dock, known for some time as the Old dock, is 1703 feet long and 254 feet broad, and its area is 10 acres. In 1809 the Humber dock at the south end of the town was opened; it is 914 feet long and 342 feet broad, and its area is 7 acres. These two docks were connected by a third, opened in 1829, at first named the Junction dock, its length being 645 feet and a breadth of 238 feet; its area is 6 acres. After a visit paid to Hull by the Queen and Prince Albert in 1854, the name of the Old dock was changed to the Queen's dock, and that of the Junction dock to the Prince's dock. The Railway dock, opened in 1846, extends to 3 acres. In 1850 the Victoria dock was opened, on the east side of the river Hull, with entrances from it and the



Plan of Hull.

Humber, and occupied an area of about 12½ acres. In 1863 this dock was extended 7½ acres eastward. In connexion with this dock was a timber pond of 9½ acres, subsequently enlarged to 14 acres, and a new one of 11 acres was about the same date constructed near it. The Albert dock, opened by the prince of Wales in July 1869, occupies an area of 24½ acres, and has a length of 3370 feet, with a breadth at the eastern end of 480 feet, and at the western end of 200 feet. To the west of it an additional dock of 6 acres was opened in May 1880. A capacious graving dock, 460 feet long, which is entered from the last-mentioned dock is now (1880) in course of construction. Another dock of 24 acres, to the west of the new West dock, has been commenced. Rails in connexion with the North-Eastern Railway are laid along the quays of the docks. In 1880 an Act was obtained for a railway from Hull to Barnsley, and a dock in connexion with it. The shipping trade of Hull is chiefly with the Baltic ports, Denmark, Norway, Germany, and Holland; but it has also regular steam communication with the other principal ports of Europe, as well as with the United States, the Black Sea, Egypt, &c. In 1878 the number of ships that entered was 4996, with a tonnage of 1,750,977, and the number that cleared 4802, with a tonnage of 1,788,214. For the five years ending 1878 the average number of ships that entered was 4987, with a tonnage of 1,742,120, while 4857 cleared, with a tonnage of 1,726,151.

The value of imports of foreign and colonial merchandise in 1878 was £17,849,197, and the average value for the five years 1874–78 was £18,038,263. The value of exports of produce of the United Kingdom in 1878 was £19,109,797, and the average value for the five years was £21,267,391. Hull is one of the principal shipping ports for the manufactures of Yorkshire and Lancashire, and imports large quantities of grain from Russia, Prussia, America, and the British colonies, and of timber from Norway and Sweden. The import of cattle is very large, and a commodious cattle depôt has been constructed. The deep-sea fishing is extensively prosecuted, and, in addition to several small steamers, employs about 450 boats, with 2500 hands. Whale-fishing, once an important industry, is now discontinued.

The staple industry of Hull is seed-crushing for oil and cake making. It possesses extensive engineering works and foundries, large iron shipbuilding yards, rope-yards, sail-lofts, tanneries, breweries, flax and cotton mills, chemical works, and manufactures of blue and black lead, paints, colours, and varnishes, Portland and Roman cement, phosphate of lime, tobacco, starch, paper, soap, furniture, and organs.

The population of the parliamentary borough, which was 84,690 in 1851, had in 1871 reached 123,408. The population of the municipal borough in 1861 was 97,661, and in 1871 it had increased to 121,892. The area of the municipal borough is 3635 acres, and of the parliamentary 4447 acres.

History.—Hull originated in the two nearly contiguous villages of Myton and Wyke, the latter of which was a considerable port not long after the Norman Conquest. For some period the united village was known as Myton-Wyke, but even before the reign of Edward I. it is also occasionally mentioned as Hull. In 1298 Edward I., on returning from the battle of Dunbar, happened to pay it a visit, when, struck with its advantages as a commercial port, he purchased it from the abbot of Meaux, with the purpose of fortifying it. He created the town a manor of itself, bestowed upon it the name of Kingston-upon-Hull, and issued a proclamation offering to all who settled in it special advantages. In 1299 it received a royal charter constituting it a free borough. About the same time the improvements on its harbour were completed, and from this period its increase in prosperity was rapid and uninterrupted. In 1316 a regular ferry was established between Hull and Barton in Lincolnshire, and a few years later the town was fortified with walls and ditches. Much of the early prosperity of the town was due to the enterprise of the famous merchants, the De la Poles, who were high in favour with successive monarchs, and the head of which house was in 1385 created earl of Suffolk. Such was the importance of the town in the reign of Edward III. that in 1359 it supplied for the armament against France 16 ships and 466 seamen, the quota of London being 25 ships and 662 seamen, and that of Newcastle 17 ships and 314 seamen. In the reign of Richard II. the fortresses were repaired and a strong castle was erected on the east side of the river Hull. By Henry VI. additional charters were granted, erecting the town and liberties into a county in itself, under the designation of "The Town and County of the Town of Kingston-upon-Hull," constituting it a corporate town, and appointing, instead of a mayor and bailiffs, for its government a mayor, sheriff, and aldermen. In the Wars of the Roses it strenuously maintained the cause of Lancaster; and so zealous was it in its loyalty that after the borough funds were exhausted additional money was raised by the sale of the materials of the market cross. In the 15th, 16th, and 17th centuries it suffered greatly from the plague, and in 1527 and 1549 much damage was caused by inundations. During the insurrection in 1536 called the Pilgrimage of Grace, originated by the dissolution of the monasteries, Hull was seized by the insurgents, but, after the dispersion of the main body at Doncaster, the ringleaders in the town were seized by the magistrates and executed. During the second rebellion in Yorkshire in 1537 the town was taken possession of by the insurgents headed by Sir Robert Constable, and held for a month, but the loyal inhabitants, surprising them in the middle of the night, compelled them to surrender; many of them were executed, and the body of Sir Robert Constable was hung in chains over the Beverley gate. In 1540 Hull was visited by Henry VIII., who, after a careful survey of the town and neighbourhood, gave directions for the erection of a castle and other fortifications, for the cutting of a canal from Newland to Hull in order to provide "additions of fresh water," and for the improvement of Suffolk palace, originally erected by the De la Poles, but since then acquired by the crown. During the parliamentary war the possession of Hull was an object of ambition to both parties on account of its importance as a depôt for arms and military stores. In 1642 the governor, Sir John Hotham, refused to admit Charles I. into the town. In 1643 and 1644 it sustained two long sieges and many vigorous attacks by the royalists.

In 1534 Hull was made the see of a suffragan bishop, but the office was abolished on the death of Edward VI. By the 33d of Edward I. the town returned burgesses to parliament. The privilege was afterwards for some time in abeyance till the 12th of Edward II., since which period it has returned two members.

Among the eminent natives of Hull, besides the De la Poles, are Andrew Marvell, William Mason the friend of Gray the poet, William Wilberforce, and Major-General Perronet Thompson.

The principal histories of Hull are those of Gent, 1735, reprinted 1869 Hadley, 1788; Tickell, 1798; Frost, 1827; and Sheahan, 1864. See also Symons's *High-Street, Hull, some years since, and Biographical Sketches interspersed with Historical Accounts of the Town, Ancient and Modern, &c.*, 1862; Wooley's *Statutes relating to Kingston-upon-Hull*, 1830; Symons's *Hullinia, or Selections from Local History*, 1872, and *Sketches of Hull Authors*, 1879.

HULS, a town of Prussia, in the circle of Kempen, and government district of Düsseldorf, is situated at the terminus of a branch railway line to Crefeld and Düsseldorf, 4 miles north of Crefeld and 17 north-west of Düsseldorf. It possesses manufactures of damask and velvet, and in the neighbourhood ironstone is obtained. The population in 1875 was 6096.

HULSE, JOHN (1708-1789), founder of the Hulsean lectureship at the university of Cambridge, was born at Middlewich, in Cheshire, in 1708. Entering St John's College, Cambridge, he graduated in 1728, and on taking holy orders was presented to a small country curacy. His father having died in 1753, Hulse succeeded to his estates in Cheshire, where, owing to feeble health, he lived in retirement till his death in 1789. He bequeathed his estates to Cambridge University for the purpose of maintaining two scholars at St John's College, of founding a prize for a dissertation, and of instituting the offices of Christian advocate and of Christian preacher or Hulsean lecturer. By a statute in 1860 the Hulsean professorship of divinity was substituted for the office of Christian advocate, and the lectureship was considerably modified. The first course of lectures under the benefaction was delivered in 1820. In 1830 the number of annual lectures or sermons was reduced from twenty to eight; subsequently they were restricted to four. The annual value of the Hulse endowment is between £800 and £900, of which eight-tenths go to the professor of divinity and one-tenth to the prize and lectureship respectively.

HUMBLE-BEE, a name applied by phonetic instinct under various inflexions (such as "Bumble-bee" in England provincially, and "Hummel" in Germany) to the large bees of the genus *Bombus* (which, like the French "Bourdon," is probably also suggested by the noise made by these insects). They belong to the social section of the great family *Apidæ*, of which the common hive-bee is the type, and, like that well-known insect, live in colonies composed of the two sexes and neuters. Instead of a single female (or queen), however, many are found in one nest; and the workers do not hibernate. The female also differs from the queen hive-bee in having dense fringes of hairs on the pollen-plates of the hind legs, and a widened base to the hind tarsi, a structure necessitated by her having to work single-handed at the commencement of the season, as the workers and males do not survive the winter. Early in the spring these large hibernated females may be observed on the wing, each becoming the founder of a fresh colony, in which the neuters are first produced. There are two kinds of females, the smaller one only producing male eggs, but not surviving the winter. The number of individuals in a colony varies with the different species, and as a rule is least in those building their nest above ground. In one very common subterranean species, *Bombus terrestris*, as many as 107 males, 56 females, and 180 workers have been found in one nest. There is considerable difference between the males, females, and neuters; the last two differ, however, but little except in size, whereas the males often exhibit a very varying coloration, and have structural peculiarities, such as an additional segment to the abdomen, longer antennæ and tongue, no pollen-basket, &c. They have also no sting, whereas both female and worker are armed like the hive-bee. Great difficulty exists in referring these three constituents to their proper species, owing to individual variation, alteration with age, and the difficulty of seeing all the members of a colony at the same time; so that naturalists are not by any means agreed as to the specific status of many of them, and the synonymy is very complicated. The nests are not constructed after the symmetrical fashion of those of the hive-bee, but consist of a collection of oval brownish cells, at first few in number, but receiving additions and extensions as the brood increases, and accompanied by cells containing pollen and honey. The workers assist in rearing the larvæ, and in disengaging the individuals from their pupal integuments as they reach the perfect state; and it has been noticed that this metamorphosis is accelerated by a kind of incubation. The nests are made under bushes, in banks, &c., sometimes as much as 5 feet from the surface. A well-known one is made by the "Moss-carder" humble-bee, *Bombus muscorum*, which has often been observed collecting the natural material for its dome, working in line. As usual with provident or social animals, these interesting insects are subject to encroachment by parasites of various kinds; most noteworthy among which are some species (there are three or four in England) of the closely allied genus *Apathus* (or *Psithyrus*), superficially resembling exactly the true humble-bees, but with no pollen-collecting apparatus, and no workers. They exist apparently on friendly terms with their hosts, whose stores are at times materially preyed upon by the larvæ of *Volucella*, a genus of *Diptera* or two-winged flies also resembling humble-bees. Various beetles, such as *Antherophagus*, *Cryptophagus*, *Leptinus*, &c., and the larvæ of *Tinea pellionella*, a small moth, also occur in their nests.

As regards distribution, the *Bombi* are found in Europe, America (North and South), Africa, India, China, and Java, but not in Australasia, where, indeed, it has even been attempted to introduce some species for the purpose of fertilizing the introduced clover, for which the structure of the native insects is apparently insufficient. It is, however, in the northern zone that they flourish best, their hardy nature enabling them to exist in the Arctic regions, as far as man has penetrated; and the numerous additions continually being made to the list of known species from the Caucasus, the Amur district, Turkistan, Arizona, &c., point, not only to a wide geographical range, but to a large adaptation to some useful end. The experiments of Darwin, Müller, and others show how important a part is played by humble-bees in the economy of nature as plant fertilizers; and, though perhaps not exhibiting such highly-developed instincts as the hive-bee, they possess sufficient reasoning power to enable them, by perforating the base of the calyx of certain flowers, to obtain otherwise inaccessible honey.

HUMBOLDT, Friedrich Heinrich Alexander, Baron von (1769–1859), a distinguished naturalist and traveller, was born at Berlin, September 14, 1769. His father, who was a major in the Prussian army, belonged to a Pomeranian family of consideration, and was rewarded for his services during the Seven Years' War with the post of royal chamberlain. He married in 1766 Maria Elizabeth von Colomb, widow of Baron von Hollwede, and had by her two sons, of whom the younger is the subject of this notice. The childhood of Alexander von Humboldt was not a promising one, as regards either health or intellect. His characteristic tastes, however, soon displayed themselves; and from his fancy for collecting and labelling plants, shells, and insects he received the playful title of "the little apothecary." The care of his education, on the unexpected death of his father in 1779, devolved upon his mother, who discharged the trust with constancy and judgment. Destined for a political career, he studied finance during six months at the university of Frankfort-on-the-Oder; and a year later, April 25, 1789, he matriculated at Göttingen, then eminent for the lectures of Heyne and Blumenbach. His vast and varied powers were by this time fully developed; and during the vacation of 1789 he gave a fair earnest of his future performances in a scientific excursion up the Rhine, and in the treatise thence issuing, *Mineralogische Beobachtungen über einige Basalte am Rhein* (Brunswick, 1790). His native passion for distant travel was confirmed by the friendship formed by him at Göttingen with George Forster, Heyne's son-in-law, the distinguished companion of Cook's second voyage. Henceforth his studies, which his rare combination of parts enabled him to render at once multifarious, rapid, and profound, were directed with extraordinary insight and perseverance to the purpose of preparing himself for his distinctive calling as a scientific explorer. With this view he studied commerce and foreign languages at Hamburg, geology at Freiberg under Werner, anatomy at Jena under Loder, astronomy and the use of scientific instruments under Zach and Köhler. His researches into the vegetation of the mines of Freiberg led to the publication in 1793 of his *Floræ Fribergensis Specimen*; and the results of a prolonged course of experiments on the phenomena of muscular irritability, then recently discovered by Galvani, were contained in his *Versuche über die gereizte Muskel- und Nervenfaser* (Berlin, 1797), enriched in the French translation with notes by Blumenbach.

In 1794 he was admitted to the intimacy of the famous Weimar coterie, and contributed (June 1795) to Schiller's new periodical, *Die Horen*, a philosophical allegory entitled *Die Lebenskraft, oder der rhodische Genius*. In the summer of 1790 he paid a flying visit to England in company with Forster. In 1792 and 1797 he was in Vienna; in 1795 he made a geological and botanical tour through Switzerland and Italy. He had obtained in the meantime official employment, having been appointed assessor of mines at Berlin, February 29, 1792. Although the service of the state was consistently regarded by him but as an apprenticeship to the service of science, he fulfilled its duties with such conspicuous ability that he not only rapidly rose to the highest post in his department, but was besides entrusted with several important diplomatic missions. The death of his mother, November 19, 1796, set him free to follow the bent of his genius, and, finally severing his official connexions, he waited for an opportunity of executing his long-cherished schemes of travel. On the postponement of Captain Baudin's proposed voyage of circumnavigation, which he had been officially invited to accompany, he left Paris for Marseilles with Bonpland, the designated botanist of the frustrated expedition, hoping to join Bonaparte in Egypt. The means of transport, however, were not forthcoming, and the two travellers eventually found their way to Madrid, where the unexpected patronage of the minister d'Urquijo determined them to make Spanish America the scene of their explorations.

Armed with powerful recommendations, they sailed in the "Pizarro" from Corunna, June 5, 1799, stopped six days at Teneriffe for the ascent of the Peak, and landed, July 16, at Cumana. There Humboldt observed, on the night of the 12–13th of November, that remarkable meteor-shower which forms the starting-point of our acquaintance with the periodicity of the phenomenon; thence he proceeded with Bonpland to Caracas; and in February 1800 he left the coast for the purpose of exploring the course of the Orinoco. This trip, which lasted four months, and covered 1725 miles of wild and uninhabited country, had the important result of establishing the existence of a communication between the water-systems of the Orinoco and Amazon, and of determining the exact position of the bifurcation. On the 24th of November the two friends set sail for Cuba, and after a stay of some months regained the mainland at Cartagena. Ascending the swollen stream of the Magdalena, and crossing the frozen ridges of the Cordilleras, they reached

Quito after a tedious and difficult journey, January 6, 1802. Their stay there was signalized by the ascent of Pichincha and Chimborazo, and terminated in an expedition to the sources of the Amazon *en route* for Lima. At Callao Humboldt observed the transit of Mercury on November 9, and studied the fertilizing properties of guano, the introduction of which into Europe was mainly due to his writings. A tempestuous sea-voyage brought them to the shores of Mexico, and after a year's residence in that province, followed by a short visit to the United States, they set sail for Europe from the mouth of the Delaware, and landed at Bordeaux, August 3, 1804.

Humboldt may justly be regarded as having in this memorable expedition laid the foundation of the sciences of physical geography and meteorology in their larger bearings. By his delineation (in 1817) of "isothermal lines," he at once suggested the idea and devised the means of comparing the climatic conditions of various countries. He first investigated the rate of decrease in mean temperature with increase of elevation above the sea-level, and afforded, by his investigations into the origin of tropical storms, the earliest clue to the detection of the more complicated law governing atmospheric disturbances in higher latitudes; while his essay on the geography of plants was based on the then novel idea of studying the distribution of organic life as affected by varying physical conditions. His discovery of the decrease in intensity of the earth's magnetic force from the poles to the equator was communicated to the Paris Institute in a memoir read by him, December 7, 1804, and its importance was attested by the speedy emergence of rival claims. His services to geology were mainly based on his attentive study of the volcanoes of the New World. He showed that they fell naturally into linear groups, presumably corresponding with vast subterranean fissures; and by his demonstration of the igneous origin of rocks hitherto held to be of aqueous formation, he contributed largely to the spread of juster views than those then prevailing.

The reduction into form and publication of the encyclopædic mass of materials—scientific, political, and archæological—collected by him during his absence from Europe was now Humboldt's most urgent desire. After a short trip to Italy with Gay-Lussac for the purpose of investigating the law of magnetic declination, and a sojourn of two years and a half in his native city, he finally, in the spring of 1808, settled in Paris with the view of securing the scientific co-operation required for bringing his great work through the press. This colossal task, which he at first hoped would have occupied but two years, eventually cost him twenty-one, and even then remained incomplete. With the exception of Napoleon Bonaparte, he was now the most famous man in Europe. A chorus of applause greeted him from every side. Academies, both native and foreign, were eager to enrol him among their members. Frederick William III. of Prussia conferred upon him the honour, without exacting the duties, attached to the post of royal chamberlain, together with a pension of 2500 thalers, afterwards doubled. He refused the appointment of Prussian minister of public instruction in 1810. In 1814 he accompanied the allied sovereigns to London. Three years later he was summoned by the king of Prussia to attend him at the congress of Aix-la-Chapelle. Again in the autumn of 1822 he accompanied the same monarch to the congress of Verona, proceeded thence with the royal party to Rome and Naples, and returned to Paris in the spring of 1823.

The French capital he had long regarded as his true home. There he found, not only scientific sympathy, but the social stimulus which his vigorous and healthy mind eagerly craved. He was equally in his element as the lion of the *salons* and as the *savant* of the institute and the observatory. Thus, when at last he received from his sovereign a summons to join his court at Berlin, he obeyed indeed, but with deep and lasting regret. The provincialism of his native city was odious to him. He never ceased to rail against the bigotry without religion, æstheticism without culture, and philosophy without common sense, which he found dominant on the banks of the Spree. The unremitting benefits and sincere attachment of two well-meaning princes secured indeed his gratitude, but could not appease his discontent. At first he sought relief from the "nebulous atmosphere" of his new abode by frequent visits to Paris; but as years advanced his excursions were reduced to accompanying the monotonous "oscillations" of the court between Potsdam and Berlin. On the 12th of May 1827 he settled permanently in the Prussian capital, where his first efforts were directed towards the furtherance of the science of terrestrial magnetism. For many years it had been one of his favourite schemes to secure, by means of simultaneous observations at distant points, a thorough investigation of the nature and law of "magnetic storms"—a term invented by him to designate abnormal disturbances of the earth's magnetism. The meeting at Berlin, September 18, 1828, of a newly-formed scientific association, of which he was elected president, gave him the opportunity of setting on foot an extensive system of research in combination with his diligent personal observations. His appeal to the Russian Government in 1829 led to the establishment of a line of magnetic and meteorological stations across northern Asia; while his letter to the duke of Sussex, then (April 1836) president of the Royal Society, secured for the undertaking the wide basis of the British dominions. Thus that scientific conspiracy of nations which is one of the noblest fruits of modern civilization was by his exertions first successfully organized.

In 1811, and again in 1818, projects of Asiatic exploration were proposed to Humboldt, first by the Russian, and afterwards by the Prussian Government; but on each occasion untoward circumstances interposed, and it was not until he had entered upon his sixtieth year that he resumed his early *rôle* of a traveller in the interests of science. Between May and November 1829 he, together with his chosen associates Gustav Rose and Ehrenberg, traversed the wide expanse of the Russian empire from the Neva to the Yenesei, accomplishing in twenty-five weeks a distance of 9614 miles. The journey, however, though carried out with all the advantages afforded by the immediate patronage of the Russian Government, was too rapid to be profitable. Its most important fruits were the correction of the prevalent exaggerated estimate of the height of the Central-Asian plateau, and the discovery of diamonds in the gold-washings of the Ural—a result which Humboldt's Brazilian experiences enabled him to predict, and by predicting to secure.

Between 1830 and 1848 Humboldt was frequently employed in diplomatic missions to the court of Louis Philippe, with whom he always maintained the most cordial personal relations. The death of his brother, Wilhelm von Humboldt, who expired in his arms, April 8, 1836, saddened the later years of his life. In losing him, Alexander lamented that he had "lost half himself." The accession of the crown prince as Frederick William IV., on the death of his father, in June 1840, added to rather than detracted from his court favour. Indeed, the new king's craving for his society became at times so importunate as to leave him only some hours snatched from sleep for the prosecution of his literary labours.

It is not often that a man postpones to his seventy-sixth year, and then successfully executes, the crowning task of his life. Yet this was Humboldt's case. The first two volumes of the *Kosmos* were published, and in the main composed, between the years 1845 and 1847. The idea of a work which should convey, not only a graphic description, but an imaginative conception of the physical world—which should support generalization by details, and dignify details by generalization, had floated before his mind for upwards of half a century. It first took definite shape in a set of lectures delivered by him before the university of Berlin in the winter of 1827–28. These lectures formed, as his latest biographer expresses it, "the cartoon for the great fresco of the *Kosmos*." The scope of this remarkable work may be briefly described as the representation of the unity amid the complexity of nature. In it the large and vague ideals of the 18th are sought to be combined with the exact scientific requirements of the 19th century. And, in spite of inevitable shortcomings, the attempt was in an eminent degree successful. Nevertheless, the general effect of the book is rendered to some extent unsatisfactory by its tendency to substitute the indefinite for the infinite, and thus to ignore, while it does not deny, the existence of a power outside and beyond those of nature. A certain heaviness of style, too, and laborious picturesqueness of treatment make it more imposing than attractive to the general reader. Its supreme and abiding value, however, consists in its faithful reflexion of the mind of a great man. No higher eulogium can be passed on Alexander von Humboldt than that, in attempting, and not unworthily attempting, to portray the universe, he succeeded still more perfectly in portraying his own comprehensive intelligence.

The last decade of his long life—his "improbable" years, as he was accustomed to call them—was devoted to the continuation of this work, of which the third and fourth volumes were published in 1850–58, and a fragment of a fifth appeared posthumously in 1862. In these he sought to fill up what was wanting of detail as to individual branches of science in the sweeping survey contained in the first volume. Notwithstanding their high separate value, it must be admitted that, from an artistic point of view, these additions were deformities. The characteristic idea of the work, so far as such a gigantic idea admitted of literary incorporation, was completely developed in its opening portions, and the attempt to convert it into a scientific encyclopædia was in truth to nullify its generating motive. Humboldt's remarkable industry and accuracy were never more conspicuous than in the erection of this latest trophy to his genius. Nor did he rely entirely on his own labours. He owed much of what he accomplished to his rare power of assimilating the thoughts and availing himself of the co-operation of others. He was not more ready to incur than to acknowledge obligations. The notes to *Kosmos* overflow with laudatory citations, which were, indeed, the current coin in which he discharged his intellectual debts.

On the 24th of February 1857 Humboldt was attacked with a slight apoplectic stroke, which, however, passed away without leaving any perceptible trace. It was not until the winter of 1858–59 that his strength began to decline, and on the ensuing 6th of May he tranquilly expired, wanting but six months of completing his ninetieth year. The honours which had been showered on him during life followed him after death. His remains, previously to being interred in the family resting-place at Tegel, were conveyed in state through the streets of Berlin, and received by the prince-regent with uncovered head at the door of the cathedral. The first centenary of his birth was celebrated September 14, 1869, with equal enthusiasm in the New as in the Old World; and the numerous monuments erected in his honour, and newly-explored regions called by his name, bear witness to the universal diffusion of his fame and popularity.

Humboldt was never married, and seems to have been at all times more social than domestic in his tastes. To his brother's family he was, however, much attached; and in his later years the somewhat arbitrary sway of an old and faithful servant held him in more than matrimonial bondage. By a singular example of weakness, he executed, four years before his death, a deed of gift transferring to this man Seifert the absolute possession of his entire property. It is right to add that no undue advantage appears to have been taken of this extraordinary concession. Of the qualities of his heart it is less easy to speak than of those of his head. The clue to his inner life might probably be found in a certain egotism of self-culture which influenced his affections as well as regulated his studies. His attachments, however, once formed, were sincere and lasting. He made innumerable friends; and it does not stand on record that he ever lost one. His benevolence was throughout his life active and disinterested. His early zeal for the improvement of the condition of the miners in Galicia and Franconia, his consistent detestation of slavery, his earnest patronage of rising men of science, bear witness to the large humanity which formed the ground-work of his character. The faults of his old age have been brought into undue prominence by the injudicious publication of his letters to Varnhagen von Ense. The chief of these was his habit of smooth speaking, almost amounting to flattery, which formed a painful contrast with the caustic sarcasm of his confidential utterances. His vanity, at all times conspicuous, was tempered by his sense of humour, and was so frankly avowed as to invite sympathy rather than provoke ridicule. After every deduction has been made, he yet stands before us as a colossal figure, not unworthy to take his place beside Goethe as the representative of the scientific side of the culture of his country.

The best biography of Humboldt is that of Professor Karl Bruhns (3 vols., 8vo, Leipsic, 1872), excellently translated into English by the Misses Lassell, with the omission, however, of the exhaustive bibliographical notice and scientific summary contained in the original. The *Voyage aux régions équinoxiales du Nouveau Continent, fait* 1799–1804, *par Alexandre de Humboldt et Aimé Bonpland*, (Paris, 1807, &c.), consisted of thirty folio and quarto volumes, and comprised a considerable number of subordinate but important works. Among these may be enumerated *Vue des Cordillères et monuments des peuples indigènes de l'Amérique*, 2 vols., folio, 1810; *Examen critique de l'histoire de la géographie du Nouveau Continent*, 1814–34; *Atlas géographique et physique du royaume de la Nouvelle Espagne*, 1811; *Essai politique sur le royaume de la Nouvelle Espagne*, 1811; *Essai sur la géographie des plantes*, 1805 (now very rare); and *Relation historique*, 1814–25, an unfinished narrative of his travels, including the *Essai politique sur l'île de Cuba*. The *Nova genera et species plantarum* (7 vols. folio, 1815–25), containing descriptions of above 4500 species of plants collected by Humboldt and Bonpland, was mainly compiled by C. S. Kunth; Oltmanns assisted in preparing the *Recueil d'observations astronomiques*, 1808; Cuvier, Latreille, Valenciennes, and Gay-Lussac co-operated in the *Recueil d'observations de zoologie et d'anatomie comparée*, 1805–33. Humboldt's *Ansichten der Natur* (Stuttgart and Tübingen, 1808) went through three editions in his lifetime, and was translated into nearly every European language. The results of his Asiatic journey were published in *Fragments de géologie et de climatologie asiatiques*, (2 vols. 8vo, 1831), and in *Asie centrale* (3 vols. 8vo, 1843)—an enlargement of the earlier work. The memoirs and papers read by him before scientific societies, or contributed by him to scientific periodicals, are too numerous for specification.

Since his death considerable portions of his correspondence have been made public. The first of these, in order both of time and of importance, is his *Briefe an Varnhagen von Ense*, Leipsic, 1860. This was followed in rapid succession by *Briefwechsel mit einem jungen Freunde* (Friedrich Althaus), Berlin, 1861; *Briefwechsel mit Heinrich Berghaus*, 3 vols., Jena, 1863; *Correspondance scientifique et littéraire*, 2 vols., Paris, 1865–69; *Lettres à Marc-Aug. Pictet*, published in *Le Globe*, tome vii., Geneva, 1868; *Briefe an Bunsen*, Leipsic, 1869; *Briefe an seinen Bruder Wilhelm*, Stuttgart, 1880; besides some other collections of less note. An octavo edition of Humboldt's principal works was published in Paris by Th. Morgand, 1864–66. (A. M. C.)

HUMBOLDT, KARL WILHELM VON (1767–1835), the elder brother of the more celebrated Alexander von Humboldt, was born at Potsdam, on the 22d of June 1767. After being educated at Berlin, Göttingen, and Jena, in the last of which places he formed a close and lifelong friendship with Schiller, he married Fräulein von Dacherode, a lady of birth and fortune, and in 1802 was appointed by the Prussian Government first resident and then minister plenipotentiary at Rome. While there he published a poem entitled *Rom*, which was reprinted in 1824. This was not, however, the first of his literary productions; his critical essay on Goethe's *Hermann and Dorothea*, published in 1800, had already placed him in the first rank of authorities on æsthetics, and, together with his family connexions, had much to do with his appointment at Rome; while in the years 1795 and 1797 he had brought out translations of several of the odes of Pindar, which were held in high esteem. On quitting his post at Rome he was made councillor of state and minister of public instruction. He soon, however, retired to his estate at Tegel, near Berlin, but was recalled and sent as ambassador to Vienna in 1812 during the exciting period which witnessed the closing struggles of the French empire. In the following year, as Prussian plenipotentiary at the congress of Prague, he was mainly instrumental in inducing Austria to unite with Prussia and Russia against France; in 1815 he was one of the signatories of the capitulation of Paris, and the same year was occupied in drawing up the treaty between Prussia and Saxony, by which the territory of the former was largely increased at the expense of the latter. The next year he was at Frankfort settling the future condition of Germany, but was summoned to London in the midst of his work, and in 1818 had to attend the congress at Aix-la-Chapelle. The reactionary policy of the Prussian Government made him resign his office of privy councillor and give up political life in 1819; and from that time forward he devoted himself solely to literature and study.

During the busiest portion of his political career, however, he had found time for literary work. Thus in 1816 he had published a translation of the *Agamemnon* of Æschylus, and in 1817 corrections and additions to Adelung's *Mithridates*, that famous collection of specimens of the various languages and dialects of the world. Among these additions that on the Basque language is the longest and most important, Basque having for some time specially attracted his attention. In fact, Wilhelm von Humboldt may be said to have been the first who brought Basque before the notice of European philologists, and made a scientific study of it possible. In order to gain a practical knowledge of the language and complete his investigations into it, he visited the Basque country itself, the result of his visit being the valuable "Researches into the Early Inhabitants of Spain by the help of the Basque language" (*Prüfung der Untersuchungen über die Urbewohner Hispaniens vermittelst der vaskischen Sprache*), published in 1821. In this work he endeavoured to show, by an examination of geographical names, that a race or races speaking dialects allied to modern Basque once extended through the whole of Spain, the southern coast of France, and the Balearic Islands, and suggested that these people, whom he identified with the Iberians of classical writers, had come from Northern Africa, where the name of Berber still perhaps perpetuates their old designation. Another work on what has sometimes been termed the metaphysics of language appeared from his pen in 1828, under the title of *Ueber den Dualis*; but the great work of his life, on the ancient Kawi language of Java, was unfortunately interrupted by his death on the 8th of April 1835. The imperfect fragment was edited by his brother and Dr Buschmann in 1836, and contains the remarkable introduction on "The Heterogeneity of Language and its Influence on the Intellectual Development of Mankind" (*Ueber die Verschiedenheit des menschlichen Sprachbaues und ihren Einfluss auf die geistige Entwickelung des Menschengeschlechts*), which has been since edited and defended against Steinthal's criticisms by Professor Pott (2 vols., 1876). This essay, which has been called the text-book of the philosophy of speech, first clearly laid down that the character and structure of a language expresses the inner life and knowledge of its speakers, and that languages must differ from one another in the same way and to the same degree as those who use them. Sounds do not become words until a meaning has been put into them, and this meaning embodies the thought of a community. What Humboldt terms the inner form of a language is just that mode of denoting the relations between the parts of a sentence which reflects the manner in which a particular body of men regards the world about them. It is the task of the morphology of speech to distinguish the various ways in which languages differ from each other as regards their inner form, and to classify and arrange them accordingly. Other linguistic publications of Humboldt, which had appeared in the *Transactions* of the Berlin Academy, the *Journal* of the Royal Asiatic Society, or elsewhere, were republished by his brother in the seven volumes of Wilhelm von Humboldt's *Gesammelte Werke* (1841–52). These volumes also contain poems, essays on æsthetical subjects, and other creations of his prolific mind. Perhaps, however, the most generally interesting of his works, outside those which deal with language, is his correspondence with Schiller, published in 1830. Both poet and philosopher come before us in it in their most genial mood. For, though Humboldt was primarily a philosopher, he was a philosopher rendered practical by his knowledge of statesmanship and wide experience of life, and endowed with keen sympathies, warm imagination, and active interest in the method of scientific inquiry. (A. H. S.)

HUME, DAVID (1711–1776), the most subtle metaphysician and one of the greatest historians and political economists of Great Britain, was born at Edinburgh, on the 26th April (O.S.) 1711. His father, Joseph Hume or Home, a scion of the noble house of Home of Douglas, was owner of a small estate in Berwickshire, on the banks of the Whitadder, called, from the spring rising in front of the dwelling-house, Ninewells. David was the youngest of a family of three, two sons and a daughter, who after the early death of the father were brought up with great care and devotion by their mother, the daughter of Sir David Falconer, president of the college of justice. She survived till 1749, long enough to see securely established the foundations of the literary fame of the younger son, for whose powers she seems at one time to have entertained no great respect. "Our Davie," she is reported to have said, perhaps with reference to what seemed his folly in rejecting more lucrative professions than that of literature, "Our Davie 's a fine good-natured crater, but uncommon wake-minded."

Of Hume's early education little is known beyond what he has himself stated in his *Life*. He appears to have entered the Greek classes of the university of Edinburgh in 1723, and, he tells us, "passed through the ordinary course of education with success." It is uncertain how long he remained at the university, though a passage in the remarkable letter first printed by Mr Burton fixes this with comparative definiteness.[1] "As our college education in Scotland, extending little further than the languages, ends commonly when we are about fourteen or fifteen, I

[1] Burton's *Life*, i. 30–39.

was after that left to my own choice in my reading." We may conclude, then, that about the year 1726 Hume returned to Ninewells with a fair knowledge of Latin, slight acquaintance with Greek, and literary tastes decidedly inclining to "books of reasoning and philosophy, and to poetry and the polite authors." He has nowhere given any indications of an explicit character with regard to his reading, or to the works which contributed most in forming his own opinions; and in his writings, save where the subject is of an historical kind, literary references are conspicuous by their rarity. Yet it seems possible from what we know of the sources open to him, of his own preferences, of the problems with which he first busied himself, and of the general current of his speculations regarding them, to infer with some exactness the course of his studies. It is to be noted that at a very early period of his life the dominant passion had declared itself. The love of literature for its own sake was combined with the keen overmastering desire for a literary reputation. At an unusually early age he had determined for himself his future course, and no inducement was strong enough to make him swerve from it. His temperament, on the whole placid and even phlegmatic, readily inclined him to seek as his mode of life the golden mean, equally removed from such external influences as could distract or disturb contemplative repose. He practised what he taught and learned of the Stoic rules, and was concerned only to obtain such external fortune as would place him above the necessity of wasting his powers on temporary and transient objects. His prudence was as remarkable as his moderation; and his life, on the whole, may be regarded as one of the most perfect and successful instances of constant devotion to literary aims. While he was thus fortunate in choosing early and maturely the object towards which all his industry was to be directed, he was no less fortunate in the selection of the special form of literary work to which he was to devote himself. It is clear that his inclinations at a very early age led him towards the analysis of human nature, from which all his later writings take their origin. Speculation upon the nature and certainty of knowledge, whether in its abstract form, that of mere psychology, or in its more concrete applications, as in theology, seems to have been the earliest occupation of his thought; and in this speculation we cannot doubt he was directed largely by the writings of Cicero and Seneca, though the main factor was unquestionably the great English works which had begun to exert their influence at the time. While we trace the matter of Hume's later reflexions to Locke, Berkeley, and Butler, we must not overlook the great part in his mental development which is due to the sceptical or academical writings of the earlier thinkers. The philosophical treatises of Cicero were familiar to Hume, whose writings have a colouring undeniably due to this source. The form in which he cast some of the most important of his speculations is an imitation, more or less conscious, of these ancient models.

We see Hume, then, in the years during which the influences that mould a man's character and career are most actively at work, resolutely devoting himself to a life of literature, possessed by the most intense ambition for literary fame, and busying himself with reflexion upon those problems of "philosophy and critics" in which, as he found, "nothing was yet established." His means were slender, and it was necessary for him, even in view of his primary object, to endeavour after independence. The first choice of a profession, that of law, made for him by his relatives, who thought it suited to his "studious habits, sobriety, and industry," proved unsuccessful. Although his intellect was acute and practical, yet at this period he was so entirely devoted to the more subtle and speculative problems that law could present nothing beyond a barren waste of technical jargon. While his friends thought "he was poring over Voet and Vinnius, Cicero and Virgil were the authors he was secretly devouring." The intensity of his studies, the agitation due to the novelty of the ideas which began to crowd upon him as he tried to carry out systematically the first principles of human knowledge which he learned from Locke and Berkeley, combined to throw him for a time into a state of physical exhaustion and lassitude. His health was gradually restored by more careful regimen; but, as we learn from the curious diagnosis he made of his own state, the vigour requisite for protracted and connected speculation seemed to have vanished. "I have collected," he writes, the "rude materials for many volumes; but in reducing these to words, when one must bring the idea he comprehended in gross nearer to him, so as to contemplate its minutest parts, and keep it steadily in his eye, so as to copy these parts in order, this I found impracticable for me, nor were my spirits equal to so severe an employment." In these circumstances he determined to try the effect of complete change of scene and occupation. "I resolved to seek out a more active life, and, though I could not quit my pretensions to learning but with my last breath, to lay them aside for some time, in order the more effectually to resume them." The effectual remedy which commended itself to him was the trial of a mercantile life, and early in 1734 he set out for Bristol, armed with recommendations to some eminent merchants. A residence of a few months was sufficient to convince him that in this attempt at least he had not hit the mark. He found "the scene wholly unsuitable" to him, and about the middle of the year 1734 set out for France, resolved to spend some years in quiet study and retirement. He visited Paris, resided for a time at Rheims, and then settled at La Flèche, famous in the history of philosophy as the school of Descartes. His health seems to have been perfectly restored, and during the three years of his stay in France his speculations were worked into systematic form in the *Treatise of Human Nature.* In the autumn of 1737 he was in London negotiating with publishers and printers regarding the appearance of his great work, and carefully pruning and polishing it in preparation for the judgments of the learned. In January 1739 there appeared the first and second volumes of the *Treatise of Human Nature, being an Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects*, containing book i., *Of the Understanding*, and book ii., *Of the Passions.* The third volume, containing book iii., *Of Morals*, was published in the following year. Few phrases are better known than the laconic sentence in which Hume, looking back on his own life, tells the tale of his first venture. "Never literary attempt was more unfortunate; it fell *dead-born from the press*, without reaching such distinction as even to excite a murmur among the zealots." "But," he adds, "being naturally of a cheerful and sanguine temper, I very soon recovered the blow, and prosecuted with great ardour my studies in the country." This brief notice, however, is not sufficient to explain the full significance of the event for Hume's own life. The work undoubtedly failed to do what its author expected from it; even the notice, otherwise not unsatisfactory, which it obtained in the *History of the Works of the Learned*, then the principal critical journal, did not in the least appreciate the true bearing of the *Treatise* on the current philosophical and theological discussions. Hume, who had been living in abstractions, to whom the disputes of the time had presented themselves in their real nature as fundamental differences of philosophical analysis, naturally expected that the world would see with as great clearness as he did the connexion between the concrete problems agitating contemporary thought and the abstract principles on which their solution depended. Accordingly he looked for the intensest opposition, and expected that, if his principles were received, the greatest of revolutions, a change in general conceptions of things, would ensue. Apart from all considerations of personal reputation, which undoubtedly had no small influence on him, he was, therefore, on the eve of the publication of his work, with justice perturbed "at the nearness and greatness of the event." It is true that in the *Treatise* there is little or no direct reference to the theological questions which were then prolific in the production of literature, and probably this omission contributed towards the first failure of the work; but Hume, as before said, is invariably chary of his references, and one cannot doubt that he was himself fully alive to the fact that in his philosophic analysis the matters in debate in the theological world had been reduced to their purest essence, had been brought back to first principles. Overlooking, then, the obvious fact that nothing is less common than systematic thinking, that the greater portion of opinion rests on the accidents of training and surroundings rather than on clearly perceived and rationally tested grounds, he anticipated an immediate and vehement onslaught on his work. His disappointment was great in proportion to the height of his expectations; and though he never entirely relinquished his metaphysical speculations, though all that is of value in his later writings depends on the acute analysis of human nature to which he was from the first attracted, one cannot but regret that his high powers were henceforth withdrawn for the most part from the consideration of the foundations of belief, and expended on its practical applications. In later years he was accustomed to explain his want of success as due to the immature style of his early thoughts and exposition, to the rashness of a young innovator in an old and well-established province of literature. "So vast an undertaking, planned before I was one-and-twenty, and composed before twenty-five, must necessarily be very defective." The disclaimer of the *Treatise* in the preface to the *Inquiry concerning Human Understanding* is well known. But all this has little foundation beyond the personal irritation of an author at his own failure to attract such attention as he deems his due. None of the principles of the *Treatise* are given up in the later writings, and no addition was made to them. Nor can the superior polish of the more mature productions overbalance the freshness and concentrated vigour of the more youthful work. Hume is at his best in the *Treatise*; and it is curious to think what might have been the position of British philosophy at the close of the 18th century had the success of his first attempt encouraged him to continue with equal zeal and undivided attention his early metaphysical speculations.

After the publication of the *Treatise* Hume retired to his brother's house at Ninewells and carried on his studies, mainly in the direction of politics and political economy, adding to this, however, a wide if not exact reading in classical literature. In 1741 he published the first volume of his *Essays*, which had a considerable and immediate success. A second edition was called for in the following year, in which also a second volume was published. It is interesting to learn from one of Hume's letters that Butler, to whom he had sent a copy of his *Treatise*, but with whom he had failed to make personal acquaintance, warmly commended the *Essays* to all his friends. The philosophical relation between Butler and Hume is one of the curious points in history. So far as analysis of knowledge is concerned both are in thorough harmony, and Hume's sceptical conclusions regarding belief in matters of fact are the foundations on which Butler's defence of religion rests. Butler, however, appears to retain, alongside of his destructive theory of knowledge, confidence in the rational proofs for the existence of God, and certainly maintains what may be vaguely described as an *a priori* view of conscience. It is probable that, though Butler never worked out the system of his belief, his theological principles will be found to rest ultimately on ethical grounds. Hume had the greatest respect for the author of the *Analogy*, ranks him with Locke and Berkeley as the originators of the experimental method in moral science, and in his specially theological essays, such as that on *Particular Providence and a Future State*, has Butler's views specifically in mind. See BUTLER.

The success of the *Essays*, though hardly great enough to satisfy the author's somewhat exorbitant cravings, was a great encouragement to Hume. He began to hope that his earlier and heavier work, if recast and lightened, might share the fortunes of its successor; and at intervals throughout the next four years he occupied himself in reducing its fundamental principles into a more succinct form, and in giving to them all the literary grace at his command. Meantime he continued to look about for some post which might secure him the modest independence he desired. In 1744 we find him, in anticipation of a vacancy in the chair of moral philosophy at Edinburgh university, moving his friends to do him good offices with the electors; and though, as he tell us, "the accusation of heresy, deism, scepticism, or theism, &c., &c., was started" against him, it had no effect, "being bore down by the contrary authority of all the good people in town." To his great mortification, however, he thought he could discover that Hutcheson and Leechman, with whom he had been on terms of friendly correspondence, were giving the weight of their opinion against the propriety of electing him to such a post. The after history of these negotiations is obscure. Hume in all probability perceived that fortune was against him, and accepted in 1745 a very anomalous post, that of tutor or guardian or keeper to the marquis of Annandale, a harmless literary lunatic. Although the salary paid during the year Hume spent in this capacity "made a considerable accession" to his fortune, the position was unmistakably false and painful. The letters relating to this episode of his life, first printed by Dr Thomas Murray, 1841 (see Burton's *Life*, i. ch. v.), are not pleasant reading; and the close of the connexion between Hume and his pupil left the philosopher under the necessity of instituting an action for recovery of arrears due to him. The details of the affair are not sufficiently clear to enable a modern judge to assign either admiration or blame to Hume's tenacity in the matter of his rights.

In 1746 Hume accepted the office of secretary to General St Clair, and was a spectator of the ill-fated expedition to France in the autumn of that year. His admirable account of the transaction has been printed by Mr Burton. After a brief sojourn at Ninewells, doubtless occupied in preparing for publication his *Philosophical Essays* (afterwards entitled *An Inquiry concerning Human Understanding*), Hume was again associated with General St Clair, and in 1748 accompanied him as secretary in the embassy to Vienna and Turin. The notes of this journey are written in a light and amusing style, showing Hume's usual keenness of sight in some directions and his almost equal blindness in others. During his absence from England, early in the year 1748, the *Philosophical Essays* were published; but, to his great disappointment, the first reception of the work was little more favourable than that accorded to the unfortunate *Treatise*. "On my return from Italy," he writes, "I had the mortification to find all England in a ferment on account of Dr Middleton's *Free Inquiry*, while my performance was entirely overlooked and neglected." To the later editions of the work Hume prepared an "Advertisement" referring to the *Treatise*, and desiring that the *Essays* "may alone be regarded as containing his philosophical sentiments and principles." Not a few modern critics have accepted this disclaimer as of real value, but in fact it has no significance; and Hume has himself in a striking letter to Gilbert Elliott indicated the true relation of the two works. "I believe the *Philosophical Essays* contain everything of consequence relating to the understanding which you would meet with in the *Treatise*, and I give you my advice against reading the latter. By shortening and simplifying the questions, I really render them much more complete. *Addo dum minuo.* The philosophical principles are the same in both." The *Essays* are undoubtedly written with more maturity and skill than the *Treatise*; they contain in more detail application of the principles to concrete problems, such as miracles, providence, immortality; but the entire omission of the discussion forming part ii. of the first book of the *Treatise*, and the great compression of part iv., are real defects which must always render the *Treatise* the more important work in the history of philosophy.

In 1749 Hume returned to England, enriched with "near a thousand pounds." Two years he spent at Ninewells, and then in 1751 removed to Edinburgh, where for the most part he resided during the next twelve years of his life. These years are the richest so far as literary production is concerned. In 1751 he published his *Political Discourses*, which had a great and well-deserved success. In the same year appeared the recast of the third book of the *Treatise*, called *Inquiry concerning the Principles of Morals*, of which he says that "of all his writings, philosophical, literary, or historical, it is incomparably the best." At this time also we hear of the *Dialogues concerning Natural Religion*, a work which Hume was prevailed on not to publish, but which he touched and retouched with the greatest care, and evidently regarded with the greatest favour. The work itself, left by Hume with instructions that it should be published, did not appear till 1779.

In 1751 Hume was again unsuccessful in the attempt to gain a professor's chair. A candidate unknown to fame then or afterwards was appointed to the chair of logic at Glasgow. In the following year he received the first public preferment that had ever fallen to his lot, the librarianship of the Advocates' Library in Edinburgh, small in emoluments, but rich in opportunity for literary work. His delight was great. In his playful style he writes to Dr Clephane, "I have been ready to burst with vanity and self-conceit this week past, and, being obliged from decorum to keep a strict watch over myself and check all emphasis of that kind, I really begin to find my health injured by it." The usual objections had been raised to his election without avail; but, "what is more extraordinary, the cry of religion could not hinder the ladies from being violently my partisans, and I owe my success in a great measure to their solicitations. One has broke off all commerce with her lover because he voted against me; and W. Lockhart, in a speech to the faculty, said that there was no walking the streets, nor even enjoying one's own fireside, on account of their importunate zeal. The town says that even his bed was not safe for him, though his wife was cousin-german to my antagonist."

The only work published at this time which requires somewhat special notice is the set of essays called *Political Discourses*. In these Hume shows greater aptitude for economical inquiries, and makes greater advances in political economy, than any previous writer. Although only a few of the many subjects of discussion are touched upon, the general principles of the science are firmly expressed and illustrated with clearness that leaves nothing to be desired. The fundamental theorem, "everything in the world is purchased by labour, and our passions are the only causes of labour," on which Smith afterwards constructed his more elaborate system, is used as the key to resolve the difficulties regarding the advantages of foreign trade, the causes of the efflux and influx of bullion, the general range of prices in a country, the influence of credit on prices and on trade, the connexion of interest, profits, and the general conditions of industry, and the most economical modes of levying taxes. In many respects the analysis of the complex phenomena of commerce is more sound and thorough than that given in the *Wealth of Nations*, for Hume never forgets that the ultimate causes of our economic movements are the "customs and manners" of the people, and always finds his solution by referring to the elementary factors of industry. It is curious that on the publication of the *Wealth of Nations* Hume indicated to Smith that he differed from him regarding the influence of rent on prices, the point from which the later advances of English political economy have taken their start. It is also remarkable that Hume had formed a much sounder judgment than Smith on the merits of the French Economists. In short, the main errors of the *Wealth of Nations* are to be found in the deviations from the principles of the *Political Discourses.*

In 1753 Hume was fairly settled in Edinburgh, enjoying the dignity and delights of householding, and preparing for his new attempt in literature, the *History of England.*[1] He had decided to begin the *History*, not with Henry VII., as Adam Smith recommended, but with James I., considering that the political differences and parties of his time took their origin from that period, and that then, as he thought, "the misrepresentations of faction began chiefly to take place." On the whole his attitude in respect to disputed political principles seems not to have been at first consciously unfair. "I am sensible," he writes to Clephane, "that the history of the two first Stuarts will be most agreeable to the Tories, that of the two last to the Whigs; but we must endeavour to be above any regard either to Whigs or Tories." As for the qualities necessary to secure success as a *writer* on history, he felt that he possessed them in a high degree; and, though neither his ideal of an historian nor his equipment for the task of historical research would now appear adequate, in both he was much in advance of his contemporaries and predecessors. Naturally, then, he was "sanguine in his expectations of the success of his work." "But," he writes in the well-known passage of his *Life*, "miserable was my disappointment. I was assailed by one cry of reproach, disapprobation, and even detestation; . . . what was still more mortifying, the book seemed to sink into oblivion. Mr Millar told me that in

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[1] "About seven months ago," he writes to Dr Clephane, "I got a house of my own, and completed a regular family, consisting of a head, viz., myself, and two inferior members, a maid and a cat. My sister has since joined me, and keeps me company. With frugality I can reach, I find, cleanliness, warmth, light, plenty, and contentment. What would you have more? Independence? I have it in a supreme degree. Honour? That is not altogether wanting. Grace? That will come in time. A wife? That is none of the indispensable requisites of life. Books? That is one of them; and I have more than I can use. In short, I cannot find any blessing of consequence which I am not possessed of in a greater or less degree; and without any great effort of philosophy, I may be easy and satisfied. As there is no happiness without occupation, I have begun a work which will employ me several years, and which yields me much satisfaction. 'Tis a history of Great Britain, from the Union of the Crowns to the present time. I have already finished the reign of King James I. My friends flatter me (by which I mean that they don't flatter me) that I have succeeded. You know that there is no post of honour in the English Parnassus more vacant than that of history. Style, judgment, impartiality, care—everything is wanting in our historians; and even Rapin, during this latter period, is extremely deficient. I make my work very concise, after the manner of the ancients. It divides into three very moderate volumes: one to end with the death of Charles the First; the second at the Revolution; the third at the Accession, for I dare come no nearer the present times. The work will neither please the duke of Bedford nor James Fraser; but I hope it will please you and posterity. Κτῆμα εἰς ἀεί."

a twelvemonth he sold only forty-five copies of it." This account must be accepted with great qualification. It expresses Hume's feelings rather than the real facts. In Edinburgh, as we learn from one of his letters, the book succeeded well, no fewer than 450 copies being disposed of in five weeks. Nor is there anything in Hume's correspondence to show that the failure of the book was so complete as he declared it to have been. Within a very few years the sale of the *History* was sufficient to gain for the author a larger revenue than had ever before been known in his country to flow from literature, and to place him in comparative affluence. At the same time the bitterness of Hume's feelings and their effect are of importance in his life. It is from the publication of the *History* that we date the extraordinary virulence of his hatred towards everything English, towards society in London, Whig principles, Whig ministers, and the public generally.[1] He was convinced that to be a Scotchman and a Tory was to be an object of contempt and hatred to all Englishmen; and that on the whole there was a conspiracy to suppress and destroy everything that was Scotch.[2] As a consequence of these strong feelings, the remainder of the *History* became little better than a party pamphlet, written with a definite bias and a definite aim. The second volume, published in 1756, carrying on the narrative to the Revolution, was better received than the first; but Hume then resolved to work backwards, and to show from a survey of the Tudor period that his Tory notions were grounded upon the history of the constitution. In 1759 this portion of the work appeared, and in 1761 the work was completed by the history of the pre-Tudor periods. The numerous editions of the various portions,—for, despite Hume's wrath and grumblings, the book was a great literary success,—gave him an opportunity of careful revision, which he employed to remove from it all the "villainous seditious Whig strokes," and "plaguy prejudices of Whiggism" that he could detect lurking in it. In other words, he bent all his efforts towards making his *History* more of a party work than it had originally been, and in his effort he was entirely successful. It has been the business of subsequent historians to correct his misrepresentations so far as they referred to the period of which he had fair knowledge, and to supersede his accounts of those periods which his insufficient knowledge disabled him from treating in a manner worthy of him. The early portion of his *History* may be regarded as now of little or no value. The sources at Hume's command were few, and he did not even use them all. None the less, the *History* has a distinct place in the literature of England. It was the first attempt at a really comprehensive and thoughtful treatment of historic facts, the first to introduce the social and literary aspects of a nation's life as of importance only second to its political fortunes, and the first historical writing in an animated yet refined and polished style. It has received from later writers its due meed of praise and blame.[3]

While the *History* was in process of publication, Hume did not entirely neglect his other lines of activity. In 1757 appeared *Four Dissertations: The Natural History of Religion, Of the Passions, Of Tragedy, Of the Standard of Taste.* Of these the dissertation on the passions is a very subtle piece of psychology, containing the essence of the second book of the *Treatise*. It is remarkable that Hume does not appear to have been acquainted with Spinoza's analysis of the affections. The last two essays are contributions of no great importance to æsthetics, a department of philosophy in which Hume was not strong. The *Natural History of Religion* is a powerful contribution to the deistic controversy; but, as in the case of Hume's earlier work, its significance was at the time overlooked. It is an attempt to carry the war directly into a province hitherto allowed to remain at peace, the theory of the general development of religious ideas. Deists, though raising doubts regarding the historic narratives of the Christian faith, had never disputed the general fact that belief in one God was natural and primitive. Hume endeavours to show that polytheism was the earliest as well as the most natural form of religious belief, and that theism or deism is the product of reflexion upon experience, thus reducing the validity of the historical argument to that of the theoretical proofs.

In 1763 he accompanied Lord Hertford to Paris, doing the duties of secretary to the embassy, with the prospect of the appointment to that post. He was everywhere received "with the most extraordinary honours"; in fact, he was "lionized." The society of Paris was peculiarly ready to receive a great philosopher and historian, especially if he were known to be an avowed antagonist of religion. Hume basked in the sunshine of his popularity; but at the same time he made some valuable friendships, especially with D'Alembert and Turgot, the latter of whom admired sincerely and profited much by Hume's economical essays. In 1766 he left Paris and returned to Edinburgh; but in the following year (1767) he accepted the post of under-secretary to General Conway, and spent two years in London. He settled finally in Edinburgh in 1769, having now through his pension and otherwise the handsome fortune of £1000 a year. The solitary incident of note in this period of his life is the ridiculous quarrel with Rousseau, an episode still amusing, and throwing much light upon the strange character of the great sentimentalist. Hume certainly did his utmost to secure for Rousseau a comfortable retreat in England, but his usually sound judgment seems at first to have been quite at fault with regard to his protégé. That is surely an amusing likeness which Hume discovered between Rousseau and Socrates; and it is interesting to note the conflict between his preconceived opinion

[1] "If a man have the misfortune, in the former place (*i.e.*, London), to attach himself to letters, even if he succeeds, I know not with whom he is to live nor how he is to pass his time in a suitable society. The little company there that is worth conversing with are cold and unsociable, or are warmed only by faction and cabal; so that a man who plays no part in public affairs becomes altogether insignificant; and, if he is not rich, he becomes even contemptible. Hence that nation are fast relapsing into the deepest stupidity and ignorance."—Burton, ii. 268. "There are fine doings in America. O! how I long to see America and the East Indies revolted, totally and finally—the revenue reduced to half—public credit fully discredited by bankruptcy,—the third of London in ruins, and the rascally mob subdued."—*Ib.*, ii. 417. "Our government has become a chimera, and is too perfect, in point of liberty, for so rude a beast as an Englishman, who is a man, a bad animal too, corrupted by above a century of licentiousness."—*Ib.*, ii. 434.

[2] "The rage and prejudice of parties frighten me; and above all, this rage against the Scots, which is so dishonourable and indeed so infamous to the English nation. We hear that it increases every day without the least appearance of provocation on our part. It has frequently made me resolve never in my life to set foot on English ground." —Burton, ii. 265; *cf.* ii. 148, 238. Perhaps our knowledge of Johnson's sentiments regarding the Scotch in general, and of his expressions regarding Hume and Smith in particular, may lessen our surprise at this vehemence.

[3] We append the judgment of Macaulay on Hume's characteristic fault as an historian:—"Hume is an accomplished advocate. Without positively asserting much more than he can prove, he gives prominence to all the circumstances which support his case; he glides lightly over those which are unfavourable to it; his own witnesses are applauded and encouraged; the statements which seem to throw discredit on them are controverted; the contradictions into which they fall are explained away; a clear and connected abstract of their evidence is given. Everything that is offered on the other side is scrutinized with the utmost severity; every suspicious circumstance is a ground for argument and invective; what cannot be denied is extenuated, or passed by without notice; concessions even are sometimes made; but this insidious candour only increases the effect of the vast mass of sophistry."—*Miscell. Writings*, "History." With this may be compared the more favourable verdict by the late Prof. Brewer, in the preface to his edition of the *Student's Hume*.

and that which detached circumstances gave him occasion to form. He finds "Rousseau a very modest, mild, well-bred, gentle-spirited, and warm hearted man as ever I knew in my life," and thinks he "could live with him all his life in mutual friendship and esteem." At the same time he cannot avoid remarking that Rousseau "is a great humorist" (*i.e.*, full of caprices); that though "he intends seriously to draw his own picture in its true colours . . . nobody knows himself less;" that he would be unhappy in solitude, "as he has, indeed, been always in all situations." The quarrel which all the acquaintances of the two philosophers had predicted soon came, and no language had expressions strong enough for Rousseau's hatred and distrust of his protector. Hume, it must be admitted, came well out of the business, and had the sagacity to conclude that, after all, his admired friend was little better than a madman.

In 1769 Hume settled in Edinburgh, and in one of his most delightful letters he gives an animated description of the domestic economy of his later years.[1] The house alluded to as that to which he was about to remove was built under his own directions at the corner of what is now called St David Street; and we may picture it to ourselves as being, during the closing period of Hume's life, the centre of the most lively and cultivated society of Edinburgh. The gay and cheerful temper of the philosopher, his unfailing equanimity, and the solid goodness of his heart had made him many friends, even among those who dissented most from his religious views. The resolute strength with which he pushed speculation to its limits was combined with a perfect gentleness of disposition and an amiability that endeared him to all who had the pleasure of knowing him. He was singularly free from jealousy, and no feature of his character is more attractive than the unfailing cordiality with which he welcomed the literary successes of those who might have been thought his rivals. To Robertson and Smith, his personal friends, he is open and unrestrained in his praise and commendation; and his good services were ever exerted in their cause. To opponents of whose merits he was convinced, to Campbell and Reid, he was cordial and generous. His respect for his own profession led him always to encourage those who had engaged their fortunes in the perilous hazard of literary success, and to extend to them his good offices. For Blackwell and for Smollett, in their misfortunes, he exerted himself to the utmost. Nor was he without his recompense. During the closing decade of his life he was the acknowledged patriarch of literature; the veneration and respect of his friends, for his character no less than for his abilities, were unbounded. The "gaiety of his temper," says Adam Smith, "so agreeable in society, and which is so often accompanied with frivolous and superficial qualities, was in him certainly attended with the most severe application, the most extensive learning, the greatest depth of thought, and a capacity in every respect the most comprehensive. Upon the whole, I have always considered him, both in his lifetime and since his death, as approaching as nearly to the idea of a perfectly wise and virtuous man as perhaps the nature of human frailty will permit."

In the spring of 1775 Hume was struck with a tedious and harassing though not painful illness. A visit to Bath seemed at first to have produced good effects, but on the return journey northwards more alarming symptoms developed themselves, his strength rapidly sank, and, little more than a month after he had reached Edinburgh, he died (25th August 1776).

No notice of Hume would be complete without the sketch of his character drawn by his own hand:—"To conclude historically with my own character, I am, or rather was (for that is the style I must now use in speaking of myself, which emboldens me the more to speak my sentiments),—I was, I say, a man of mild dispositions, of command of temper, of an open, social, and cheerful humour, capable of attachment, but little susceptible of enmity, and of great moderation in all my passions. Even my love of literary fame, my ruling passion, never soured my temper, notwithstanding my frequent disappointments. My company was not unacceptable to the young and careless, as well as to the studious and literary; and as I took a particular pleasure in the company of modest women, I had no reason to be displeased with the reception I met with from them. In a word, though most men anywise eminent have found reason to complain of calumny, I never was touched, or even attacked, by her baleful tooth; and, though I wantonly exposed myself to the rage of both civil and religious factions, they seem to be disarmed on my behalf of their wonted fury. My friends never had occasion to vindicate any one circumstance of my character and conduct; not but that the zealots, we may well suppose, would have been glad to invent and propagate any story to my disadvantage, but they could never find any which they thought would wear the face of probability. I cannot say there is no vanity in making this funeral oration of myself, but I hope it is not a misplaced one; and this is a matter of fact which is easily cleansed and ascertained." The more his life has become known, the more confidence we place in this admirable estimate.

The philosophical writings of Hume, which mark a distinct epoch in the development of modern thought, can here be considered in two only of the many aspects in which they present themselves as of the highest interest to the historian of philosophy. In the *Treatise of Human Nature*, which is in every respect the most complete exposition of Hume's philosophical conception, we have the first thorough-going attempt to apply the fundamental principles of Locke's empirical psychology to the construction of a theory of knowledge, and, as a natural consequence, the first systematic criticism of the chief metaphysical notions from this point of view. Hume, in that work, holds the same relation to Locke and Berkeley as the late J. S. Mill held with his *System of Logic* to Hartley and James Mill. In certain of the later writings, pre-eminently in the *Dialogues on Natural Religion*, Hume brings the results of his speculative criticism to bear upon the problems of current theological discussion, and gives in their regard as previously with respect to general philosophy the final word of the empirical theory in its earlier form. The interesting parallel between Hume and J. S. Mill in this second feature will not be overlooked.

In the first instance, then, Hume's philosophical work is to be regarded as the attempt to supply for empiricism in psychology a consistent, that is, a logically developed theory of knowledge. In Locke, indeed, such theory is not wanting, but, of all the many inconsistencies in the *Essay on the Human Understanding*, none is more apparent or more significant than the complete want of harmony between the view of knowledge developed in the fourth book and the psychological principles laid down in the earlier part of the work. Though Locke, doubtless, drew no distinction between the problems of psychology and of theory of knowledge, yet the discussion of the various forms of cognition given in the fourth book of the *Essay* seems to be based on grounds quite distinct from and in many respects inconsistent with the fundamental psychological principle of his work. The perception of relations, which, according to him, is the essence of cognition, the demonstrative character which he thinks attaches to our inference of God's existence, the intuitive knowledge of self, are doctrines incapable of being brought into harmony with the view of mind and its development which is the keynote of his general theory. To some extent Berkeley removed this radical inconsistency, but in his philosophical work it may be said with safety there are two distinct aspects, and while it holds of Locke on the one hand, it stretches forward to Kantianism on the other. Nor in Berkeley are these divergent features ever united into one harmonious whole. It was left for Hume to approach the theory of knowledge with full consciousness from the psychological point of view, and to work out the final consequences of that view so far as cognition is concerned. The terms which he employs in describing the aim and scope of his work are not those which we should now employ, but the declaration, in the introduction to the *Treatise*, that the science of human nature must be treated according to the

[1] "I live still, and must for a twelvemonth, in my old house in James' Court, which is very cheerful, and even elegant, but too small to display my great talent for cookery, the science to which I intend to addict the remaining years of my life! I have just now lying on the table before me a receipt for making *soupe à la reine*, copied with my own hand; for beef and cabbage (a charming dish), and old mutton, and old claret, nobody excels me. I make also sheep-head broth, in a manner that Mr Keith speaks of it for eight days after; and the Duc de Nivernois would bind himself apprentice to my lass to learn it. I have already sent a challenge to David Moncrief; you will see that in a twelvemonth he will take to the writing of history, the field I have deserted; for, as to the giving of dinners, he can now have no further pretensions. I should have made a very bad use of my abode in Paris, if I could not get the better of a mere provincial like him. All my friends encourage me in this ambition, as thinking it will redound very much to my honour."

experimental method, is in fact equivalent to the statement of the principle implied in Locke's *Essay*, that the problems of psychology and of theory of knowledge are identical. And this view is the characteristic of what we may call the English school of philosophy.

In order to make perfectly clear the full significance of the principle which Hume applied to the solution of the chief philosophical questions, it is necessary to render somewhat more precise and complete the statement of the psychological view which lies at the foundation of the empirical theory, and to distinguish from it the problem of the theory of knowledge upon which it was brought to bear. Without entering into details, which it is the less necessary to do because the subject has been recently discussed with great fulness in works readily accessible, it may be said that for Locke as for Hume the problem of psychology was the exact description of the contents of the individual mind, and the determination of the conditions of the origin and development of conscious experience in the individual mind. And the answer to the problem which was furnished by Locke is in effect that with which Hume started. The conscious experience of the individual is the result of interaction between the individual mind and the universe of things. It is evident that this solution presupposes a peculiar conception of the general relation between the mind and things which in itself requires justification, and which, so far at least as the empirical theory was developed by Locke and his successors, could not be obtained from psychological analysis. Either we have a right to the assumption contained in the conception of the individual mind as standing in relation to things, in which case the grounds of the assumption must be sought elsewhere than in the results of this reciprocal relation, or we have no right to the assumption, in which case reference to the reciprocal relation can hardly be accepted as yielding any solution of the psychological problem. But in any case,—and, as we shall see, Hume endeavours so to state his psychological premises as to conceal the assumption made openly by Locke,—it is apparent that this psychological solution does not contain the answer to the wider and radically distinct problem of the theory of knowledge. For here we have to consider how the individual intelligence comes to know any fact whatsoever, and what is meant by the cognition of a fact. With Locke, Hume professes to regard this problem as virtually covered or answered by the fundamental psychological theorem; but the superior clearness of his reply enables us to mark with perfect precision the nature of the difficulty inherent in the attempt to regard the two as identical. For purposes of psychological analysis the conscious experience of the individual mind is taken as given fact, to be known, *i.e.*, observed, discriminated, classified, and explained in the same way in which any one special portion of experience is treated. Now if this mode of treatment be accepted as the only possible method, and its results assumed to be conclusive as regards the problem of knowledge, the fundamental peculiarity of cognition is overlooked. In all cognition, strictly so-called, there is involved a certain synthesis or relation of parts of a characteristic nature, and if we attempt to discuss this synthesis as though it were in itself but one of the facts forming the *matter* of knowledge, we are driven to regard this relation as being of the quite external kind discovered by observation among matters of knowledge. The difficulty of reconciling the two views is that which gives rise to much of the obscurity in Locke's treatment of the theory of knowledge; in Hume the effort to identify them, and to explain the synthesis which is essential to cognition as merely the accidental result of external relations among the elements of conscious experience, appears with the utmost clearness, and gives the keynote of all his philosophical work. The final perplexity, concealed by various forms of expression, comes forward at the close of the *Treatise* as absolutely unsolved, and leads Hume, as will be pointed out, to a truly remarkable confession of the weakness of his own system.

While, then, the general idea of a theory of knowledge as based upon psychological analysis is the groundwork of the *Treatise*, it is a particular consequence of this idea that furnishes to Hume the characteristic criterion applied by him to all philosophical questions. If the relations involved in the fact of cognition are only those discoverable by observation of any particular portion of known experience, then such relations are quite external and contingent. The only necessary relation which can be discovered in a given fact of experience is that of non-contradiction; the thing must be what it is, and cannot be conceived as having qualities contradictory of its nature. The universal test, therefore, of any supposed philosophical principle, seeing that such principles are but expressions of relations among facts, is the possibility or impossibility of imagining its contradictory. All our knowledge is but the sum of our conscious experience, and is consequently material for imagination. "Let us fix our attention out of ourselves as much as possible; let us chase our imagination to the heavens or to the utmost limits of the universe; we never really advance a step beyond ourselves, nor can conceive any kind of existence, but those perceptions which have appeared in that narrow compass. This is the universe of the imagination, nor have we any idea but what is there produced" (*Works*, ed. of 1854, i. 93, *cf.* i. 107).

The course of Hume's work follows immediately from his fundamental principle, and the several divisions of the treatise, so far as the theoretical portions are concerned, are but its logical consequences. The first part of the first book contains a brief statement of the contents of mind, a description of all that observation can discover in conscious experience. The second part deals with those judgments which rest upon the formal elements of experience, space and time. The third part discusses the principle of real connexion among the elements of experience, the relation of cause and effect. The fourth part is virtually a consideration of the ultimate significance of this conscious experience, of the place it is supposed to occupy in the universe of existence, in other words, of the relations between the conscious experience of an individual mind as disclosed to observation and the supposed realities of self and external things.

In the first part Hume gives his own statement of the psychological foundations of his theory. Viewing the contents of mind as matter of experience, he can discover among them only one distinction, a distinction expressed by the terms *impressions* and *ideas*. Ideas are secondary in nature, copies of data supplied we know not whence. All that appears in conscious experience as primary, as arising from some unknown cause, and therefore relatively as original, Hume designates by the term *impression*, and claims to imply by such term no theory whatsoever as to the origin of this portion of experience. There is simply the fact of conscious experience, arising we know not how. Moreover, if we remain faithful to the fundamental conception of the contents of mind as being merely matters of experience, it is evident in the first place that as impressions are strictly individual, ideas also must be strictly particular, and in the second place that the faculties of combining, discriminating, abstracting, and judging, which Locke had admitted, are merely expressions for particular modes of having mental experience, *i.e.*, are modifications of *conceiving* (*cf.* i. 128 n., 137, 192). Thus at a single stroke Hume removes all the philosophical discussions that had centred round the problem of abstract ideas and the nature of judgment. It is merely by accidental concomitance, which on the subjective side is custom, that one fact, a word, sign, symbol, or type comes to stand for a series of resembling facts, while the comparison of perceptions, with resulting consciousness of their resemblance or difference, is in itself a single, isolated perception (see i. 37, 38, 100).

Such, in substance, is Hume's restatement of Locke's empirical view. Conscious experience consists of isolated states, each of which is as a fact and is related to others in a quite external fashion. It remains to be seen how knowledge can be explained from such a basis; but, before proceeding to sketch Hume's answer to this question, it is necessary to draw attention, first, to the peculiar device invariably resorted to by him when any exception to his general principle that ideas are secondary copies of impressions presents itself, and, secondly, to the nature of the substitute offered by him for that perception of relations or synthesis which even in Locke's confused statements had appeared as the essence of cognition. Whenever Hume finds it impossible to recognize in an idea the mere copy of a particular impression, he introduces the phrase "manner of conceiving." Thus general or abstract ideas are merely copies of a particular impression conceived in a particular manner. The ideas of space and time, as will presently be pointed out, are copies of impressions conceived in a particular manner. The idea of necessary connexion is merely the reproduction of an impression which the mind *feels* itself compelled to conceive in a particular manner. Such a fashion of disguising difficulties points, not only to an inconsistency in Hume's theory as stated by himself, but to the initial error upon which it proceeds; for these perplexities are but the consequences of the doctrine that cognition is to be explained from what can be discovered by observation among the facts of experience, and observation can discover none but external relations. These external relations are, in fact, what Hume describes as the natural bonds of connexion among ideas, and, regarded subjectively as principles of association among facts of mental experience, they form the substitute he offers for the synthesis implied in knowledge. These principles of association determine the imagination to combine ideas in various modes, and by this mechanical combination Hume, for a time, endeavoured to explain what are otherwise called judgments of relation. It was impossible, however, for him to carry out this view consistently. The only combination which, even in appearance, could be explained satisfactorily by its means was the formation of a complex idea out of simpler parts, but it is absurd to describe the idea of a relation among facts as a complex idea; and, as such relations have no basis in impressions, Hume is finally driven to a confession of the absolute impossibility of explaining them. Such confession, however, is only reached after a vigorous effort had been made to render some account of knowledge by the experimental method.

The psychological conception, then, on the basis of which Hume proceeds to discuss the theory of knowledge, is that of conscious experience as containing merely the succession of isolated impressions and their fainter copies, ideas, and as bound together by merely natural or external links of connexion, the principles of association among ideas. The foundations of cognition must be discovered by observation or analysis of experience so conceived. Hume wavers somewhat in his division of the various kinds of cognition, laying stress now upon one now upon another of the points in which mainly they differ from one another. Nor is it of the first importance, save with the view of criticizing his own consistency, that we should adopt any of the divisions implied in his exposition. For practical purposes we may regard the most important discussions in the *Treatise* as falling under two heads. In the first place there are certain principles of cognition which appear to rest upon and to express relations of the universal elements in conscious experience, viz., space and time. The propositions of mathematics seem to be independent of this or that special fact of experience, and to remain unchanged even when the concrete matter of experience varies. They are formal. In the second place, cognition, in any real sense of that term, implies connexion for the individual mind between the present fact of experience and other facts, whether past or future. It appears to involve, therefore, some real relation among the portions of experience, on the basis of which relation judgments and inferences as to matters of fact can be shown to rest. The theoretical question is consequently that of the nature of the supposed relation, and of the certainty of judgments and inferences resting on it.

Hume's well-known distinction between relations of ideas and matters of fact corresponds fairly to this separation of the formal and real problems in the theory of cognition, although that distinction is in itself inadequate and not fully representative of Hume's own conclusions.

With regard, then, to the first problem, the formal element in knowledge, Hume has to consider several questions, distinct in nature and hardly discriminated by him with sufficient precision. For a complete treatment of this portion of the theory of knowledge, there require to be taken into consideration at least the following points : (*a*) the exact nature and significance of the space and time relations in our experience, (*b*) the mode in which the primary data, facts or principles, of mathematical cognition are obtained, (*c*) the nature, extent, and certainty of such data, in themselves and with reference to the concrete material of experience, (*d*) the principle of inference from the data, however obtained. Not all of these points are discussed by Hume with the same fulness, and with regard to some of them it is difficult to state his conclusions. It will be of service, however, to attempt a summary of his treatment under these several heads,—the more so as almost all expositions of his philosophy are entirely defective in the account given of this essential portion. The brief statement in the *Inquiry*, § iv., is of no value, and indeed is almost unintelligible unless taken in reference to the full discussion contained in part ii. of the *Treatise*.

The nature of space and time as elements in conscious experience is considered by Hume in relation to a special problem, that of their supposed infinite divisibility. Evidently upon his view of conscious experience, of the world of imagination, such infinite divisibility must be a fiction. The ultimate elements of experience must be real units, capable of being represented or imagined in isolation. Whence then do these units arise ? or, if we put the problem as it was necessary Hume should put it to himself, in what orders or classes of impressions do we find the elements of space and time ? Beyond all question Hume, in endeavouring to answer this problem, is brought face to face with one of the difficulties inherent in his conception of conscious experience. For he has to give some explanation of the nature of space and time which shall identify these with impressions, and at the same time is compelled to recognize the fact that they are not identical with any single impression or set of impressions. Putting aside, then, the various obscurities of terminology, such as the distinction between the objects known, viz., "points" or several mental states, and the impressions themselves, which disguise the full significance of his conclusion, we find Hume reduced to the following as his theory of space and time. Certain impressions, the sensations of sight and touch, have in themselves the element of space, for these impressions (Hume skilfully transfers his statement to the *points*) have a certain order or mode of arrangement. This mode of arrangement or manner of disposition is common to coloured points and tangible points, and, considered separately, is the impression from which our idea of space is taken. All impressions and all ideas are received, or form parts of a mental experience only when received, in a certain order, the order of succession. This manner of presenting themselves is the impression from which the idea of time takes its rise.

It is almost superfluous to remark, first, that Hume here deliberately gives up his fundamental principle that ideas are but the fainter copies of impressions, for it can never be maintained that order of disposition is an impression, and, secondly, that he fails to offer any explanation of the mode in which *coexistence* and *succession* are possible elements of cognition in a conscious experience made up of isolated presentations and representations. For the consistency of his theory, however, it was indispensable that he should insist upon the real, *i.e.*, presentative character of the ultimate units of space and time.

How then are the primary data of mathematical cognition to be derived from an experience containing space and time relations in the manner just stated ? It is important to notice that Hume, in regard to this problem, distinctly separates geometry from algebra and arithmetic, *i.e.*, he views extensive quantity as being cognized differently from number. With regard to geometry, he holds emphatically that it is an empirical doctrine, a science founded on observation of concrete facts. The rough appearances of physical facts, their outlines, surfaces, and so on, are the data of observation, and only by a method of approximation do we gradually come near to such propositions as are laid down in pure geometry. He definitely repudiates a view often ascribed to him, and certainly advanced by many later empiricists, that the data of geometry are hypothetical. The ideas of perfect lines, figures, and surfaces have not, according to him, any existence. (See *Works*, i. 66, 69, 73, 97, and iv. 180.) It is impossible to give any consistent account of his doctrine regarding number. He holds, apparently, that the foundation of all the science of number is the fact that each element of conscious experience is presented as a unit, and adds that we are capable of considering any fact or collection of facts as a unit. This *manner of conceiving* is absolutely general and distinct, and accordingly affords the possibility of an all-comprehensive and perfect science, the science of discrete quantity. (See *Works*, i. 97.)

In respect to the third point, the nature, extent, and certainty of the elementary propositions of mathematical science, Hume's utterances are far from clear. The principle with which he starts and from which follows his well known distinction between relations of ideas and matters of fact, a distinction which Kant appears to have thought identical with his distinction between analytical and synthetical judgments, is comparatively simple. The *ideas* of the quantitative aspects of phenomena are exact representations of these aspects or quantitative impressions ; consequently, whatever is found true by consideration of the ideas may be asserted regarding the real impressions. No question arises regarding the *existence* of the fact represented by the idea, and in so far, at least, mathematical judgments may be described as hypothetical. For they simply assert what will be found true in any conscious experience containing coexisting impressions of sense (specifically, of sight and touch), and in its nature successive. That the propositions are hypothetical in this fashion does not imply any distinction between the abstract truth of the ideal judgments and the imperfect correspondence of concrete material with these abstract relations. Such distinction is quite foreign to Hume, and can only be ascribed to him from an entire misconception of his view regarding the ideas of space and time. (For an example of such misconception, which is almost universal, see Riehl, *Der philosophische Kriticismus*, i. 96, 97.)

From this point onwards Hume's treatment becomes exceedingly confused. The identical relation between the ideas of space and time and the impressions corresponding to them apparently leads him to regard judgments of continuous and discrete quantity as standing on the same footing, while the ideal character of the data gives a certain colour to his inexact statements regarding the extent and truth of the judgments founded on them. The emphatic utterances in the *Inquiry* (iv. 30, 186), and even at the beginning of the relative section in the *Treatise* (i. 95), may be cited in illustration. But in both works these utterances are qualified in such a manner as to enable us to perceive the real bearings of his doctrine, and to pronounce at once that it differs widely from that commonly ascribed to him. "It is from the idea of a triangle that we discover the relation of equality which its three angles bear to two right ones ; and this relation is invariable, so long as our idea remains the same" (i. 95). If taken in isolation this passage might appear sufficient justification for Kant's view that, according to Hume, geometrical judgments are analytical and therefore perfect. But it is to be recollected that, according to Hume, an idea is actually a *representation* or individual picture, not a notion or even a *schema*, and that he never claims to be able to extract the predicate of a geometrical judgment by analysis of the subject. The properties of this individual subject, the idea of the triangle, are, according to him, discovered by observation, and as observation, whether actual or ideal, never presents us with more than the rough or general appearances of geometrical quantities, the relations so discovered have only approximate exactness. "Ask a mathematician what he means when he pronounces two quantities to be equal, and he must say that the idea of *equality* is one of those which cannot be defined, and that it is sufficient to place two equal qualities before any one in order to suggest it. Now this is an appeal to the general appearances of objects to the imagination or senses" (iv. 180). "Though it (*i.e.*, geometry) much excels, both in universality and exactness, the loose judgments of the senses and imagination, yet [it] never attains a perfect precision and exactness" (i. 97). Any exactitude attaching to the conclusions of geometrical reasoning arises from the comparative simplicity of the data for the primary judgments.

So far, then, as geometry is concerned, Hume's opinion is perfectly definite. It is an experimental or observational science, founded on primary or immediate judgments (in his phraseology, *perceptions*), of relation between facts of intuition; its conclusions are hypothetical only in so far as they do not imply the existence at the moment of corresponding real experience; and its propositions have no exact truth. With respect to arithmetic and algebra, the science of numbers, he expresses an equally definite opinion, but unfortunately it is quite impossible to state in any satisfactory fashion the grounds for it or even its full bearing. He nowhere explains the origin of the notions of unity and number, but merely asserts that through their means we can have absolutely exact arithmetical propositions (*Works*, i. 97, 98). Upon the nature of the reasoning by which in mathematical science we pass from data to conclusions, Hume gives no explicit statement. If we were to say that on his view the essential step must be the establishment of identities or equivalences, we should probably be doing justice to his doctrine of numerical reasoning, but should have some difficulty in showing the application of the method to geometrical reasoning. For in the latter case we possess, according to Hume, no standard of equivalence other than that supplied by immediate observation, and consequently transition from one premise to another by way of reasoning must be, in geometrical matters, a purely verbal process.

Taken as a whole, the theory is perhaps the only consistent development from the psychological principle with which Hume had started, and its incompleteness, even incoherence, points to the gravest defects of that principle. Hume has not offered even a plausible explanation of the mode by which it becomes possible for a consciousness made up of isolated momentary impressions and ideas to be aware of coexistence and number, or succession. The relations of ideas are accepted as facts of immediate observation, as being themselves perceptions or individual elements of conscious experience, and to all appearance they are regarded by Hume as being in a sense analytical, because the formal criterion of identity is applicable to them. It is applicable, however, not because the predicate is contained in the subject, but because, such judgments of relation being thought as immediate facts of conscious experience, the supposition of their non-existence is a contradiction in terms. The ambiguity in his criterion, however, seems entirely to have escaped Hume's attention.

A somewhat detailed consideration of Hume's doctrine with regard to mathematical science has been given for the reason that this portion of his theory has been very generally overlooked or misinterpreted. It does not seem necessary to endeavour to follow his minute examination of the principle of real cognition with the same fulness. It will probably be sufficient to indicate the problem as conceived by Hume, and the relation of the method he adopts for solving it to the fundamental doctrine of his theory of knowledge.

Real cognition, as Hume points out, implies transition from the present impression or feeling to something connected with it. As this thing can only be an impression or perception, and is not itself present, it is represented by its copy or idea. Now the supreme, all-comprehensive link of connexion between present feeling or impression and either past or future experience is that of causation. The idea in question is, therefore, the idea of something connected with the present impression as its cause or effect. But this is explicitly the idea of the said thing as having had or as about to have existence,—in other words, belief in the existence of some matter of fact. What, for a conscious experience so constituted as Hume will admit, is the precise significance of such belief in real existence?

Clearly the real existence of a fact is not demonstrable. For whatever is may be conceived not to be. "No negation of a fact can involve a contradiction." Existence of any fact, not present as a perception, can only be proved by arguments from cause or effect. But as each perception is in consciousness only as a contingent fact, which might not be or might be other than it is, we must admit that the mind can conceive no necessary relations or connexions among the several portions of its experience.

If, therefore, a present perception leads us to assert the existence of some other, this can only be interpreted as meaning that in some natural, *i.e.*, psychological, manner the idea of this other perception is excited, and that the idea is viewed by the mind in some peculiar fashion. The natural link of connexion Hume finds in the similarities presented by experience. One fact or perception is discovered by experience to be uniformly or generally accompanied by another, and its occurrence therefore naturally excites the idea of that other. But when an idea is so roused up by a present impression, and when this idea, being a consequence of memory, has in itself a certain vivacity or liveliness, we regard it with a peculiar indefinable feeling, and in this feeling consists the immense difference between mere imagination and belief. The mind is led easily and rapidly from the present impression to the ideas of impressions found by experience to be the usual accompaniments of the present fact. The ease and rapidity of the mental transition is the sole ground for the supposed necessity of the causal connexion between portions of experience. We mistake the subjective transition resting upon custom or past experience for an objective connexion independent of special feelings. All reasoning about matters of fact is therefore a species of feeling, and belongs to the sensitive rather than to the cogitative side of our nature.

While it is evident that some such conclusion must follow from the attempt to regard the cognitive consciousness as made up of disconnected feelings, it is equally clear, not only that the result is self-contradictory, but that it involves certain assumptions not in any way deducible from the fundamental view with which Hume starts. For in the problem of real cognition he is brought face to face with the characteristic feature of knowledge, distinction of self from matters known, and reference of transitory states to permanent objects or relations. Deferring his criticism of the significance of self and object, Hume yet makes use of both to aid his explanation of the belief attaching to reality. The reference of an idea to past experience has no meaning, unless we assume an identity in the object referred to. For a past impression is purely transitory, and, as Hume occasionally points out, can have no connexion of fact with the present consciousness. His exposition has thus a certain plausibility, which would not belong to it had the final view of the permanent object been already given.

The final problem of Hume's theory of knowledge, the discussion of the real significance of the two factors of cognition, self and external things, is handled in the *Treatise* with great fulness and dialectical subtlety.

As in the case of the previous problem, it is unnecessary to follow the steps of his analysis, which are, for the most part, attempts to substitute qualities of feeling for the relations of thought which appear to be involved. The results follow with the utmost ease from his original postulate. If there is nothing in conscious experience save what observation can disclose, while each act of observation is itself an isolated feeling (an impression or idea), it is manifest that a permanent identical thing can never be an object of experience. Whatever permanence or identity is ascribed to an impression or idea is the result of association, is one of those "propensities to feign" which are due to natural connexions among ideas. We regard as successive presentations of one thing the resembling feelings which are experienced in succession. Identity, then, whether of self or object, there is none, and the supposition of *objects*, distinct from impressions, is but a further consequence of our "propensity to feign." Hume's explanation of the belief in external things by reference to association is well deserving of careful study and of comparison with the more recent analysis of the same problem by J. S. Mill.

At the close of his presentation of the empirical theory of cognition, Hume gives one of those comprehensive reviews of its significance and its difficulties which mark the rare acuteness of his intellect. He has done what was possible to manufacture cognition out of the isolated, disconnected states of mental experience. He has endeavoured to contemplate conscious experience *ab extra*, as itself an object of experience, and to admit nothing which was not capable of being presented in the fashion of an immediate fact of experience. And as the result of the whole he has to confess that his laboriously constructed theory of cognition is but a rope of sand, that no ingenuity can conjure coherence into elements assumed from the outset as incoherent, that the attempt to regard cognition of a fact as being merely one isolated state leads to hopeless confusion. The passage in which, with the utmost frankness, he expresses his opinion on the sum total of his speculative analysis is so remarkable, both in reference to his own work and in reference to later developments of philosophy, that it is well to quote it in full. In the *Appendix* to the *Treatise* he gives a brief *résumé* of what he clearly recognized to be the *crux* in his theory, the explanation of belief, a cognition which involves the relation among themselves of the parts of experience, and then goes on to say:—

"If perceptions are distinct existences, they form a whole only by being connected together. But no connexions among distinct existences are ever discoverable by human understanding. We only *feel* a connexion or determination of the thought to pass from one object to another. It follows, therefore, that the thought alone feels personal identity, when, reflecting on the train of past perceptions that compose a mind, the ideas of them are felt to be connected together and naturally introduce each other.

"However extraordinary this conclusion may seem, it need not surprise us. Modern philosophers seem inclined to think that personal identity *arises* from consciousness, and consciousness is nothing but a reflected thought or perception. The present philosophy, therefore, has a promising aspect. But all my hopes vanish when I come to explain the principles that unite our successive perceptions in our thought or consciousness. I cannot discover any theory which gives me satisfaction on this head. . . . .

"In short, there are two principles which I cannot render consistent, nor is it in my power to renounce either of them; viz., *that all our distinct perceptions are distinct existences*, and *that the mind never perceives any real connexion among distinct existences.* Did our perceptions either inhere in something simple or individual, or did the mind perceive some real connexion among them, there would be no difficulty in the case" (ii. p. 551).

The closing sentences of this passage may be regarded as pointing to the very essence of the Kantian attempt at solution of the problem of knowledge. Hume sees distinctly that if conscious experience be taken as containing only isolated states, no progress in explanation of cognition is possible, and that the only hope of further development is to be looked for in a radical change in our mode of conceiving experience. The work of the critical philosophy is the introduction of this new mode of regarding experience, a mode which, in the technical language of philosophers, has received the title of *transcendental* as opposed to the psychological method followed by Locke and Hume. It is because Kant alone perceived the full significance of the change required in order to meet the difficulties of the empirical theory that we regard his system as the only sequel to that of Hume. The writers of the Scottish school, Reid in particular, did undoubtedly indicate some of the weaknesses in Hume's fundamental conception, and their attempts to show that the isolated feeling cannot be taken as the ultimate and primary unit of cognitive experience are efforts in the right direction. But the question of knowledge was never generalized by them, and their reply to Hume, therefore, remains partial and inadequate, while its effect is weakened by the uncritical assumption of principles which is a characteristic feature of their writings.

The results of Hume's theoretical analysis are applied by him to the problems of practical philosophy and religion. For the first of these the reader is referred to the article ETHICS, where Hume's views are placed in relation to those of his predecessors in the same field of inquiry. His position, as regards the second, is very noteworthy. As before said, his metaphysic contains *in abstracto* the principles which were at that time being employed, uncritically, alike by the deists and by their antagonists. There can be no doubt that Hume has continually in mind the theological questions then current, and that he was fully aware of the mode in which his analysis of knowledge might be applied to them. A few of the less important of his criticisms, such as the argument on miracles, became then and have since remained public property and matter of general discussion. But the full significance of his work on the theological side was not at the time perceived, and justice has barely been done to the admirable manner in which he has reduced the theological disputes of the century to their ultimate elements. The importance of the *Dialogues on Natural Religion*, as a contribution to the criticism of theological ideas and methods, can hardly be overestimated. A brief survey of its contents will be sufficient to show its general nature and its relations to such works as Clarke's *Demonstration* and Butler's *Analogy*. The *Dialogues* introduce three interlocutors, Demea, Cleanthes, and Philo, who represent three distinct orders of theological opinion. The first is the type of a certain *a priori* view, then regarded as the safest bulwark against infidelity, of which the main tenets were that the being of God was capable of *a priori* proof, and that, owing to the finitude of our faculties, the attributes and modes of operation of deity were absolutely incomprehensible. The second is the typical deist of Locke's school, improved as regards his philosophy, and holding that the only possible proof of God's existence was *a posteriori*, from design, and that such proof was, on the whole, sufficient. The third is the type of completed empiricism or scepticism, holding that no argument, either from reason or experience, can transcend experience, and consequently that no proof of God's existence is at all possible. The views of the first and second are played off against one another, and criticized by the third with great literary skill and effect. Cleanthes, who maintains that the doctrine of the incomprehensibility of God is hardly distinguishable from atheism, is compelled by the arguments of Philo to reduce to a minimum the conclusion capable of being inferred from experience as regards the existence of God. For Philo lays stress upon the weakness of the analogical argument, points out that the demand for an ultimate cause is no more satisfied by thought than by nature itself, shows that the argument from design cannot warrant the inference of a perfect or infinite or even of a single deity, and finally, carrying out his principles to the full extent, maintains that, as we have no experience of the origin of the world, no argument from experience can carry us to its origin, and that the apparent marks of design in the structure of animals are only results from the conditions of their actual existence. So far as argument from nature is concerned, a total suspension of judgment is our only reasonable resource. Nor does the *a priori* argument in any of its forms fare better, for reason can never demonstrate a matter of fact, and, unless we know that the world had a beginning in time, we cannot insist that it must have had a cause. Demea, who is willing to give up his abstract proof, brings forward the ordinary theological topic, man's consciousness of his own imperfection, misery, and dependent condition. Nature is throughout corrupt and polluted, but "the present evil phenomena are rectified in other regions and in some future period of existence." Such a view satisfies neither of his interlocutors. Cleanthes, pointing out that from a nature thoroughly evil we can never prove the existence of an infinitely powerful and benevolent Creator, hazards the conjecture that the deity, though all-benevolent, is not all-powerful. Philo, however, pushing his principles to their full consequences, shows that unless we assumed (or knew) beforehand that the system of nature was the work of a benevolent but limited deity, we certainly could not, from the facts of nature, infer the benevolence of its creator. Cleanthes's view is, therefore, an hypothesis, and in no sense an inference.

The *Dialogues* ought here to conclude. There is, however, appended one of those perplexing statements of personal opinion (for Hume declares Cleanthes to be his mouthpiece) not uncommon among writers of this period. Cleanthes and Philo come to an agreement, in admitting a certain illogical force in the *a posteriori* argument, or, at least, in expressing a conviction as to God's existence, which may not perhaps be altogether devoid of foundation. The precise value of such a declaration must be matter of conjecture. Probably the true statement of Hume's attitude regarding the problem is the somewhat melancholy utterance with which the *Dialogues* close.

It is apparent, even from the brief summary just given, that the importance of Hume in the history of philosophy consists in the vigour and logical exactness with which he develops a particular metaphysical view. Inconsistencies, no doubt, are to be detected in his system, but they arise from the limitations of the view itself, and not, as in the case of Locke and Berkeley, from imperfect grasp of the principle, and endeavour to unite with it others radically incompatible. In Hume's theory of knowledge we have the final expression of what may be called psychological individualism or atomism, while his ethics and doctrine of religion are but the logical consequences of this theory. So far as metaphysic is concerned, Hume has given the final word of the empirical school, and all additions, whether from the specifically psychological side or from the general history of human culture, are subordinate in character, and affect in no way the nature of his results. It is no exaggeration to say that the more recent English school of philosophy, represented by J. S. Mill, has made in theory no advance beyond Hume. In the *logic* of Mill, *e.g.*, we find much of a special character that has no counterpart in Hume, much that is introduced *ab extra*, from general considerations of scientific procedure, but, so far as the groundwork is concerned, the *System of Logic* is a mere reproduction of Hume's doctrine of knowledge. Such a statement does not detract from the merits of the *Logic* or even from its originality, for it is remarkable how slight seems to have been the acquaintance of Mill with the works of his greatest predecessor, but it does imply that, so far as solution of the philosophical problem is concerned, no advance has been made beyond the position of Hume. The same remark, indeed, may be applied to the few efforts of the later empirical writers in the region of metaphysics or theology. It is impossible for any reader of Mill's remarkable posthumous essay on theism to avoid the reflexion that in substance the treatment is identical with that of the *Dialogues on Natural Religion*, while on the whole the superiority in critical force must be assigned to the earlier work. All this merely shows how fully the conclusion one would naturally draw from Hume's writings has been borne out by the history of later thought. From his position, and on his lines, no further advance was possible. For a new treatment of philosophical problems a thorough revision of those premises, the adoption of new ground, was requisite. So far as one can see, the only systems of thought which have endeavoured or are endeavouring in a comprehensive fashion to take up anew the work of philosophy are, on the one hand, the Kantian, with its extensive developments, and, on the other, that of scientific naturalism, which latter, though weak in its metaphysic, is yet penetrated with a truly philosophical spirit.

The chief work for Hume's life is that of Mr J. H. Burton, *Life and Correspondence of David Hume*, 2 vols., 1846. Of his collected writings, the standard edition has been till recently that of 1826 (reprinted 1854), in 4 vols. The best edition, containing, in addition to philosophical introductions, much bibliographical matter, is that of 1874, in 4 vols., by T. H. Green and T. H. Grose. Of works upon Hume, the numerous sketches and essays being omitted, the following are the most important:—Jodl, *Leben und Philosophie David Hume's*, 1872; E. Pfleiderer, *Empirismus und Skepsis in David Hume's Philosophie*, 1874 (containing good matter, but too much spun out); T. H. Green, "Introduction to the *Treatise*," in vol. i. of *Hume's Works*, 1874 (by far the most elaborate and minute analysis of Hume in his philosophical relation to Locke and Berkeley); Spicker, *Kant, Hume, und Berkeley*, 1875; Compayré, *La Philosophie de David Hume*, 1873, A. Meinong, *Hume-Studien*, i., 1877 (a very careful study of Hume's nominalism); V. Gizycki, *Die Ethik David Hume's in ihrer geschichtlichen Stellung*, 1878 (the most thorough exposition of Hume's utilitarianism); T. H. Huxley, *Hume*, 1879 (a clear reproduction of the more popular results of Hume's philosophy, without criticism or historical treatment). Mr Leslie Stephen's *English Thought in the Eighteenth Century*, vol. i., 1876, contains the best account of Hume's theological position. Most works on the Kantian philosophy contain sections specially on Hume. The treatments in the general histories of philosophy cannot be pronounced satisfactory. (R. AD.)

HUME, JOSEPH (1777-1855), an eminent political reformer, was born in January 1777, of humble parents, at Montrose, Scotland. After completing his course of medical study at the university of Edinburgh he sailed in 1797 for India, where he was attached as surgeon to a regiment; and his knowledge of the native tongues and his capacity for business threw open to him the lucrative offices of interpreter and commissary-general. On the eve of Lord Lake's Mahratta war in 1803 his chemical knowledge enabled him to render a signal service to the administration by making available a large quantity of gunpowder which damp had spoiled. In 1808, on the restoration of peace, he resigned all his civil appointments, and returned home in the prime of life, and in the possession of a well-earned fortune. His first care on arriving in England was to study thoroughly the country and its resources, for which purpose he made various journeys, to see the actual state of the people and the practical operation of the laws. In 1812 he took his seat for the borough of Weymouth and Melcombe-Regis; but he was soon obliged to resign it, when it was discovered by his Tory patron that he had had the audacity to talk of reform. Six years elapsed before he again entered the House, and during that interval he had made the acquaintance and imbibed the doctrines of James Mill and the philosophical reformers of the school of Bentham. He had joined his efforts to those of Mr Place, of Westminister, and other philanthropists, to relieve and improve the condition of the working classes, labouring especially to establish schools for them on the Lancasterian system, and promoting the formation of savings banks. In 1818, soon after his marriage with Miss Burnley, the daughter of an East India director, he was returned to parliament as member for the Aberdeen burghs. He was afterwards successively elected for Middlesex (1830), Kilkenny (1837), and for the Montrose burghs (1842), in the service of which constituency he died. From the date of his re-entering the House Hume began, unaided and alone, that course of reform in which he persevered to his death. He became the self-elected guardian of the public purse, withstanding every abuse of the public money, by challenging and bringing to a direct vote every single item of public expenditure. The difficulties Hume encountered in the course of his efforts to reduce the enormous burden of taxation under which the country groaned were aggravated by the confused state of the public accounts. But no obstacle daunted or discouraged him in his enlightened efforts as the pioneer of commercial, financial, and parliamentary reform. Other labours with which his name is connected deserve to be recorded. He unravelled the Orange Lodge conspiracy, the ramifications of which spread over England, Scotland, and the colonies, and the object of which was to make the duke of Cumberland king in place of William IV. He carried on a successful warfare against the old combination laws that hampered workmen and favoured masters; he brought about the repeal of the laws prohibiting the export of machinery and of the Act preventing workmen from going abroad. He constantly protested against flogging in the army, the impressment of sailors, and imprisonment for debt. He took up the question of lighthouses and harbours; in the former he secured greater efficiency, in the latter he prevented useless expenditure. At first despised and ridiculed, afterwards dreaded for his tenacity of purpose, he ended by gaining the respect of friends and of foes, and the confidence of the whole nation. The breadth of his action, his singleness of aim, his perfect independence of all party or personal considerations, and an almost heroic earnestness and self-denial in carrying out his views, were the secrets of his influence. Himself as incorruptible as Aristides, he made it a special duty to hunt out and expose political corruption under whatever guise it lurked, and the whole army of place-hunters and jobbers found in him their most indefatigable and inexorable foe. There were many abler, but there was no more useful member in the House during the greater portion of his parliamentary career. He died February 20, 1855.

HUMERUS, Lars Johansson (*c.* 1642–1674), Swedish poet, more commonly known as Lucidor the Unfortunate, was born in Stockholm about the year 1642. His father, Captain Johan Erichsson, and his mother died in his infancy; in 1656 he was entered as a student of the university of Upsala, at the expense of his patron, Admiral Wrangel, whose sons he afterwards conducted through Germany, Italy, France, England, and Holland, and back to Sweden in the autumn of 1668. He returned to Upsala, received a professorship, and took the pseudonym of Lucidor, which he employed until his death. He stayed but one year at Upsala, and in the winter of 1669 settled again in Stockholm. There one of his poems gave offence to the Government, and he was banished from the city for a year and a day. After his return he lived by his pen, writing odes and epithalamia for the rich burghers. He boasted that he would "live like a poet," that is to say, with but slight regard for the conventions of society. He was murdered on the night of August 13, 1674, in a cellar at Stockholm, by a drunken soldier, Lieutenant Arvid Storm, with whom he was quarrelling. The body of the poet was carried out into the street; but he only said, "I am stabbed," and died. Storm was condemned to death for the murder, but was helped by his mother to escape. The stories, so long repeated, of Lucidor's romantic intrigue with a lady of high rank, and his assassination in her arms, must be relegated to the domain of fable.

Lucidor's poems were not collected until after his death, when they were published in a volume called *Flowers of Helicon.* He wrote verses, not merely in Swedish, but also in Latin, French, German, English, Italian, and Dutch. His style is deeply tinged with the prevalent fashion for conceit and tasteless ingenuity, but he possesses force and passion; and he is certainly the most important Swedish writer between Stjernhjelm and Dahlstjerna. The best edition of his works is that published in 1876 by J. Linck, who has dedicated a great deal of time and care to the investigation of the life of Humerus.

HUMILIATI, a religious order founded at Milan early in the 12th century by certain noblemen of Lombardy, who, having been carried captive into Germany, had regained their freedom by their "humility," did not, according to Helyot in his *Ordres Monastiques,* take the monastic vows till 1134, when they were induced to do so by St Bernard. In 1164 their ranks were recruited by other Milanese noblemen who had been similarly carried into Germany by Frederick Barbarossa. About 1151 the order was brought under the rule of St Benedict, and in 1200 it was approved by Innocent III. Confirmed and privileged by succeeding popes, the Humiliati began to be corrupted by their popularity and prosperity, until, after a futile attempt to reform the order, Pius V. finally suppressed it in 1571. At that date they had ninety-four houses under their jurisdiction. The wives of the original founders instituted a female order of *Humiliatæ,* also called, from a prominent early member, the *Nuns of Blassoni,* which, exempted from Pius's bull of suppression, still has representatives in Italy.

HUMMEL, Johann Nepomuk (1778–1837), a celebrated composer and pianist, was born November 14, 1778, at Pressburg, in Hungary, and received his first artistic training from his father, himself a musician in a humble way. In 1785 the latter received an appointment as conductor of the orchestra at the theatre of Schikaneder, the friend of Mozart and the librettist of the *Magic Flute.* It was in this way that young Hummel became acquainted with the great composer, who took a great fancy to him, and even invited him to his house for a considerable period. During two years Hummel received the invaluable instructions of Mozart, after which he set out with his father on an artistic tour through Germany, England, and other countries, his clever playing winning for the boy the admiration of amateurs. After his return to Vienna he completed his studies under Albrechtsberger, the celebrated contrapuntist, and Haydn, and for a number of years devoted himself exclusively to composition. For eight years (1803–1811) he held the appointment of orchestral conductor to Prince Eszterhazy, previously occupied by Haydn. It was not till 1816 that he again appeared in public as a pianist, his success being quite extraordinary. His gift of improvisation at the piano was especially admired, but his larger compositions also were highly appreciated, and for a time Hummel was considered one of the leading musicians of an age in which Beethoven was in the zenith of his power. In Prussia, which he visited in 1822, the ovations offered to him were unprecedented, and other countries—France in 1825 and 1829, Belgium in 1826, and England in 1830 and 1833—added further laurels to his crown. He died in 1837 at Weimar, where for a long time he had been the musical conductor of the court theatre. His compositions are very numerous, and comprise almost every branch of music. He wrote amongst other things several operas, both tragic and comic, and two grand masses (*Op.* 80 and 111). Infinitely more important are his compositions for the pianoforte (his two concerti in A minor and B minor, and the sonata in F sharp minor), and his chamber music (the celebrated septet, and several trios, &c.). His experience as a player and teacher of the pianoforte was embodied in his *Great Pianoforte School* (Vienna), and the excellence of his method is further proved by such pupils as Henselt and Ferdinand Hiller. Both as a composer and as a pianist Hummel continued the traditions of the earlier Viennese school of Mozart and Haydn; his style in both capacities was marked by purity and correctness rather than by passion and imagination. In his compositions there is much that is now antiquated; but to deny him all merit would be as uncritical as were his contemporaries in the opposite direction when they mentioned him in the same breath with Beethoven.

HUMMING-BIRD, a name in use for more than two centuries, and possibly ever since English explorers first knew of the beautiful little animals to which, from the sound occasionally made by the rapid vibrations of their wings, it is applied. Among books that are ordinarily in naturalists' hands, the name seems to be first found in the *Musæum Tradescantianum*, published in 1656, but it therein occurs (p. 3) so as to suggest its having already been accepted and commonly understood; and its earliest use, as yet discovered, is said to be by Thomas Morton in the *New English Canaan*, printed in 1632—a rare work reproduced by Peter Force in his *Historical Tracts* (vol. ii., Washington, 1838). Thevet, in his *Singularitez de la France antarctique* (Antwerp, 1558, fol. 92), has been more than once cited as the earliest author to mention Humming-birds, which he did under the name of *Gouambuch*; but it is quite certain that Oviedo, whose *Hystoria general de las Indias* was published at Toledo in 1525, preceded him by more than thirty years, with an account of the "*paxaro mosquito*" of Hispaniola, of which island "the first chronicler of the Indics" was governor.[1] This name, though now apparently disused in Spanish, must have been current about that time, for we find Gesner in 1555 (*De avium natura*, iii. p. 629) translating it literally into Latin as *Passer muscatus*, owing, as he says, his knowledge of the bird to Cardan, the celebrated mathematician, astrologer, and physician, from whom we learn (*Comment. in Ptolem. de astr. judiciis*, Basel, 1554, p. 472) that, on his return to Milan from professionally attending Archbishop Hamilton at Edinburgh, he visited Gesner at Zurich, about the end of the year 1552.[2] The name still survives in the French *Oiseau-mouche*; but the ordinary Spanish appellation is, and long has been, *Tominejo*, from *tomin*, signifying a weight equal to the third part of an *adarme* or drachm, and used metaphorically for anything very small. Humming-birds, however, are called by a variety of other names, many of them derived from American languages, such as *Guainumbi*, *Ourissia*, and *Colibri*, to say nothing of others bestowed upon them (chiefly from some peculiarity of habit) by Europeans, like *Picaflores*, *Chuparosa*, and *Froufrou*. Barrere, in 1745, conceiving that Humming-birds were allied to the Wren, the *Trochilus*,[3] in part, of Pliny, applied that name in a generic sense (*Ornith. Spec. novum*, pp. 47, 48) to both. Taking the hint thus afforded, Linnæus very soon after went further, and, excluding the Wrens, founded his genus *Trochilus* for the reception of such Humming-birds as were known to him. The unfortunate act of the great nomenclator cannot be set aside; and, since his time, ornithologists with but few exceptions have followed his example, so that now-a-days Humming-birds are universally recognized as forming the Family *Trochilidæ*.

The relations of the *Trochilidæ* to other birds were for a long while very imperfectly understood. Nitzsch first drew attention to their agreement in many essential characters with the Swifts, *Cypselidæ*, and placed the two Families in one group, which he called *Macrochires*, from the great length of their manual bones, or those forming the extremity of the wing. The name was perhaps not very happily chosen, for it is not the distal portion that is so much out of ordinary proportion to the size of the bird, but the proximal and median portions, that in both Families are curiously dwarfed. Still the *manus*, in comparison with the other parts of the wing, is so long that the term *Macrochires* is not wholly inaccurate. The affinity of the *Trochilidæ* and *Cypselidæ*, once pointed out, became obvious to every careful and unprejudiced investigator, and there are probably few systematists now living who refuse to admit its validity. More than this, it is confirmed by an examination of other osteological characters. The "lines," as a boat-builder would say, upon which the skeleton of each form is constructed are precisely similar, only that whereas the bill is very short and the head wide in the Swifts, in the Humming-birds the head is narrow and the bill long—the latter developed to an extraordinary degree in some of the *Trochilidæ*, rendering them the longest-billed birds known.[4] Professor Huxley considers these two Families,

[1] In the edition of Oviedo's work, published at Salamanca in 1547, the earliest the present writer has been able to see, the account (lib. xiv. cap. 4) runs thus:—"Ay assi mismo enesta ysla vnos paxaricos tan negros como vn terciopelo negro muy bueno & son tan pequeños que ningunos he yo visto en Indias menores/ excepto el que aca se llama paxaro mosquito. El qual es tan pequeño que el bulto del es menor harto o assaz que le cabeça del dedo pulgar de la mano. Este no le he visto enesta Ysla pero dizen me que aqui los ay: & por esso dexo de hablar enel pa lo' dezir dõde los he visto que es en la tierra firme quãdo della se trate." A modern Spanish version of this passage will be found in the beautiful edition of Oviedo's works published by the Academy of Madrid in 1851 (i. p. 444).

[2] See also Prof. Morley's *Life of Girolamo Cardano* (ii. pp. 152,153).

[3] Under this name Pliny perpetuated (*Hist. Naturalis*, viii. 25) the confusion that had doubtless arisen before his time of two very distinct birds. As Sundevall remarks (*Tentamen*, p. 87, note), *τροχίλος* was evidently the name commonly given by the ancient Greeks to the smaller Plovers, and was not improperly applied by Herodotus (ii. 68) to the species that feeds in the open mouth of the Crocodile—the *Pluvianus ægyptius* of modern ornithologists—in which sense Aristotle (*Hist. Animalium*, ix. 6) also uses it. But the received text of Aristotle has two other passages (ix. 1 and 11) wherein the word appears in a wholly different connexion, and can there be only taken to mean the Wren—the usual Greek name of which would seem to be *ὄρχιλος* (Sundevall, *Om Aristotl. Djurarter*, No. 54). Though none of his editors or commentators have suggested the possibility of such a thing, one can hardly help suspecting that in these passages some early copyist has substituted *τροχίλος* for *ὄρχιλος*, and so laid the foundation of a curious error. It may be here remarked that the Crocodile of St Domingo is said to have the like office done for it by some kind of bird, which is called by Descourtilz (*Voyage*, iii. p. 26), a "*Todier*," but, as Geoffr. St Hilaire observes (*Descr. de l'Égypte*, ed. 2, xxiv. p. 440), is more probably a Plover. Unfortunately the fauna of Hispaniola is not much better known now than in Oviedo's days.

[4] Thus *Docimastes ensifer*, in which the bill is longer than both head and body together.

together with the Goatsuckers (*Caprimulgidæ*), to form the division *Cypselomorphæ*—one of the two into which he has separated his larger group *Ægithognathæ*. However, the most noticeable portion of the Humming-bird's skeleton is the *sternum*, which in proportion to the size of the bird is enormously developed both longitudinally and vertically, its deep keel and posterior protraction affording abundant space for the powerful muscles which drive the wings in their rapid vibrations as the little creature poises itself over the flowers where it finds its food.[1]

So far as is known, all Humming-birds possess a protrusible tongue, in conformation peculiar among the class *Aves*, though to some extent similar to that member in the Woodpeckers (*Picidæ*)[2]—the "horns" of the hyoid apparatus upon which it is seated being greatly elongated, passing round and over the back part of the head, near the top of which they meet, and thence proceed forward, lodged in a broad and deep groove, till they terminate in front of the eyes. But, unlike the tongue of the Woodpeckers, that of the Humming-birds consists of two cylindrical tubes, tapering towards the point, and forming two sheaths which contain the extensile portion, and are capable of separation, thereby facilitating the extraction of honey from the nectaries of flowers, and with it, what is of far greater importance for the bird's sustenance, the small insects that have been attracted to feed upon the honey.[3] These, on the tongue being withdrawn into the bill, are caught by the mandibles (furnished in the males of many species with fine, horny, saw-like teeth[4]), and swallowed in the usual way. The stomach is small, moderately muscular, and with the inner coat slightly hardened. There seem to be no cæca. The trachea is remarkably short, the bronchi beginning high up on the throat, and song-muscles are wholly wanting, as in all other *Cypselomorphæ*.[5]

Humming-birds, as is well known, comprehend the smallest members of the class *Aves*. The largest among them measures no more than 8 inches and a half,[6] and the least 2 inches and three-eighths in length, for it is now admitted generally that Sloane must have been in error when he described (*Voyage*, ii. p. 308) the "Least Humming-bird of Jamaica" as "about $1\frac{1}{4}$ inch long from the end of the bill to that of the tail"—unless, indeed, he meant the proximal end of each, an interpretation, however, that will not save Edwards and Latham from the charge of careless misstatement, when they declare that they had received such a bird from that island. Next to their generally small size, the best known characteristic of the *Trochilidæ* is the wonderful brilliancy of the plumage of nearly all their forms, in which respect they are surpassed by no other birds, and are only equalled by a few, as, for instance, by the *Nectariniidæ*, or Sun-birds of the tropical parts of the Old World, in popular estimation so often confounded with them, and even by some mistaken naturalists thought to be their allies.

The number of species of Humming-birds now known to exist considerably exceeds 400; and, though none depart very widely from what a morphologist would deem the typical structure of the Family, the amount of modification, within certain limits, presented by the various forms is surprising and even bewildering to the uninitiated. But the features that are ordinarily chosen by systematic ornithologists in drawing up their schemes of classification are found by the "trochilidists," or special students of the *Trochilidæ*, insufficient for the purpose of arranging these birds in groups, and characters on which genera can be founded have to be sought in the style and coloration of plumage, as well as in the form and proportions of those parts which are most generally deemed sufficient to furnish them. Looking to the large number of species to be taken into account, convenience has demanded what science would withhold, and the genera established by the ornithologists of a preceding generation have been broken up by their successors into multitudinous sections—the more adventurous making from 150 to 180 of such groups, the modest being content with 120 or thereabouts, but the last dignifying each of them by the title of genus. It is of course obvious that these small divisions cannot be here considered in detail, nor would much advantage accrue by giving statistics from the works of the latest trochilidists, Messrs Gould,[7] Mulsant,[8] and Elliot.[9] It would be as unprofitable here to trace the successive steps by which the original genus *Trochilus* of Linnæus, or the two genera *Polytmus* and *Mellisuga* of Brisson, have been split into others, or have been added to, by modern writers, for not one of these professes to have arrived at any final, but only a provisional, arrangement; it seems, however, expedient to notice the fact that some of the authors of the last century[10] supposed themselves to have seen the way to dividing what we now know as the Family *Trochilidæ* into two groups, the distinction between which was that in the one the bill was arched and in the other straight, since that difference has been insisted on in many works. This was especially the view taken by Brisson and Buffon, who termed the birds having the arched bill "*Colibris*," and those having it straight "*Oiseaux-mouches*." The distinction wholly breaks down, not merely because there are *Trochilidæ* which possess almost every gradation of decurvation of the bill, but some which have the bill upturned after the manner of that strange bird the Avocet,[11] while it may be remarked that several of the species placed by those authorities among the "*Colibris*" are not Humming-birds at all.

The extraordinarily brilliant plumage which most of the *Trochilidæ* exhibit has been already mentioned, and in describing it ornithologists have been compelled to adopt the vocabulary of the jeweller in order to give an idea of the indescribable radiance that so often breaks forth from some part or other of the investments of these feathered gems. In all save a few of other birds, the most imaginative writer sees gleams which he may adequately designate metallic, from their resemblance to burnished gold, bronze, copper, or steel, but such similitudes wholly fail when he has to do with the *Trochilidæ*, and there is hardly a precious stone—ruby, amethyst, sapphire, emerald, or topaz—the name of which may not fitly, and without any exaggeration, be employed in regard to Humming-birds. In some cases this radiance beams from the brow, in some it glows from the throat, in others it shines from the tail-coverts, in others it sparkles from the tip only of elongated feathers that crest the head or surround the neck as with a frill, while again in others it may appear as a luminous streak across the cheek or auriculars. The feathers that cover the upper parts of the body very frequently have a metallic lustre of golden-green, which in other birds would be thought sufficiently beautiful, but in the *Trochilidæ* its sheen is overpowered by the almost dazzling splendour that radiates from the spots where Nature's lapidary has set her jewels. The flight feathers are almost invariably dusky—the rapidity of their movement would, perhaps, render any display of colour ineffective; while, on the contrary, the feathers of the tail, which, as the bird hovers over its food-bearing flowers, is almost always expanded, and is therefore comparatively motionless, often exhibit a rich translucency, as of stained glass, but iridescent in a manner that no stained glass ever is—cinnamon merging into crimson, crimson changing to purple, purple to violet,

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[1] This is especially the case with the smaller species of the group, for the larger, though shooting with equal celerity from place to place, seem to flap their wings with comparatively slow but not less powerful strokes. The difference was especially observed with respect to the largest of all Humming-birds, *Patagona gigas*, by Mr Darwin.

[2] The resemblance, so far as it exists, must be merely the result of analogical function, and certainly indicates no affinity between the families.

[3] It is probable that in various members of the *Trochilidæ* the structure of the tongue, and other parts correlated therewith, will be found subject to several and perhaps considerable modifications, as is the case in various members of the *Picidæ*. At present there are scarcely half a dozen species of Humming-birds of which it can be said that any part of their anatomy is known.

[4] These are especially observable in *Rhamphodon nævius* and *Androdon æquatorialis*.

[5] Mr Gosse (*Birds of Jamaica*, p. 130) says that *Mellisuga minima*, the smallest species of the Family, has "a real song"—but the like is not recorded of any other.

[6] There are several species in which the tail is very much elongated, such as the well-known *Aithurus polytmus* of Jamaica, and the remarkable *Loddigesia mirabilis* of Chachapoyas in Peru, which last was until lately only known from a unique specimen (*Ibis*, 1880, p. 152); but "trochilidists" in giving their measurements do not take these extraordinary developments into account.

[7] *A Monograph of the Trochilidæ or Humming-birds*, 5 vols. imp. fol., London, 1861 (with Introduction in 8vo).

[8] *Histoire naturelle des Oiseaux-Mouches ou Colibris*, 4 vols. with supplement, imp. 4to, Lyon-Genève-Bale, 1874–77.

[9] *Smithsonian Contributions to Knowledge*, No. 317, *A Classification and Synopsis of the Trochilidæ*, 1 vol. imp. 4to, Washington, 1879.

[10] Salerne must be excepted, especially as he was rebuked by Buffon for doing what we now deem right.

[11] For example *Avocettula recurvirostris* of Guiana and *A. euryptera* of Colombia.

and so to indigo and bottle-green. But this part of the Humming-bird is subject to quite as much modification in form as in colour, though always consisting of ten *rectrices*. It may be nearly square, or at least but slightly rounded, or wedge-shaped with the middle quills prolonged beyond the rest; or, again, it may be deeply forked, sometimes by the overgrowth of one or more of the intermediate pairs, but most generally by the development of the outer pair. In the last case the lateral feathers may be either broadly webbed to their tip, or acuminate, or again, in some forms, may lessen to the filiform shaft, and suddenly enlarge into a terminal spatulation as in the forms known as "Racquet-tails." The wings do not offer so much variation; still there are a few groups in which diversities occur that require notice. The primaries are invariably ten in number, the outermost being the longest, except in the single instance of *Aithurus*, where it is shorter than the next. The group known as "Sabre-wings," comprising the genera *Campylopterus*, *Eupetomena*, and *Sphenoproctus*, present a most curious sexual peculiarity, for while the female has nothing remarkable in the form of the wing, in the male the shaft of two or three of the outer primaries is dilated proximally, and bowed near the middle in a manner almost unique among birds. The feet again, diminutive as they are, are very diversified in form. In most the tarsus is bare, but in some groups, as *Eriocnemis*, it is clothed with tufts of the most delicate down, sometimes black, sometimes buff, but more often of a snowy whiteness. In some the toes are weak, nearly equal in length, and furnished with small rounded nails; in others they are largely developed, and armed with long and sharp claws.

Apart from the well-known brilliancy of plumage, of which enough has been here said, many Humming-birds display a large amount of ornamentation in the addition to their attire of crests of various shape and size, elongated ear-tufts, projecting neck-frills, and pendant beards—forked or forming a single point. But it would be impossible here to dwell on a tenth of these beautiful modifications, each of which as it comes to our knowledge excites fresh surprise and exemplifies the ancient adage—*maxime miranda in minimis Natura*. It must be remarked, however, that there are certain forms which possess little or no brilliant colouring at all, but, as most tropical birds go, are very soberly clad. These are known to trochilidists as "Hermits," and by Mr Gould have been separated as a Subfamily under the name of *Phaethornithinæ*, though Mr Elliot says he cannot find any characters to distinguish it from the *Trochilidæ* proper. But sight is not the only sense that is affected by Humming-birds. The large species known as *Pterophanes temmincki* has a strong musky odour, very similar to that given off by the Petrels, though, so far as appears to be known, that is the only one of them that possesses this property.[1]

All well-informed people are aware that the *Trochilidæ* are a Family peculiar to America and its islands, but one of the commonest of common errors is the belief that Humming-birds are found in Africa and India—to say nothing even of England. In the first two cases the mistake arises from confounding them with some of the brightly-coloured Sun-birds (*Nectariniidæ*), to which British colonists or residents are apt to apply the better-known name; but in the last it can be only due to the want of perception which disables the observer from distinguishing between a bird and an insect—the object seen being a Hawk-Moth (*Macroglossa*), whose mode of feeding and rapid flight certainly bears some resemblance to that of the *Trochilidæ*, and hence one of the species (*M. stellarum*) is very generally called the "Humming-bird Hawk-Moth." But though confined to the New World the *Trochilidæ* pervade almost every part of it. In the south *Eustephanus galeritus* has been seen flitting about the fuchsias of Tierra del Fuego in a snow-storm, and in the north-west *Selatophorus rufus* in summer visits the ribes-blossoms of Sitka, while in the north-east *Trochilus colubris* charms the vision of Canadians as it poises itself over the althæa-bushes in their gardens, and extends its range at least so far as lat. 57° N. Nor is the distribution of Humming-birds limited to a horizontal direction only, it rises also vertically. *Oreotrochilus chimborazo* and *O. pichincha* live on the lofty mountains whence each takes its trivial name, but just beneath the line of perpetual snow, at an elevation of some 16,000 feet, dwelling in a world of almost constant hail, sleet, and rain, and feeding on the insects which resort to the indigenous flowering plants, while other peaks, only inferior to these in height, are no less frequented by one or more species. Peru and Bolivia produce some of the most splendid of the Family—the genera *Cometes*, *Diphlogæna*, and *Thaumastura*, whose very names indicate the glories of their bearers. The comparatively gigantic *Patagona* inhabits the west coast of South America, while the isolated rocks of Juan Fernandez not only afford a home to the *Eustephanus* before mentioned, but also to two other species of the same genus which are not found elsewhere (see BIRDS, vol. iii. p. 745). The slopes of the Northern Andes and the hill country of Colombia furnish perhaps the greatest number of forms, and some of the most beautiful, but leaving that great range, we part company with the largest and most gorgeously arrayed species, and their number dwindles as we approach the eastern coast. Still there are many brilliant Humming-birds common enough in the Brazils, Guiana, and Venezuela. The *Chrysolampis mosquitus* is perhaps the most plentiful. Thousands of its skins are annually sent to Europe to be used in the manufacture of ornaments, its rich ruby-and-topaz glow rendering it one of the most beautiful objects imaginable. In the darkest depths of the Brazilian forests dwell the russet-clothed brotherhood of the genus *Phaethornis*—the "Hermits"; but the great wooded basin of the Amazons seems to be particularly unfavourable to the *Trochilidæ*, and from Pará to Ega there are scarcely a dozen species to be met with. There is no island of the Antilles but is inhabited by one or more Humming-birds, and there are some very remarkable singularities of geographical distribution to be found (see BIRDS, vol. iii. p. 749). Northwards from Panama, the highlands present many genera, whose names it would be useless here to insert, few or none of which are found in South America—though that must unquestionably be deemed the metropolis of the Family, and advancing towards Mexico the numbers gradually fall off. Eleven species have been enrolled among the fauna of the United States, but some on slender evidence, while others only just cross the frontier line.

FIG. 1.—*Mellisuga minima* on nest, natural size. (After Gosse.)

But little room is left to speak of the habits of Humming-birds, which is perhaps of the less consequence since the subject, as regards most of the species which in life have come under the observation of ornithologists, has been so ably treated by writers like Waterton, Wilson, and Audubon, to say nothing of Mr Gosse, Mr Wallace, Mr Bates, and some others, while, whatever novelty further investigation may supply, it is certain that at present we lack information that will explain the origin or the function of the many modifications of external structure of which mention has been made. But there is no one appreciative of the beauties of nature who will not recall to memory with delight the time when a live Humming-bird first met his gaze. The suddenness of the apparition, even when expected, and its brief duration, are alone enough to fix the fluttering vision on the mind's eye. The wings of the bird, if flying, are only visible as a thin grey film, bounded above and below by fine black threads, in form of a St Andrew's cross,—the effect on the observer's retina of the instantaneous reversal of the motion of the wing at each beat—the strokes being so rapid as to leave no more distinct image. Consequently an adequate representation of the bird on the wing cannot be produced by the draughtsman. Humming-birds show to the greatest advantage when engaged in contest with another, for rival cocks fight fiercely, and, as may be expected, it is then that their plumage flashes with the most glowing tints. But these are quite invisible to the ordinary spectator except when very near at hand, though doubtless efficient enough for their object, whether that be to inflame their mate or to irritate or daunt their opponent, or something that we cannot compass. Humming-birds, however, will also often sit still for a while, chiefly in an exposed position, on a dead twig, occasionally darting into the air, either to catch a passing insect or to encounter an adversary; and so pugnacious are

[1] The specific name of a species of *Chrysolampis*, commonly written by many writers *moschitus*, would lead to the belief that it was a mistake for *moschatus*, *i.e.*, "musky," but in truth it originates with their carelessness, for though they quote Linnæus as their authority they can never have referred to his works, or they would have found the word to be *mosquitus*, the "mosquito" of Oviedo, awkwardly, it is true, Latinized. If emendation be needed, *muscatus*, after Gesner's example, is undoubtedly preferable.

they that they will frequently attack birds many times bigger than themselves, without, as would seem, any provocation.

The food of Humming-birds consists mainly of insects, mostly gathered in the manner already described from the flowers they visit; but, according to Mr Wallace, there are many species which he has never seen so occupied, and the "Hermits" especially seem to live almost entirely upon the insects which are found on the lower surface of leaves, over which they will closely pass their bill, balancing themselves the while vertically in the air. The same excellent observer also remarks that even among the common flower-frequenting species he has found the alimentary canal entirely filled with insects, and very rarely a trace of honey. It is this fact doubtless that has hindered almost all attempts at keeping them in confinement for any length of time—nearly every one making the experiment having fed his captives only with syrup, which is wholly insufficient as sustenance, and seeing therefore the wretched creatures gradually sink into inanition and die of hunger.

The beautiful nests of Humming-birds, than which the work of fairies could not be conceived more delicate, are to be seen in most museums, and will be found on examination to be very solidly and tenaciously built, though the materials are generally of the slightest—cotton-wool or some vegetable down and spiders' webs. They vary greatly in form and ornamentation—for it would seem that the portions of lichen which frequently bestud them are affixed to their exterior with that object, though probably concealment was the

Fig. 2.—*Phaethornis eurynome*, and nest. (After Gould.)

original intention. They are mostly cup-shaped, and the singular fact is on record (*Zool. Journal*, v. p. 1) that in one instance as the young grew in size the walls were heightened by the parents, until at last the nest was more than twice as big as when the eggs were laid and hatched. Some species, however, suspend their nests from the stem or tendril of a climbing plant, and more than one case has been known in which it has been attached to a hanging rope. These pensile nests are said to have been found loaded on one side with a small stone or bits of earth to ensure their safe balance, though how the compensatory process is applied no one can say. Other species, and especially those belonging to the "Hermit" group, weave a frail structure round the side of a drooping palm-leaf. The eggs are never more than two in number, quite white, and having both ends nearly equal. The solicitude for her offspring displayed by the mother is not exceeded by that of any other birds, but it seems doubtful whether the male takes any interest in the brood. (A. N.)

HUNDRED, in England, is an ancient territorial division intermediate between the parish or township and the county. Such subordinate districts were also known in different parts of the county as *wapentakes*, *wards*, and sometimes *shires*. The name *wapentake*, which seems to have a distinct reference to the military side of the organization, is generally connected with the Danish occupation, and is said to be found only in the Anglian districts,—Yorkshire, Lincolnshire, Nottinghamshire, Derbyshire, Rutlandshire, and Leicestershire. In some parts of England a further intermediate division is to be found between the hundred and the county. Thus in Yorkshire we have the trithing, or as it is now called the riding, in Lincolnshire the soke, the lathe in Kent, and the rape in Sussex. The origin of these divisions is generally ascribed to the creative genius of Alfred, who, according to the popular theory, divided the country into counties, the county into hundreds, and the hundreds into tithings or towns. The exact opposite would appear to have been the real process, the larger division being formed by the aggregation of the smaller groups. The significance of the name hundred is a question of some difficulty. The simplest theory is the old one that the hundred denoted first the group of a hundred families into which the community was divided, and then the district occupied by the group, just as the tithing represents ten families and the district which the ten families occupy. Another view is that the hundred is a term of measurement only, denoting a hundred hides of land. Or again, it has been supposed to be the district from which the complement of one hundred warriors was furnished to the host. The hundred as a group of persons is a well-known feature of the constitution of the German tribes, *e.g.*, as described by Tacitus, the *centeni ex singulis pagis* who formed the army, and the *centeni ex plebe comites* who acted as assessors to the chiefs. The hundred as a territorial division in later times is equally common. The real connexion between them is a matter of conjecture. "It is very probable that the colonists of Britain arranged themselves in hundreds of warriors; it is not probable that the country was carved into equal districts. The only conclusion that seems reasonable is that under the name of geographical hundreds we have the variously-sized *pagi* or districts in which the hundred warriors settled, the boundaries of these being determined by other causes" (Stubbs's *Constitutional History*, vol. i.). As a territorial division, the hundred like the shire and the parish had its appropriate moot or court, of which the lords, the priest, and four representatives of the parish were members, and in which a specially selected body of twelve appears to have been charged with active judicial functions. The two leading features of the English constitution—representation and trial by jury—thus appear in germ at least in the old constitution of the hundred.

The hundred is now for most of its ancient purposes an obsolete division. The hundred courts were for the most part extinguished by a section in the County Courts Act, 1867, which enacts that no action which can be brought in a county court shall thenceforth be brought in a hundred court, or other inferior court, not being a court of record. The court of record for the hundred of Salford is an example of the survival of this ancient jurisdiction.

Perhaps the most important of the surviving duties of the hundred is its liability to make good damages occasioned by rioters. The 7 and 8 Geo. IV. c. 31 consolidates and amends the laws relating to remedy against the hundred. The principal section enacts that, if any church, house, or other building or section shall be feloniously pulled down or destroyed, the hundred or other district in the nature of a hundred by whatever name it shall be denominated shall be liable to yield full compensation to the persons damnified, provided such person, or his servant having charge of the property, appear before a justice of the peace within seven days after the commission of the offence, to give information. Actions of this kind must be commenced within three months after the offence. The 17 and 18 Vict. c. 104 (Merchant Shipping Act) gives the same remedy in the case of a wrecked ship if plundered by a riotous assemblage, the hundred in or nearest to which the offence was committed being made liable.


Sketch Map
Shewing the Administrative and Political Divisions
of the Dominions of the
HUNGARIAN CROWN
according to Article XXXIII of the Legislature of the year 1876.
Scale of English Miles
0 10 20 30 40 50 100
Longitude East 20 from Greenwich
HUNGARY
TRANSYLVANIA
CROATIA & SLAVONIA
CROATIAN-SLAVONIAN FRONTIER DISTRICT
GALICIA
MORAVIA
SILESIA
LOWER AUSTRIA
STYRIA
CARNIOLA
BUKOVINA
ROUMANIA (MOLDAVIA)
ROUMANIA (WALLACHIA)
SERVIA
BOSNIA
DALMATIA
ADRIATIC SEA
Vienna
Brünn
Pozsony (Pressburg)
Budapest
Debreczen
Temesvár
R. Danube
R. Theiss
R. Maros
R. Drave
R. Save
Balaton L.
J. Bartholomew, Edin

HUNGARY

I. Geography and Statistics.

Plate II. Position and extent. HUNGARY (Hung., *Magyarország*; Ger., *Ungarn*; Fr., *Hongrie*; It., *Ongaria*), the second factor of the dual Austrian-Hungarian monarchy, is an extensive country in the south-eastern portion of Central Europe, lying between 44° 10′ and 49° 35′ N. lat. and between 14° 25′ and 26° 25′ E. long. It thus covers about 5 degrees of latitude and 12 of longitude, and contains an area of 124,234 square miles, or more than half of the whole Austrian-Hungarian realm, being larger than the United Kingdom of Great Britain and Ireland by about 3000 square miles.

General divisions. The kingdom of Hungary in its widest extent, or the "Realm of the Crown of St Stephen," comprises Hungary Proper, with the former grand principality of Transylvania, the town and district of Fiume, Croatia and Slavonia, and the Military Frontier. Dalmatia, which both from its geographical position and from historical associations ought also to form part of Hungary, sends its representatives to the Austrian Reichsrath.

	Area in Eng. Miles
Hungary Proper and Transylvania	108,263
Fiume	8
Croatia and Slavonia	8,665
Military Frontier	7,298
Total	124,234

In the article AUSTRIA (vol. iii. pp. 115–141) the Austrian-Hungarian monarchy has already been treated of as a whole, and under the heading CROATIA AND SLAVONIA (vol. vi. pp. 591–592) will be found further special information with reference to that province (see also FIUME, vol. ix. p. 273). In the present article we shall therefore treat generally of the lands belonging to the Hungarian crown, and more particularly of the "mother country," or Hungary Proper and Transylvania.

Hungary Proper and Transylvania. The province of Hungary Proper and Transylvania, now united under one administration, and sometimes officially styled simply "Hungary," lies between 44° 30′ and 49° 35′ N. lat. and between 16° and 26° 25′ E. long., and comprises an area of 108,263 English square miles. It is bounded on the N. by Moravia, Silesia, and Galicia; on the E. by Bukowina and Moldavia; on the S. by Wallachia, Servia, and Croatia and Slavonia; and on the W. by Styria, Lower Austria, and Moravia. The narrow strip of country known as the Military Frontier, which stretches as a border line between Bosnia and Servia and the south of Croatia and Slavonia, prior to 1873 extended beyond the limits of that province, through Hungary Proper to Transylvania. The whole Military Frontier thus constituted formerly a joint crown land, consisting of the present Croatian-Slavonian frontier, and the so-called Servian-Bánát frontier, now incorporated into the province of Hungary Proper and Transylvania. The political changes introduced between 1868 and 1876 will be considered below.

Natural boundaries. With the exception of the short extent of seaboard on the Adriatic belonging to the Hungarian Littorale, the Hungarian monarchy is entirely surrounded by other countries. Its natural boundaries are for the most part well defined: on the N.W. and N. it is separated from Moravia, Silesia, and Galicia by the Carpathian mountains; on the E. and S.E. the Eastern Carpathians form a natural barrier between Transylvania and Moldavia and Wallachia; on the S. it is bounded by the Danube, Save, and Unna, which separate it from Servia and Bosnia; on the S.W. by Dalmatia and the Adriatic; and on the W., where its natural boundaries are not so clearly marked, by Carniola, Styria, and Lower Austria. From the river Lajta or Leitha, which, like the March, forms a portion of the boundary of the last-mentioned province, originate the terms Cisleithan and Transleithan, sometimes applied to the collective provinces of Austria and of Hungary respectively.

The mountains of Hungary belong to the two great European systems, the Carpathians and the Alps. The former extend in a semicircular form over the north and east of the monarchy, enclosing the whole of the left basin of the Danube from Dévény near Pozsony (Pressburg) to Orsova, while spurs of the Styrian Alps traverse the country in the west; to these latter belong also the Bakony and Vértes ranges. The Central Carpathians consist of several groups, among which the Tátra mountains form the most imposing mass, having an average elevation of about 6000 feet, and attaining at some points an altitude of over 8000 feet. To the south of these are the various ranges of the Hungarian Ore-Mountains or Erzgebirge (Liptó, Zólyom, Bars, Hont), and the midland chains which connect the Carpathians with the Styrian Alps. The Eastern Carpathians and Transylvanian highlands cover the greater part of Transylvania, and the eastern portion of the old Servian-Bánát; the Fogaras is the highest group, some crests of which, as, for instance, the Négoj, Bucsesd, and Vurfu Ourla, attain an elevation of between 8000 and 9000 feet. The low western mountains of Hungary which traverse Croatia and Slavonia belong to the Julian Alps. Taking a general survey, it will be observed that the greatest elevations are in the north of Hungary Proper, in the east and south of Transylvania, and in the eastern portion of the Bánát. In the Northern Carpathians large plateaus are not unfrequent, but in Transylvania the Alpine character predominates. The sides of the Carpathians are generally covered with forests to a considerable height, and on some favourable slopes barley, oats, wheat, and rye are cultivated. The mountainous lands in the south-west of the Hungarian monarchy are in elevation much inferior to those in the north and east, but their greater proximity to the sea and their frequently bare and rugged character cause them to have a considerable influence both on the climate and commercial relations of the country. Mountains.

The great Carpathian and Alpine mountain systems enclose two extensive plains, the smaller of which, called the "Little Hungarian Alföld" or "Pressburg Basin," covers an area of about 6000 square miles, and lies to the west of the Bakony and Mátra ranges, which separate it from the "Pest Basin" or "Great Hungarian Alföld." This is the largest plain in Europe, and comprises an area of about 37,000 square miles, with an average elevation of from 300 to 350 feet above the level of the sea. The Pest Basin extends over the greater portion of central and southern Hungary, and is traversed by the Theiss and its numerous tributaries. This immense tract of low land, though in some parts covered with barren wastes of sand, alternating with marshes, presents in general a very rich and productive soil. The monotonous aspect of the Alföld is in summer time varied by the *déli-báb*, or *Fata Morgana*. Plains.

The geological constitution of the mountains of Hungary is on the whole similar to that of the Alps.[1] The central axis is in some places composed of granite, on which crystalline schists are superposed; in other places the rocks are of Mesozoic age, and associated with Tertiary beds. Whilst Geology.

[1] *Cf.* Dr Max Hantken, in Keleti's *Skizze der Landeskunde Ungarns*, p. 13, Budapest, 1874.

the Palæozoic formations are of comparatively rare occurrence, the Mesozoic attain a very considerable development. These latter in part crop out at the base of the granite and schistose mountain masses, or themselves are the nucleus of more extensive ranges. In some neighbourhoods independent mountain groups are formed by Tertiary strata. Alluvial formations constitute the general external crust out of which the mountains arise. Recent formations on the banks of rivers, more especially in the south at the junction of the Danube, Theiss, Temes, Drave, and Save, are mainly confined to the tracts subject to the inundations of the same, but are here and there, as in the neighbourhood of Pest, Totis, Esztergom (Gran), and some parts of the Great Alföld, represented by accumulations of drift-sand; and in other places, as for instance on the left bank of the lake of Totis, and at Szomod in Komárom county, there are deposits of calcareous tufa.

Caverns. The numerous caverns deserve a passing notice. One of them, the Aggtelek cave, in the county of Gömör, is about 50 feet in breadth by 16 in height, and extends in its recesses for a length of several thousand feet. In it various fossil mammalian remains have been found. The Fonácza cave, in the county of Bihar, has also yielded fossils. No less remarkable are the Okno, Vodi, and Deményfalva caverns in the county of Liptó, the Veterani in the Bánát, and the ice cave at Dobsina in Gömör county. Of the many interesting caverns in Transylvania the most remarkable are the sulphureous Büdös in the county of Háromszék, the Almás to the south of Udvarhely, and the brook-traversed rocky caverns of Csetate-Boli, Pestere, and Ponor in the southern mountains of Hunyad county.

Rivers. Nature has amply provided the greater part of Hungary with both rivers and springs, but some trachytic and limestone mountainous districts show a marked deficiency in this respect. The Mátra group, *e.g.*, is poorly supplied, while the outliers of the Vértes mountains towards the Danube are almost entirely wanting in streams, and have but few water sources. A relative scarcity in running waters prevails in the whole region between the Danube and the Drave. The greatest proportionate deficiency, however, is observable in the arenaceous region between the Danube and Theiss, where for the most part only periodical floods occur. This, however, is far from being the case in the north and east of the kingdom, where the rivers and streams are numerous. The misfortune is that the rivers of Hungary nearly all flow either mediately or immediately to the Danube, and are therefore not available in any other direction as a means of external communication, and even within the country can only serve to a limited extent as water-ways. Thus the Theiss, the greatest wholly native river, is at the present time serviceable for regular steam navigation only as far as Szolnok, while the Maros cannot be navigated except at certain seasons and for a portion of its course; the Drave and the Save, in like manner, are only partly available for steam vessels. But although the length of permanent water-way in Hungary might be much increased by means of canals and other improvements, the Danube must still remain the only river communication with foreign countries, either by way of Austria or the Black Sea, on account of the insurmountable obstacles to connecting the small extent of Hungarian seaboard with the regions through which the Danube flows. This river, which is navigable during the whole of its course through Hungary, enters the monarchy at Dévény near Pressburg, and leaves it at Orsova on the Turkish frontier, receiving numerous tributaries in its course, among which are, on the right, the Raab, Drave, and Save, and, on the left, Waag, Neutra, Gran, Eipel, Theiss, Temes, and Czerna. The breadth of the Danube is about 900 feet near its entrance, 1400 at Budapest, 1800 at Földvár, and 3500 near Pétervárad (Peterwardein). Among the extensive islands formed by branches of the Danube are the Great Schütt and the Csepel in its upper course. The Theiss, the greatest tributary of the Danube, rises in the north-east, in the county of Máramaros, and flowing first in a north-westerly and afterwards in a southerly direction ultimately joins the main river near Tittel, draining in its course the Great Hungarian Plain. Amongst the many affluents of the Theiss are (*r.*) the Bodrog, Sajó, and Zagyva, and (*l.*) the Szamos, Körös, and the Maros, which last, after traversing Transylvania and eastern Hungary, joins the Theiss at Szeged. The Save, rising in Carniola, winds through Croatia, is fed by the Unna and Kulpa, and falls into the Danube at Belgrade. It will be observed that the whole river system of Hungary belongs to the Danube or the Theiss,—the Poprád, which runs through the county of Szepes (Zips), alone having a northerly course, and flowing to the Dunajec, an affluent of the Vistula. The south-western or Trans-Danubian division of Hungary Proper, although comparatively meagre in water-courses, includes the two principal lakes.

Lakes and marshes. The Balaton or Platten-See, the largest lake, not only in Hungary, but in the whole of the Austrian-Hungarian dominions, lies between the counties of Veszprém, Somogy, and Zala, is about 47 miles in length by 3 to 9 in breadth, and with the surrounding marshes occupies an area of about 400 square miles. It is supplied by the river Zala, 31 small streams, and 9 springs, while its surplus waters are carried off by the Sió. Phenomena peculiar to the Balaton lake are, that it sometimes becomes violently agitated without any apparent cause, and that in seasons of severe cold the ice on its surface occasionally bursts with a loud report. It is navigable for steamers, and abounds in fish. The Fertö or Neusiedler See lies in the counties of Moson and Sopron, and with the Hanság marsh covers an area of some 130 square miles; it is about 23 miles in length by 6 to 8 in breadth, is very shallow, and its waters are strongly impregnated with salt and soda. In 1865 the bed became almost dry, but since 1870 it has filled again. The other lowland lakes, as, for instance, the Palics near Szabadka (Maria-Theresiopel) and the Velencze in the county of Fehér, are much smaller. Morasses and pools are generally frequent in the vicinity of the Danube and Theiss. The most extensive marshy region is the Sárrét, which covers a considerable portion of the counties of Jász-Kun-Szolnok, Békés, and Bihar. The Ecsedi Láp in the county of Szatmár is now for the most part drained; and the Alibunár and Illancsa marshes in the county of Torontál will also be soon laid dry. Many thousands of acres of marsh land have already been reclaimed in Hungary, and hydraulic operations bid fair to still further reduce the extent of the marshy districts. In the deep hollows between the peaks of the Carpathians are to be found the curious mountain lakes called "eyes of the sea;" of these there are at least thirty-eight in the Tátra alone.

Canals. The canals of Hungary are still far from sufficient for the wants of the country, although lately many improvements have been introduced, and enormous cuttings made in certain places to relieve the rivers from periodical overflow. The most important canal is the Ferencz or "Francis," which traverses the county of Bács. It is some 70 miles in length, and shortens very considerably the passage between the Theiss and the Danube. A branch of this canal called Uj Csatorna, or "New Channel," extends from Kis-Sztapár, a few miles below Zombor, to Ujvidék opposite Peterwardein. The Béga canal runs from Nagy-Becskerek, in the county of Torontál, to beyond Temesvár, but is not navigable throughout. Among other canals are the Versecz in the county of Temes; the Berzava in the county of Torontál; the Sió, which connects the Balaton with the Danube; the Kapos or Zichy in the counties of Somogy, Baranya, and Tolna; and the Sárviz or Nádor, which runs through the counties of Fehér and Tolna.

Sea-ports. On the Adriatic, at the northern extremity of the short line of sea-coast known as the "Hungarian Littorale," lies the port of FIUME (*q.v.*), which is the only direct outlet by sea for the produce of Hungary. Its commanding position at the head of the Gulf of Quarnero, and spacious new harbour works, as also its immediate connexions with both the Austrian and Hungarian railway systems, render it specially advantageous as a commercial port. As shipping stations, Buccari, Portoré, Selce, Novi, Zengg, Cirquenizza, San Giorgio, Stinizza, Jablanac, and Carlopago are of comparative insignificance. The whole of the short Hungarian seaboard is mountainous, and subject to violent winds.

Climate. The climate of Hungary, owing to the physical configuration of the country, varies considerably. If we except Transylvania, three separate zones are roughly distinguishable:—the "highland," comprising the counties in the vicinity of the Northern and Eastern Carpathians, where the winters are very severe and continue for half the year; the "intermediate" zone, embracing the tract of country stretching northwards from the Drave and Mur, with the Little Hungarian Plain, and the region of the Upper Alföld, extending from Budapest to Nyiregyháza and Sárospatak; and the "great lowland" zone, including the main portion of the Great Hungarian Plain, and the region of the lower Danube, where the heat during the summer months is almost tropical. In Transylvania the climate bears the extreme characteristics peculiar to mountainous countries interspersed with valleys; whilst that of the south-western Croatian and Frontier districts bordering on the Adriatic is modified by the neighbourhood of the sea. The minimum of the temperature is attained in January and the maximum in July. At Buda, which, if we exclude Transylvania, is near the centre of the kingdom, the mean average temperature (1862–77) in January is 31° 0' and in July 71° 7'; at Kolozsvár (Klausenburg) in the same months it is 32° 7' and 68° 9' respectively. The rainfall in Hungary is small in comparison with that of Austria. At Buda, where the number of rainy days is 122,[1] the rainfall is about 21½ inches, whilst in the two Hungarian plains generally the rainy days are estimated not to exceed 96 annually. In the vicinity of the Carpathians, however, rain is very prevalent, amounting to between 30 and 40 inches. In these regions the greatest fall is during the summer, though in some years the autumn showers are heavier. Hail storms are of frequent occurrence in the Carpathians. On the plains rain rarely falls during the heats of summer; and, generally speaking, the showers though violent are of but short duration, whilst the moisture is quickly evaporated owing to the aridity of the atmosphere. The vast sandy wastes mainly contribute to the dryness of the winds on the Great Hungarian Alföld. Occasionally, as in the year 1863, the whole country suffers much from drought; but, on the other hand, disastrous floods not unfrequently occur, particularly in the spring, when the beds of the rivers and streams are inadequate to contain the increased volume of water caused by the rapid melting of the snows on the Carpathians. The low-lying arable and pasture lands in the vicinity of the Theiss and Maros are thus sometimes submerged for weeks, and in March 1879 the town of Szeged, situated at the point of junction of these two rivers, was almost completely destroyed. In December of the same year the counties of Arad and Bihar were extensively inundated by the Maros and the Körös. In 1838 the city of Pest, and in February 1876 several localities on the Danube, suffered disastrously from the sudden rising of that river. The average annual number of snow showers is estimated at 23 for the two Hungarian plains, 44 for Transylvania, 50 for the northern, and 30 to 35 for the western and south-western portions of the monarchy. In 1866–67, and again in 1872–73, cholera was very rife; of the 447,571 persons who were attacked by the epidemic in the latter case, 189,017, or over 42 per cent., died. Nevertheless Hungary cannot, on the whole, be regarded as an unhealthy country, excepting in the marshy tracts, where intermittent fever and diphtheria sometimes exhibit great virulence.

Flora. The whole of Hungary, but more especially Hungary Proper, can boast of the great variety and number of its natural productions. This is attributable partly to its geographical position, but chiefly to the varied nature of its surface and climate. The fertility of the soil, if we except the mountainous and sandy regions, is remarkable. The vegetable products include almost every description of grain, especially wheat and maize, besides Turkish pepper, rapeseed, hemp and flax, beans, potatoes, and root crops. Fruits of various descriptions, and more particularly melons and stone fruits, are abundant. In the southern districts almonds, figs, rice, and olives are grown. Amongst the forest and other trees are the oak, which yields large quantities of galls, the beech, fir, pine, ash, and alder, also the chestnut, walnut, and filbert. The vine is cultivated over the greater part of Hungary, the chief grape-growing districts being those of the Hegyalja (Tokay), Sopron, and Ruszt, Ménes, Szerémség, Szekszárd, Somlyó (Schomlau), Béllye and Villány,[1] Balaton, Neszmély, Visonta, Eger (Erlau), and Buda. Next to France, Hungary is the greatest wine-producing country in Europe, and the quality of some of the vintages, especially that of Tokay, is unsurpassed. A great quantity of tobacco is also grown, but it is wholly monopolized by the crown. In Hungary Proper and in Croatia and Slavonia there are many species of indigenous plants, which are unrepresented in Transylvania. Besides 12 species peculiar to the former grand-principality, 14 occur only there and in Siberia.

Fauna. The fauna of Hungary includes about 14,000 species. The horned cattle are amongst the finest in Europe, and large herds of swine are reared in the oak forests. In 1870 the total number of cattle (including 73,243 buffaloes) was estimated at 5,279,193, and of swine at 4,443,279. Of sheep, the breed of which is now greatly improved, the number amounted to 15,076,997; of horses there were 2,158,819, asses 30,480, mules 3,266, and goats 572,951. The wild animals are bears, wolves, foxes, lynxes, wild cats, badgers, otters, martens, stoats, and weasels. Among the rodents there are hares, marmots, beavers, squirrels, rats, and mice,—the last in enormous swarms. Of the larger game the chamois and deer are specially noticeable. Among the birds are the vulture, eagle, falcon, buzzard, kite, lark, nightingale, heron, stork, and bustard. Domestic and wild fowl are generally abundant. The rivers and lakes yield enormous quantities of fish, and leeches also are plentiful. The Theiss, once better supplied with fish than any other river in Europe, has for many years fallen off in its productiveness. The culture of the silkworm is chiefly carried on in the south—in the Military Frontier, and in Croatia and Slavonia. The principal bee-rearing localities are in the counties of Gömör, Szepes, and Mosony, the Military Frontier, and the former Saxon districts of Transylvania. In 1870 the number of bee-hives was estimated at 617,407.

Minerals. The chief mineral products are coal, nitre, sulphur, alum, soda, saltpetre, gypsum, porcelain-earth, pipe-clay, asphalt, petroleum, marble, and ores of gold, silver, mercury, copper, iron, lead, zinc, antimony, cobalt, and arsenic. The opals of Sáros are famous, and precious stones of various descriptions (calcedony, garnet, jacinth, amethyst, carnelian, agate, rock-crystals, &c.) are met with in several localities. Amber occurs at Magura in Szepes county. Gold and silver are found chiefly in the districts of Selmecz (Schemnitz), Körmöcz (Kremnitz), Nagybánya, Szomolnok, Oravicza, Abrudbánya, and Zalatna. The average yearly yield of gold is equal in value to about £219,000, and that of silver to some £178,600. The sand of some of the rivers, as for instance the Maros, Szamos, Körös, and Aranyos, is auriferous. Iron is extensively produced in the counties of Gömör, Zólyom, Liptó, Szepes, Sáros, Borsod, Torna, Abaúj, Szatmár, Bihar, and Krassó; coal in the neighbourhood of Pécsvárad, Oravicza, Salgó-Tarján, and of

[1] Strictly 122·7, the average, for the 16 years 1862–77 inclusive, being 35·3 for winter, 30·7 for spring, 29·2 for summer, and 27·5 for autumn.—*Budapest Meteorologiai Viszonyai*, issued (1879) by the Royal Hungarian Central Meteorological Institute.

[2] The quantity of (Riesling grape) wines produced on the archduke Albrecht's estates near Béllye and Villány is said to exceed 1,000,000 bottles annually.

the river Sil. There are fine marble quarries at Piszke and the neighbouring Almás in the counties of Esztergom and Komárom, as also at various places in the counties of Baranya, Veszprém, Abaúj, Szepes, and Liptó. The largest salt-mines are at Rónaszék, Sugatag, and Szlatina in the county of Máramaros, in Hungary Proper, and at Vizakna, Parajd, Torda, Decsakna, and Marosujvár in Transylvania. In 1877 the value of the salt produced was 12,369,599 florins, of other minerals 18,787,757 florins. The yearly worth of the whole mining produce of the Hungarian realm is estimated at over £3,000,000, of which, however, the amount attributable to Croatia and Slavonia is comparatively small. There are several hundred cold and 64 warm mineral springs in Hungary Proper and in Croatia and Slavonia, whilst a relatively greater number are met with in Transylvania. Of warm springs the most famous are those of Buda, Mehádia, Eger (Erlau), Nagyvárad (Grosswardein), Sztubnya, Szliács, Harkány, Pöstény, Krapina, and Teplitz. Among the cold mineral springs the more worthy of note are those of Suliguly, Borszék, Bártfa, Czigelka, Szulin, Parád, Koritnicza, and Szalatnya; the Buda *keserü viz* (bitter water) is also much prized, and largely exported.

Agriculture.

The general agricultural division of the soil is shown approximately in the following table, adapted from Keleti's *Magyarország Statistikája*:—

	Hungary Proper and Transylvania.	Fiume.	Croatia and Slavonia.	Military Frontier.	Total for the Hungarian Realm.
	Eng. Acres.	E. A.	E. Acres.	E. Acres.	Eng. Acres.
Arable	23,865,703	116	1,868,609	1,213,464	26,947,892
Meadows	9,147,793	956	607,933	465,012	10,221,694
Vineyards[1]	837,676	1077	128,558	32,112	999,423
Pastures	10,157,418	1813	500,244	936,357	11,595,832
Forests	19,449,689	635	2,210,736	1,373,347	23,034,407
Reedy tracts	381,783	...	8,200	...	389,983
Total of productive soil	63,840,062	4597	5,324,280	4,020,292	73,189,231
Barren lands	5,021,384	259	472,449	922,950	6,417,042
Total	68,861,446	4856	5,796,729	4,943,242	79,606,273

Administrative and political divisions.

Since the year 1867 the administrative and political divisions of the lands belonging to the Hungarian crown have been in great measure remodelled. In 1868 Transylvania was definitively reunited to Hungary Proper, and the town and district of Fiume declared autonomous. In 1873 the Servian-Bánát or Eastern Military Frontier was incorporated with Hungary Proper. In 1876 the whole administrative subdivision of Hungary into counties, districts, and sees was revised, and for the sake of uniformity one general system of counties was introduced, except for the Croatian-Slavonian Military Frontier, which is divided into border districts. The total number of subdivisions amounts to 80, of which 65 appertain to Hungary Proper and Transylvania, 1 to Fiume and district, 8 to Croatia and Slavonia, and 6 to the Croatian-Slavonian Military Frontier. Hungary Proper, according to ancient usage, is generally divided into four great divisions or circles, and Transylvania has since 1876 been regarded as the fifth. Neither numerically nor according to territorial extent are the present 65 counties distributed equally among their respective circles, which must be regarded as geographical rather than political divisions, for they are not recognized in the judicial, fiscal, military, postal, and administrative relations of the country.[2] The circles are—

Cis-Danubia (north and east of the Danube), containing 13 counties: Pest-Pilis-Solt-Kis-Kun, Bács-Bodrog, Nógrád, Hont, Esztergom, Bars, Zólyom, Liptó, Árva, Thurócz, Trencsén, Nyitra, Pozsony.

Trans-Danubia (south and west of the Danube), 11 counties: Moson, Sopron, Györ, Komárom, Fehér, Veszprém, Vas, Zala, Somogy, Baranya, Tolna.

Cis-Tisia[3] (north and west of the Theiss), 11 counties: Szepes, Gömör and Kis-Hont, Heves, Jász-Nagy-Kun-Szolnok, Borsod, Torna, Abaúj, Sáros, Zemplén, Ung, Bereg.

Trans-Tisia (south and east of the Theiss), 15 counties: Máramaros, Ugocsa, Szatmár, Szilágy, Szabolcs, Hajdú, Bihar, Békés, Csanád, Csongrád, Arad, Torontál, Temes, Krassó, Szörény.

Trans-Királyhágó, or *Transylvania*, 15 counties: Alsó-Fehér, Beszterczе-Naszód, Brassó, Csik, Fogaras, Háromszék, Hunyad, Kis-Küküllö, Kolozs, Maros-Torda, Nagy-Küküllö, Szeben, Szolnok-Doboka, Torda-Aranyos, Udvarhely.

In the following list of divisions the foreign forms of the names of towns are given which are most frequently met with in the German and English press. Not being recognized officially, these are falling into disuse in Hungary.

Political and Administrative Divisions.

No.	County.	County Town. Official Name.	County Town. Foreign Equivalent.
		Hungary and Transylvania.	
1	Pozsony	Pozsony	Pressburg
2	Nyitra	Nyitra	Neutra
3	Trencsén	Trencsén	Trencsin
4	Árva	Alsó-Kubin	
5	Liptó	Liptó-Szent-Miklós	
6	Thurócz	Thurócz-Szent-Márton	
7	Zólyom	Beszterczebánya	Neusohl
8	Bars	Aranyosmarót	
9	Hont	Ipolyság	
10	Nógrád	Balassa-Gyarmat	
11	Esztergom	Esztergom	Gran
12	Komárom	Komárom	Komorn
13	Györ	Györ	Raab
14	Moson	Magyar-Óvár	Ungrisch-Altenburg
15	Sopron	Sopron	Oedenburg
16	Vas	Szombathely	Stein-am-Anger
17	Zala	Zala-Egerszeg	
18	Veszprém	Veszprém	Veszprim
19	Fehér	Székesfehérvár	Stuhlweissenburg
20	Somogy	Kaposvár	
21	Tolna	Szegszárd	
22	Baranya	Pécs	Fünfkirchen
23	Bács-Bodrog	Zombor	
24	Pest-Pilis-Solt-Kis-Kun	Budapest	Pest or Pesth and Ofen or Buda (prior to 1873)
25	Csongrád	Szeged	Szegedin
26	Jász-Nagy-Kun-Szolnok	Szolnok	
27	Heves	Eger	Erlau
28	Borsod	Miskolcz	
29	Gömör and Kis-Hont	Rima-Szombat	Gross-Steffelsdorf
30	Szepes	Löcse	Leutschau
31	Torna	Torna	
32	Abaúj	Kassa	Kaschau
33	Sáros	Eperjes	Eperies
34	Zemplén	Sátoralja-Ujhely	
35	Ung	Ungvár	
36	Bereg	Beregszász	
37	Máramaros	Sziget	
38	Ugocsa	Nagy-Szöllös	
39	Szatmár	Nagy-Károly	
40	Szilágy	Zilah	
41	Bihar	Nagy-Várad	Grosswardein
42	Szabolcs	Nyiregyháza	
43	Hajdú	Debreczen	Debreczin
44	Békés	Gyula	
45	Csanád	Makó	
46	Arad	Arad	
47	Torontál	Nagy-Becskerek	
48	Temes	Temesvár	
49	Krassó	Lugos	
50	Szörény	Karánsebes	
51	Hunyad	Déva	Diemrich
52	Alsó-Fehér	Nagy-Enyed	
53	Torda-Aranyos	Torda	
54	Kolozs	Kolozsvár	Klausenburg
55	Szolnok-Doboka	Deés	
56	Beszterczе-Naszód	Beszterczе	Bistritz
57	Maros-Torda	Maros-Vásárhely	
58	Csik	Csik-Szereda	
59	Udvarhely	Székely-Udvarhely	
60	Kis-Küküllö	Erzsébetváros	Elizabethstadt
61	Nagy-Küküllö	Segesvár	Schässburg
62	Szeben	Nagy-Szeben	Hermannstadt
63	Fogaras	Fogaras	
64	Brassó	Brassó	Kronstadt
65	Háromszék	Sepsi-Szent-György	
66	Fiume (town and district)	Fiume	
		Croatia and Slavonia.	
67	Fiume	Fiume	
68	Zágráb	Zágráb	Agram
69	Varasd	Varasd	Warasdin
70	Körös	Körös	Kreuz
71	Belovár	Belovár	
72	Pozsega	Pozsega	
73	Veröcze	Eszék	Esseg
74	Szerém	Vukovár	
		Croatian-Slavonian Frontier Districts.	
75	Mitrovicz	Mitrovicz	
76	Vinkovcze	Vinkovcze	
77	Gradiska	Uj-Gradiska	Neu-Gradiska
78	Petrinja	Petrinja	
79	Ogulin	Ogulin	
80	Goszpics	Goszpics	

Population.

The population of Hungary comprises a great variety of races, differing in language and religion, although united under one common sovereignty. At the census of 1870 the whole population, civil and military (exclusive of children under the age of six), amounted to 15,509,455, while the total civil population was 15,417,327; of these 7,653,560 were males and 7,763,767 females, the ages of 185 males and 196 females being given as over 100 years.

On the occasion of the new political divisions that took place in 1873, a fresh census was taken of Croatia and Slavonia and the

[1] In good years the total produce of the vines for the whole of Hungary may be estimated at 390 million gallons, in ordinary years at 227, and in bad years at 91 million gallons.

[2] The four circles of Hungary Proper had formerly their special political significance, owing to the so-called "circular sittings," where the deputies of each of the four circles met for the preliminary discussion of parliamentary questions.

[3] Formerly, but incorrectly Cis-Tibisca.

Military Frontier. This accounts for a slight discrepancy with the above number of the civil population in the total of the following table (from MM. Ballagi and Király), in which the population is arranged according to the new administrative divisions:—

	Population.
Hungary Proper and Transylvania	13,561,245[1]
Fiume and district	17,884
Croatia and Slavonia	1,156,025
Military Frontier	691,095
	15,426,249

According to the *Magyar Statistikai Evkönyv* (Budapest, 1879), the number of births in Hungary Proper and Transylvania during the year 1876 was 623,849, viz., 320,470 boys and 303,379 girls; of these 23,060 boys and 21,889 girls were illegitimate. The number of deaths in that year was 478,684, of whom 250,698 were males and 227,986 females. The number of marriages was 135,011. At the census of 1870 there were in the whole Hungarian monarchy 180 cities and large towns, 769 rural towns, 16,376 villages, and 2,450,213 houses. Budapest,[2] the capital, contained 270,476 inhabitants, Szeged 70,179, and Szabadka (Maria-Theresiopel) 56,323. Four towns contained between 40,000 and 50,000 inhabitants, 3 between 30,000 and 40,000, and 21 between 20,000 and 30,000. Zágráb (Agram), the capital of Croatia and Slavonia, had 19,857 inhabitants.

ices. As regards nationality the Magyar or pure Hungarian race is the most numerously represented in the kingdom, amounting, according to Dr Konek (see Schwicker, *Statistik des Königreiches Ungarn*, 1877), to 6,176,612, or 40 per cent. of the whole civil population. The Magyar element is chiefly confined to Hungary Proper and Transylvania, only about 15,000 Magyars residing in Croatia and Slavonia. The German population amounts to 1,898,202 (12·3 per cent.), for the most part settled in the western and north-western counties of Hungary Proper, bordering on Austria, also in the county of Szepes in the north, in the former Bánát, and in the Saxon counties of Transylvania. The Roumanians, estimated at 2,608,120 (16·9 per cent.), are mostly resident in Transylvania and the counties immediately abutting on it. The Slovaks amount to 1,835,334 (11·9 per cent.), and the Ruthens to 469,420 (3 per cent.), the former chiefly located in the north and north-west and the latter in the north-east of Hungary Proper. The aggregate number of Croats and Serbs is 2,380,985 (15·5 per cent.), chiefly confined to Croatia and Slavonia and the Military Frontier, where they form 97 per cent. of the population, to the former Servian-Bánát, and the southern counties of Hungary Proper. The other nationalities, comprising Armenians, Greeks, Bulgarians, Macedo-Wallachians, Albanians, French, and Italians, are not largely represented, their total number being estimated at only 48,654 (about 0·3 per cent.); the Italians are, however, to be met with in considerable numbers at Fiume and in its vicinity. In the above statistics the Jews scattered over the country, and amounting altogether to rather more than half a million, have been reckoned with the various nationalities where they happen to be settled.[3] The Gipsies, classed partly as Magyars partly as Roumanians, and roughly estimated at 145,000, have their colonies in various parts of the monarchy, but more particularly in Transylvania, and in the county of Gömör in Hungary Proper. On the whole the Magyar element may be said to predominate in 27 of the 65 (new) counties appertaining to the mother country, the German or Magyar-German in 6, the Roumanian in 13, the Slovakian in 9, the Servian in 1, and the Ruthenian in 3. In 6 counties of Hungary Proper no one special nationality can be said to have the absolute majority.

l gion. The total number of the various confessions for the whole population (civil and military) has been computed thus:—

Roman Catholics	7,558,558
Greek Catholics	1,599,628
Armenian Catholics	5,133
Greek (Eastern) Church	2,589,319
Armenians	646
Lutherans	1,113,508
Calvinists	2,031,243
Unitarians	54,822
Other Christian sects	2,733
Jews	553,641
Other non-Christians	224
	15,509,455

The Roman Catholics are in overwhelming majority in 32 counties, the adherents of the Greek (Eastern) Church in 11, the Greek Catholics in 10, and the Lutherans in 5. Further the Greek Orientalists have a majority in 6 counties, the Calvinists in 5, the Roman Catholics in 4, the Lutherans in 2, and the Greek Catholics in 1 county. The Roman Catholic Church has 4 archbishops: Esztergom (Gran), Kalocsa, Eger (Erlau), and Zágráb (Agram), and 17 real diocesan bishops; to the latter must be added, moreover, the chief abbot of Pannonhalma, who likewise enjoys episcopal rights. The primate is the archbishop of Esztergom, who also bears the title of prince, and whose special privilege it is to crown the sovereigns of Hungary. The Greek Catholic Church, which is in connexion with the Romish communion, owns besides the archbishop of Esztergom the archbishop of Gyulafehérvár (Carlsburg), or rather Balásfalva (*i.e.*, "Blasiusville"), and 6 bishops. The Armenian Catholic Church is partly under the jurisdiction of the Roman Catholic bishop of Transylvania, and partly under that of the Roman Catholic archbishop of Kalocsa. The Greek (Eastern) Church in Hungary is subject to the authority of the metropolitan of Carlowitz and the archbishop of Nagyszeben (Hermannstadt); under the former are the bishops of Bács, Buda, Temesvár, Versecz, and Pakrácz, and under the latter the bishops of Arad and Karánsebes. The two great Protestant communities are divided into ecclesiastical districts, five for each; the heads of these districts bear the title of superintendents. The Unitarians, chiefly resident in Transylvania, are under the authority of a bishop, whose see is Klausenburg. The Jewish communities are comprised in ecclesiastical districts, the head direction being at Budapest. At the commencement of 1870 there were 19,858 clerics of various creeds in Hungary.

Since the year 1867 great improvements have been effected in the educational system of Hungary, especially in Hungary Proper and Transylvania. Before that year public instruction was in the hands of the ecclesiastics of the various confessions, and the public schools had in consequence more or less of a denominational character. One of the first cares of the new responsible ministry of 1867 was to provide for the education of all children not attending the then existing scholastic establishments, by the introduction of supplementary non-denominational schools. By a law passed in 1868 the Government made it compulsory on children of both sexes between the ages of 6 and 12 to attend school, and it moreover required that children from 12 to 15 should attend the "repetition schools." The educational system of Croatia and Slavonia is autonomous, being under the independent direction of the Croatian-Slavonian provincial government. Education.

The various educational establishments may be divided into four classes:—common, middle, high, and special schools. In 1877 Hungary Proper and Transylvania had 15,486 belonging to the first-mentioned class; of these 13,755 were private or denominational, and 1731 communal and state schools. These figures show a total increase of 2341 since the year 1865, when the number was only 13,145. It is estimated that at the end of 1877 there was one school for every 870 inhabitants. In that year the number of children between the ages of six and fifteen who came under the education act amounted to 2,127,950, and of these 1,559,636 or 73 per cent. attended; whereas in 1869 the percentage of day scholars barely reached 48, showing an increase of 25 per cent. in the course of eight years. In 1874 there was already an attendance of 1,497,144, or nearly 70 per cent. The number of children who attended school in Croatia and Slavonia, with the Military Frontier, at that date was 73,635, making a general total for the whole of Hungary for the year 1874 of 1,570,779. On account of the variety of languages and races prevailing in many parts of Hungary, the education in numerous schools has to be conducted in two, and in several instances even in three languages. Out of 15,486 schools[4] in Hungary Proper and Transylvania in 1877 Hungarian was used in 7024, German in 1141, Roumanian in 2773, Slovakian in 1901, Servian in 259, Croatian in 70, Ruthenian in 491, two languages in 1692, and three in 135. The aggregate number of teachers in the above schools was 20,717.

The middle schools consist of the gymnasia, real-schools, and similar institutions. In 1874 there were in Hungary Proper and Transylvania 146 gymnasia, with 1734 teachers and 26,273 pupils; in 1877 the gymnasia had increased to 149, the teachers to 1814, and the pupils to 31,455. In 1874 there were 32 real-schools, with 387 teachers and 7743 pupils; in 1877 there were 26[5] such schools, with 383 teachers and 6647 pupils. The above results added together give an aggregate, for the year 1877, of 175 schools, 2197 teachers, and 38,102 pupils. With the omission of a few of a specially sectarian, technical, or private character, the total number of middle schools at that time in the whole Hungarian monarchy (including Croatia and Slavonia and the Military Frontier) was, as nearly as can be computed, about 205, with some 2450 teachers, and 42,000 pupils. In the mother country there were also 51 training seminaries[6] for masters (2853 scholars), and 14 for mistresses (1138 scholars); of these 65 establishments, 16 of the former and 6 of the latter kind were state, and the remaining 43 confessional, viz., 26 Roman Catholic, 3 Greek Eastern Church, 4 Lutheran, 9 Calvinist,

[1] The civil population of Hungary Proper and Transylvania at the end of 1876 was 13,670,624.
[2] In 1876 the population of Budapest, including military, was 309,208.
[3] *Cf.* Dr Jos. Bergl, *Geschichte der ungarischen Juden*, Leipsic, 1879.

[4] Of the children who left these schools in 1877, the percentage of those who could both read and write was 85, of those who could only read 15.
[5] These figures refer to upper and lower real-schools fairly complete in their formation. The total number of real-schools, perfect and imperfect, in the mother country, including also Fiume, was 36 (viz., 24 upper and 12 lower).
[6] Chiefly for the lower or common school teachers.

and 1 Jewish. The number of commercial schools was 24, with 129 masters and 1114 pupils.

The high schools comprise the universities of Budapest, Kolozsvár (Klausenburg), and Zágráb (Agram), the Joseph-Polytechnic, the theological institutes, the law academies, &c. The Budapest university (founded at Tyrnau in 1635) has four faculties,—theology, jurisprudence, medicine, and philosophy. In the year 1877 the number of professors amounted to 166, and that of students to 2929 (in 1878 to 180 and 3117 respectively). The university of Kolozsvár was founded in 1872, and is similar in its organization to that of Budapest, excepting that it has a faculty for mathematics and natural science, but none for theology. The number of professors in 1877 was 64, and that of students 391. Zágráb university was founded in 1869, but was not in active operation till 1874, and was even then incomplete in its formation. It has three faculties,—jurisprudence, theology, and philosophy. The Joseph-Polytechnic, ranking as a high school at Budapest since 1871, had in 1877 as many as 56 professors with 800 students. The number of theological institutions in Hungary Proper and Transylvania at that date was 45,[1] with 284 professors and 1534 novices; 25 of these institutions were Roman Catholic, 4 Greek Catholic, 3 Greek Eastern Church, 7 Lutheran, 5 Calvinistic, and 1 Unitarian. There were, moreover, 12 law academies, with 115 professors and 1067 students. In 1878 there were 125 professors and 1043 pupils. In Croatia and Slavonia there were 5 theological institutes (4 Roman Catholic and 1 Greek Eastern Church), with about 30 professors and some 200 students. The special schools are for particular branches of science and art. Among these are the school of design at Budapest; the music academy (founded 1875); several establishments for teaching mining, at Selmecz (Schemnitz), Nagyág, Felsö-Bánya; farming and agriculture, at Magyar-Óvár (Altenburg), Keszthely, Kolozsvár, Debreczen; and the management of forests, at Selmecz; also institutes for the blind, deaf, and dumb, and for lunatics at Vácz (Waitzen), Budapest, and Pozsony; and schools for veterinary surgery, obstetrics, &c. There are, moreover, military seminaries at Budapest, Kassa (Kaschau), Déva, Köszeg (Güns), Fehértemplom, and Zágráb, and a naval school at Fiume.

The Hungarian academy of sciences is the supreme representative of the national culture. First constituted with royal sanction in 1830, the academy in 1879 consisted of 321 (224 home and 97 foreign) members, arranged in 3 classes. Next follow the Kisfaludy (comprising in 1879 only 50 home and 15 foreign members) and Petöfi societies of Budapest, the royal meteorological institute, and the medical and physical (natural science), historical, archæological, geological, geographical (founded 1872), and philological (1875) societies. To these must be added the Roman Catholic "St Stephen's union," the "Protestant union," the Zágráb "South Slavonian Academy" (founded 1861), and the various Transylvanian and provincial learned societies.

Industries. As the industrial products and commerce of Hungary have been already described in the article AUSTRIA (vol. iii. p. 119–121), we need only add here a few remarks as to the chief localities of certain trades and manufactures.

Manufactures. The principal machine factories, foundries, bell and type works, and works for iron and other metallic wares are at Pest, Buda, Temesvár, Resicza, Diósgyör, and Sopron (Oedenburg). Boat-building is carried on at the chief towns on the great rivers, especially at Szeged, Arad, Buda, Komárom (Komorn), and Györ (Raab); steam-vessels are constructed at Buda and Fiume. The glass manufacture, mostly carried on in the hilly districts, is not yet fully developed, and the articles are of an inferior quality. The best manufactories of stoneware and earthenware are those of Csákvár, Pécs (Fünfkirchen), Rimaszombat, Murány, Pápa, Köszeg (Güns), Igló, Körmöczbánya, Zágráb, and Krapina; of porcelain the most important is that of Herend. Debreczen, Pápa, Selmeczbanya, and Szigetvár are famed for their clay pipes. The preparation of chemical stuffs is carried on chiefly at Pest, Nagyszombat (Tyrnau), Pozsony (Pressburg), Nagyszeben (Hermannstadt), and Ujmoldova; whilst Debreczen and Szeged are noted for their soap and candles. Oil factories are numerous, especially in Hungary Proper and Transylvania; the chief oil mills and refining houses are at Pest, New Pest, Rákospalota, Székesfehérvár (Stuhlweissenburg), Györ, Pozsony, Kassa (Kaschau), Temesvár, Brassó, (Kronstadt), and Cservenka, which last has forty mills. The manufacture of silk stuffs is still undeveloped, but there are spinneries at Nagyczenk, Hidja, Sopron, and Féltorony, also in the Bánát, and in various parts of Transylvania and of the Frontier districts. Flax is mostly homespun, and confined to the commoner kinds of linen. There are factories for woollen yarn at Brassó, Nagyszeben, and Gurano, and for woollen stuffs at Losoncz and Szakolcza. Coarse cloth is made in many parts of the kingdom. Leather is prepared at Kassa, Pozsony, Rozsnyó (Rosenau), Körmend, Temesvár, Késmárk, and Budapest. Paper is made at Diósgyör, Nezsider (Neusiedl), Hermanecz, Szlabos, and Fiume. Breweries are chiefly to be found in the neighbourhood of the large towns, which contain a mixed population, as the Magyars are drinkers of wine and spirits rather than of beer; the breweries of Köbánya near Pest are the most extensive. The taste for beer is said to be increasing, although the total number of breweries in Hungary has since 1860 been steadily falling, and many of the smaller establishments no longer exist, or have been absorbed. A considerable quantity of beer is, moreover, imported from Bohemia and the neighbourhood of Vienna. The largest sugar-works are those of Surány, Moson (Wieselburg), Szent-Miklós, and Edelény. The most important tobacco factories are those of Pest, Kassa, Debreczen, and Fiume.

As regards the number of factories exact data are not forthcoming. It appears, however, that in 1874 there were in the whole kingdom altogether 82,570 spirit distilleries, of which 991 were substantial factories and 81,579 rural stills. The breweries in activity at that date amounted to 247, of which 211 were in the mother country, and 36 in Croatia and Slavonia. There were, besides, 20 sugar refineries, and about 30,000 flour-mills of various descriptions, of which nearly 25,000 were in Hungary Proper and Transylvania. In fact the preparation of flour, which is, moreover, largely exported to Germany and Switzerland, is one of the most important industries of Hungary.

According to a report of M. de Hieronimy, under secretary of state in the Hungarian ministry of public works, the length of Hungarian railways in operation in the year 1867 was only 1375 English miles. The length of railways constructed from that date to the year 1876 amounted to 2675 miles, and thus at the beginning of 1877 there were 4050 miles of railway in operation in Hungary. By the early part of 1879 the total length was about 7000 kilometres or 4400 miles. There are also some 18,000 miles of highways (good and bad), and more than 2500 miles of navigable river and canal communication. The imports (including those from Austria) may be roughly estimated at £45,000,000, and the exports at £35,000,000. There is also a considerable transit trade carried on between Austria and the western states and the regions of the lower Danube, estimated at £8,500,000 yearly. The number of freighted vessels that arrived at the ports of the Hungarian Littorale in 1876 was 3524, the number that left 3362; of the former 909, and of the latter 926 were steamers. Commu- nication.

Besides the several branches of the "Austrian-Hungarian Bank" at Budapest, Kassa (Kaschau), Debreczen, and Temesvár, Hungary possesses about 120 industrial, commercial, and credit banks. There are, moreover, 12 chambers of commerce and industry at Budapest, Pozsony (Pressburg), Kassa, Sopron (Oedenburg), Debreczen, Temesvár, Arad, Kolozsvár (Klausenburg), Brassó (Kronstadt), Fiume, Zágráb (Agram), and Eszék. The number of savings banks is about 310; of other associations, such as loan societies, popular, mutual, and alliance banks, &c., the aggregate is over 200. In the year 1876 the number of post-office orders issued amounted to 1,832,757. The total number of telegraphic messages sent, received, or transmitted was 6,462,335. The aggregate of postal missives was 112,851,516; of these 46,617,106 were prepaid and 1,452,233 not prepaid letters; 4,581,027 were registered, and 13,954,354 official letters; 9,016,232 were post-cards; 28,876,062 were articles per newspaper, 1,364,490 per pattern, and 6,990,012 per book post. Banks. Post-office.

The form of government in Hungary is that of a constitutional monarchy. The sovereign power is at present vested in the house of Hapsburg-Lorraine, whose descendants succeed by right of primogeniture in the male line. By virtue of the Pragmatic Sanction, females may also reign in the event of there being no male successor. The king is the guardian of the laws, and the head of the army and of the executive. His power is limited by parliament, which consists of an upper and a lower house, and must be summoned yearly and elected triennially. The upper house comprises 407 members, viz., 3 princes of the reigning house, 31 Roman and Greek Catholic prelates, 11 standard-bearers, 57 lord-lieutenants of counties, 3 dukes, 219 counts, 81 barons, and 2 deputies for Croatia and Slavonia. The lower house, elected by the eligible tax-payers, consists of 446 members, of whom 403 represent Hungary Proper and Transylvania (including also Fiume), and 43 Croatia and Slavonia and the Military Frontier. The language used in the house is the Magyar, but the representatives of Croatia and Slavonia may use their native language. The executive is vested in a president of the cabinet and the following ministries:—court; finance; interior; religion and education; justice; public works; agriculture, industry, and commerce; *honvéd* (home-defence); and a ministry for Croatia and Slavonia. For matters relating to its special provincial administration, Croatia and Slavonia has at Zágráb (Agram) its own government, at the head of which is the ban, who is nominated by the king. The departments are three,—interior and finance, religion and education, and justice. (For the relations of the kingdom of Hungary to the joint Austrian-Hungarian monarchy, and for the delegations, comparative revenue and expenditure, joint army, &c., see AUSTRIA, vol. iii. pp. 122, 123.) Government.

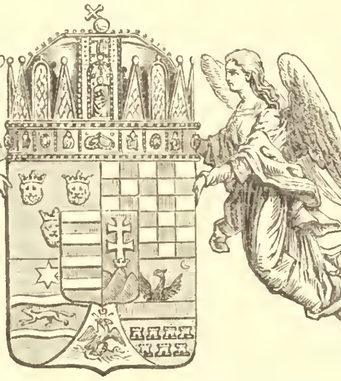
The judicial power is independent of the administrative, the functions of the minister of justice being to see that the laws are properly applied. The supreme courts of justice, as also those of second instance for Hungary Proper and Transylvania and Fiume, are at Budapest. There is also a secondary court of appeal at Maros- Justi

[1] To the above must be now added the "Rabbinerschule," opened October 4, 1877, and numbering (in 1878–79) 31 pupils.

Vásárhely in Transylvania. The number of royal courts of justice in the mother country (including also Fiume) in 1877 was 66, and there were 375 circuit courts. Of the 23,033 criminals condemned in 1877, 13,237 or 57·47 per cent. were completely illiterate, 1193 or 5·18 per cent. were able to read, 8314 or 36·10 per cent. could both read and write, and 289 or 1·25 per cent. were persons of superior education. As to the punishments awarded, 34 persons were condemned to death (of whom only 3 were executed), 13 were sentenced to prison with hard labour for life, 124 to from 10 to 20 years' imprisonment, 272 to from 5 to 10 years, 3537 to from 1 to 5 years, and 19,053 to less than a year's imprisonment.

ce. As regards the financial position of the kingdom, owing to the vast sums spent on state railways, the Fiume harbour works, and other large undertakings, the annual deficit rapidly increased until 1874, but from that date until 1878 it fell from about 33 to 21 million florins, the budget for the latter year giving a revenue of 219,846,016 and an expenditure of 240,967,435 florins.

The national colours are red, white, and green. The only order is that of St Stephen.



Crown and Arms of the Realm of St Stephen.

The shield contains four quarters:—1. azure, three leopards' heads crowned, or, for *Dalmatia*; 2, chequy, argent and gules, for *Croatia*; 3, azure, on a fess wavy gules, cotised argent, a marten courant proper, in chief an estoile of six points or (Mars), for *Slavonia*; 4. coupé: the chief azure, a demi-eagle issuant sable (*Hungarian nation*), in chief [a sun or, and] moon argent (*Szekler nation*); the base or, seven towers (Siebenbürgen) embattled four and three gules, over all a fesse gules, for *Transylvania*. In base enté, a double-headed eagle rising, contourné, for *Fiume*. On an escutcheon of pretence, barry of eight, argent and gules, impaling, gules, on a triple mount vert, out of a crown or, a patriarchal cross argent, for *Hungary Proper*; the bars argent representing emblematically the Danube, Theiss, Drave, and Save; the triple mount, the Tátra, Fátra, and Mátra. The whole is surmounted in chief by the Hungarian crown, with two genii or angel supporters. The lower part of the crown is a circlet inlaid with jewels and enamelled portraits, and heightened in the centre by a figure of Christ in majesty forming the middle portion of the arch or upper part of the crown, which is surmounted by a slanting cross.

Bibliographical Sources.—K. Ballagi and P. Kiraly, *A Magyar Birodalom leirása* (Budapest, 1877–78), compiled with special reference to the new county divisions of 1876; *Magyar Statistikai Evkönyv: Statistisches Jahrbuch*, 1874–77 (Budapest, 1875–79), issued by the Hungarian Royal Statistical Bureau; K. Keleti and L. Beöthy, *Magyarország Statistikája: Statistique de la Hongrie*, published in Hungarian and French, for the International Congress at Budapest, in 1876; S. Konek, *Magyar Birodalom statisztikai kézikönyve* (Budapest, 1875); J. H. Schwicker, *Statistik des Königreiches Ungarn* (Stuttgart, 1877); P. Hunfalvy, *Literarische Berichte aus Ungarn* (Budapest, 1877–79, vol. iii.); add K. Keleti, *Hazánk és népe* (Pest, 1871 and 1873), and *Uebersicht der Bevölkerung des Staatsgebietes der ungarischen Krone* (Pest, 1871). A good native map for the new administrative divisions of 1876 is that of J. Hátsek, *A Magyar korona országainak ...közigazgatási beosztása* (Budapest, 1877). For the physical features the *Uebersichts-Karte von Oesterreich-Ungarn* (1:2,500,000) of A. Steinhauser (Vienna, 1879) leaves little to be desired. For bibliography of geographical and statistical works and maps published previous to 1871, see F. Grassauer, *Landeskunde von Oesterreich-Ungarn* (Vienna, 1875).

II. History.

The south-western portion of Hungary, as formed by the Danube, belonged to the Roman province of Pannonia; the south-eastern portion, as formed by the Theiss (Ptol. iii. 8, § 4), to that of Dacia; the tract of country lying between these two rivers was inhabited by the Jazyges. As early as 274 A.D. Dacia was abandoned by the Romans to the Goths. In 376 the Huns crossed the Don, and, having overrun the intervening country, about 380 established themselves in Pannonia, where under Attila their power was so vastly extended that in 432 the authority of the Romans entirely ceased. After the death of Attila (453) the greater part of the country fell into the hands of the Ostrogoths and Gepidæ. These yielded in their turn to the Longobardi, who in 526–548 gained possession of the whole of Pannonia. When the latter removed to Italy in 568, the Avars entered, but they were reduced to subjection by Charlemagne in 791–796.

The history of Hungary really begins with the appearance of the Magyars in Europe about the year 884. It is generally admitted that they were a branch of the Turanian stock, and descendants of the ancient Scythians; certain affinities of language show them to be related to the Lapps, Esths, and Finns. They are believed to have wandered from the Ural mountains to the region of the middle Volga, and thence to have migrated westward over the Dnieper and the Bug. At the time of their crossing the Carpathians about 889, under the lead of Álmos, they were divided into seven tribes, united by a compact which guaranteed justice and equality among their members. At the death of Álmos in 889, the chiefs of the tribes elected his son Arpád successor. His followers overran the whole of Hungary and Transylvania, extending their conquests beyond the ancient province of Pannonia. From the time of the conquest to the year 1000, Hungary was ruled by dukes, the regal title being first assumed by Vaik (Stephen). The following table gives the dates of accession of the Árpád dynasty, which ruled over Hungary for upwards of four centuries:—

Dukes.		Ladislaus I., the Saint	1077
Árpád the Conqueror	889	Coloman the Learned	1095
Zoltán	907	Stephen II.	1114
Taksony	947	Béla II.	1131
Geyza	972	Geyza II.	1141
Vaik (afterwards Stephen I.)	997	Stephen III.	1161
Kings.		Ladislaus II. and Stephen IV. (usurpers)	1162
		Stephen III. (again)	1162
Stephen I., the Saint	1000	Béla III.	1173
Peter	1038	Emeric	1196
Aba Samú	1041	Ladislaus III.	1204
Peter (again)	1044	Andrew II.	1205
Andrew I.	1047	Béla IV.	1235
Béla I.	1061	Stephen V.	1270
Solomon	1063	Ladislaus IV.	1272
Geyza I.	1074	Andrew III.	1290

The following ruled from the extinction of the native dynasty to the commencement of the Hapsburg period:—

Wenceslaus (usurper)	1301	Uladislaus I.	1442
Otho (usurper)	1305	John Hunyady (Gubernator)	1446
Charles Robert (of Anjou)	1308		
Louis I., the Great	1342	Ladislaus V. (Posthumus)	1453
Maria	1382		
Charles II.	1385	Matthias Hunyady (Corvinus)	1458
Maria and Sigismond	1386		
Albert of Austria	1437	Uladislaus II.	1490
Elizabeth	1439	Louis II.	1516

Under Zoltán and Taksony the Hungarians made various expeditions beyond the limits of their own country, spreading terror and devastation through Europe. They were ultimately checked, however, by the emperor Henry I., near Merseburg, in 933, and afterwards by Otho the Great at the Lech (955). These defeats caused the Hungarians to turn their attention to the consolidation of their power within their own territory. Geyza, who succeeded Taksony in 972, married a Christian princess, and also furthered the introduction of Christianity by entrusting the education of his son Vaik to Adalbert, bishop of Prague. On succeeding his father, Vaik applied for and received the title of "apostolic king" from the hands of Pope Sylvester II., and was crowned in the year 1000 under the name of Stephen. This monarch, known as "St Stephen of Hungary," laid the foundation of many existing institutions. He subdivided the land into counties, and provided it with an ecclesiastical organization, establishing bishoprics, and founding churches, chapels, convents, and schools. Having elevated the bishops to the highest posts of trust and power in the state, he forced the people to pay tithes to the clergy. He also created a national council, consisting of the lords temporal and spiritual, and of the knights or lower nobility, from which assembly the subsequent diets originated. Stephen dying in 1038, and leaving no heir, the queen Gisela contrived to gain the throne for her nephew Peter, but a portion of the nobles declared for Aba, who was of Arpadian blood. In the wars which ensued both princes perished, when Andrew I., who was nearly related to Stephen I., succeeded to the throne in 1047, but he was ultimately forced to yield it to his brother Béla I. The next monarch's reign that offers anything worthy of notice is that of Ladislaus I., whose religious zeal gained him the appellation of "Saint," and who was distinguished on account of his conquest of Croatia (1089) and part of Galicia (1093), and for his victories over the Cumans (1086–89), the invaders of Transylvania and the neighbouring districts. His nephew Coloman, a brave and talented monarch, guarded the country against the depredations of the hosts of crusaders who passed through it during his reign. He also wrested Dalmatia from the Venetians (1102), and annexed it to the Hungarian kingdom. Coloman died in 1114, leaving the throne to his youthful son Stephen II., who soon entangled himself in warfare with neighbouring princes. The reign of his successor Béla II. (1131–41), like that of the other kings of the 12th century, presents few features of interest. That of Andrew II. (1205–35) is celebrated on account of the "Golden Bull," or Hungarian Magna Charta, extorted from the king by the nobles in the year 1222, after his return from a crusade forced upon him by the pope. The Golden Bull guaranteed that the states should be convoked annually, that no noble was to be arrested without being first tried and legally condemned, that the property of the nobility should be exempt from dues, that foreign service was to be rewarded, that appointments to the highest offices should be under the control of the diet. It also contained numerous other clauses granting certain freedoms, privileges, and exemptions to the nobility and the clergy, and included a proviso of the right of armed resistance to tyrannical measures on the part of the crown. This charter was duly sworn to by subsequent kings of Hungary, but the article relating to the right of appeal to arms was abrogated in 1687. A few years after the accession of Béla IV., son of Andrew II., the Mongols invaded and devastated the whole country, massacring great numbers of the population (1241–42). Béla did all in his power, by the introduction of German colonists, to retrieve the disasters inflicted by the invasion; but his wars with Austria and Styria, and the revolts of his son Stephen, were prejudicial to the restoration of order. He, however, successfully repelled a second Mongol invasion in 1261. The reigns of the next two monarchs, Stephen V. (1270–72) and Ladislaus IV. (1272–90), are noticeable chiefly for the wars on behalf of Rudolf of Austria against Ottokar of Bohemia. Ladislaus is said to have been murdered in 1290 amidst violent commotions caused by his Cumanian amours. His successor Andrew III., the last king of the Árpád dynasty, after a short but disturbed reign, died in 1301, leaving no issue.

On the death of Andrew III. the royal dignity became an object of competition. One party elected Wenceslaus, son of the king of Bohemia and Poland (1301–5), and after him Otho of Bavaria (1305–8), both connected with the Arpadian house. Pope Boniface VIII. and the bishops successfully espoused the cause of Charles Robert of Anjou, nephew of the king of Naples, and related to the extinct dynasty through his mother, a daughter of Stephen V. Under Charles and his son Louis, which latter in 1370 succeeded Casimir III. on the throne of Poland, Hungary made great progress both at home and abroad. During the reign of Louis it became the most formidable state in Europe. Among many other territories he conquered Moldavia (1352) and Bulgaria (1365); he also greatly extended and developed the royal prerogatives in his own kingdom. Upon the death of Louis (1382), the states raised to the throne his daughter Maria, who, after the assassination of the pretender Charles II. (1386), reigned conjointly with her consort Sigismond of Brandenburg, son of the emperor Charles IV. In the early part of this reign the Turks under the sultan Bajazet infested some of the Hungarian provinces, and at length in 1396 utterly defeated Sigismond at Nicopolis, obliging him to fly the kingdom. During his absence a party headed by the palatine Gara raised the standard of rebellion, and upon his return deprived him of his liberty. Scarcely was he released when he met with a rival in Uladislaus, king of Poland, who had married Hedwig, second daughter of Louis. Elected emperor (1411), and afterwards king of Bohemia (1419), Sigismond, instead of providing for the safety of the country, employed his time in persecuting the Hussites. He ended his long and troublous reign 9th December 1437, and was succeeded by his son-in-law Albert, archduke of Austria.

The year 1439 witnessed the sudden death of Albert; his widow, however, was soon delivered of a son, Ladislaus Posthumus. The states invited Uladislaus of Poland to the throne, and thus considerable dissensions existed until the death of the queen in 1442, when the party of Uladislaus secured his accession. At the commencement of his reign the Turks were several times defeated by John Hunyady (Corvinus), and they were at length forced to conclude a truce for ten years. The Hungarians, having almost immediately broken faith with the Turks, and taken the field against them, were completely routed at Varna on the 10th November 1444. In this battle Uladislaus met his end, whilst Hunyady escaped with a few followers. Amid the troubles which ensued the states proclaimed Hunyady "governor of Hungary" pending the absence of Ladislaus Posthumus, whom the emperor Frederick III. refused to deliver to the Hungarians to be acknowledged king. After the release and recognition[1] of Ladislaus in 1452, Hunyady resigned the office of governor, and was nominated generalissimo by the king.

After the fall of Constantinople in 1453, Mohammed II. made preparations for the conquest of Hungary, and in 1456 appeared before Belgrade with an army of 150,000 men. This force was, however, utterly routed on July 21, 1456, by the combined Hungarian, Italian, and Spanish troops, in all about 70,000 men, under the command of John Hunyady and the monk John Capistran. Soon after this victory, which resulted in the Turks raising the siege, Hunyady succumbed to dysentery aggravated by excessive fatigue, leaving behind him two sons, Ladislaus and Matthias. The former was executed by order of Ladislaus Posthumus, while the latter, after that monarch's death in November 1457, being supported by a strong party under the leadership of his uncle Michael Szilágyi, was elevated to the royal dignity on the 24th January 1458, under the title of Matthias I. The emperor Frederick, having disputed his right to the throne, and assumed the regal title himself, was forced by Matthias to surrender all claims to the Hungarian dominions, and to conclude a peace in July 1463. During the next few years Matthias was employed in reorganizing the military system and repelling the Turks. He after this turned his arms against Podiebrad, king of Bohemia (1468), ostensibly for the purpose of defending the Catholics against the Hussites. Being victorious in these campaigns, Matthias in May 1469 caused himself to be proclaimed king of Bohemia and Moravia at Olmütz. Meanwhile the Turks, taking advan-

[1] He took the oath in 1453, but Frederick withheld the crown.

tage of the absence of the king, made incursions into the southern provinces of Hungary. This misfortune created a party against Matthias, who, having returned to Hungary and restored order, marched against the Ottoman forces, and totally defeated them in a sanguinary battle on the plains of Kenyérmezö in Transylvania (13th November 1479). After the death of Mohammed II. in 1481, Matthias renewed hostilities with the emperor Frederick, and having taken Vienna (1485), made it the seat of his government. Matthias was not only an able and warlike monarch, but a patron of letters,[1] and administered his kingdom with impartiality, subduing the rebellious nobles, and restoring order, law, and prosperity.

At the death of Matthias, 6th April 1490, there were several pretenders to the throne, among them John Corvinus, a natural son of the late king, the emperor Frederick, and his son Maximilian. But the states disallowed their claims, and declared for Uladislaus of Bohemia, whose weak reign is marked chiefly by the insurrection of the peasantry in Transylvania, under Dózsa, which was suppressed with great bloodshed in 1514, as also for the collection made by Verböczy of the common laws of the realm, entitled "Tripartitum Opus Juris Consuetudinarii Inclyti Regni Hungariæ," which code was sanctioned by the king and the diet in 1514. Under this monarch and his son Louis II., who succeeded him, the power of Hungary rapidly declined, and it was at length utterly overthrown by the Turks under Soliman the Magnificent. This powerful ruler, having captured Belgrade and Peterwardein, advanced at the head of 200,000 men into the interior of the country, and annihilated the Hungarian army at the battle of Mohács, 29th August 1526. In the carnage several prelates and the flower of the Hungarian nobility were destroyed, and Louis himself perished in his flight. The Ottomans, after pillaging Buda and spreading devastation over the whole country, took their departure with many thousands of captives.

After the catastrophe at Mohács and death of Louis in 1526, a portion of the nobles declared for John Zápolya, waywode of Transylvania, who was accordingly crowned at Székesfehérvár (Stuhlweissenburg). Maria, the widow of Louis, immediately summoned a diet of the nobility of the western counties at Pozsony (Pressburg), who pronounced the election of Zápolya illegal, and proclaimed the queen's brother, Ferdinand of Austria, king of Hungary (16th December 1526). In the following August Ferdinand, having proceeded to Hungary, was again proclaimed king at Buda; he was afterwards crowned at Székesfehérvár, 5th November 1527. With this monarch the Hapsburg period commences, the sovereign rulers of Austria after him succeeding to the title of the Hungarian crown. The following is a list of the kings of Hungary, and of the more prominent of the princes who ruled over Transylvania to the end of the 17th century:—

Hungary.	
Ferdinand I. (rival John Zápolya)	1526
Maximilian (rival Sigismond Zápolya)	1564
Rudolph I.	1577
Matthias II.	1608
Ferdinand II.	1619
Ferdinand III.	1637
Leopold I.	1657
Joseph I.	1705
Charles III.	1711
Maria Theresa	1740
Joseph II.	1780
Leopold II.	1790
Francis I.	1792
Ferdinand V.	1835
Francis Joseph (crowned 1867)	1848

Transylvania.	
Stephen Báthori	1571
Stephen Bocskay	1605
Gabriel Báthori	1608
Gabriel Bethlen	1613
George Rákóczy I.	1631
George Rákóczy II.	1648
John Kemény	1661
Michael Apaffi I.	1661
Michael Apaffi II.	1690

Hapsburg dynasty.

John Zápolya, being compelled to retire before the superior forces of Ferdinand, took refuge for a time in Poland, whence he sought the assistance of Soliman II. The sultan listened to his request, and in 1529 conducted a large army into Hungary, took Buda by storm (3d September), reinstated Zápolya, and drove the Austrians before him to Vienna. Failing to take that city, Soliman in October retraced his steps, and after garrisoning Buda with Turkish troops returned in triumph to Constantinople. After several years of desultory warfare between John and Ferdinand, their rival claims were ultimately settled by a treaty concluded at Nagyvárad (Grosswardein) on the 25th February 1538. By this treaty it was stipulated that John was to retain the title of king, together with Transylvania and the eastern portion of Hungary then in his possession, whilst Ferdinand was to hold the remainder, with the proviso that John's male descendants were to surrender all claims to the regal dignity. John having died on the 21st July 1540, his infant son Sigismond was crowned by the adherents of his father, and he was subsequently confirmed in his title to Transylvania by Soliman. This sultan, however, retained a great portion of Hungary in his own possession, and even placed a pasha as regent at Buda; he, moreover, compelled Ferdinand to pay him an annual tribute of 30,000 ducats. Ferdinand, having caused his son Maximilian to be crowned as his successor in 1563, died on the 25th July of the following year. When Maximilian succeeded to the throne, he found himself obliged to continue the war with the young Zápolya, whose cause was espoused by Soliman. In 1566 the sultan, advancing at the head of a large force, was arrested at the small fortress of Sziget by Nicholas Zrinyi, who with a garrison of 3000 men for four weeks heroically defied the whole power of the besiegers.[2] Soliman himself died shortly before the final assault on the citadel, which was overpowered only after the destruction of a large part of his army. In the year 1570 Zápolya concluded peace with Maximilian, and on his death in the following year Stephen Báthori, with the consent of the sultan Selim, was elected prince of Transylvania. Maximilian, having in 1573 secured the succession of his son Rudolph to the throne of Hungary, died on the 12th October 1576.

By this time the Reformation had made considerable progress in Hungary, more especially among the higher classes, but with Rudolph the persecution of the Protestants commenced. In Transylvania, however, they met with a protector in Stephen Báthori, from 1576 to 1586 distinguished as king of Poland. In 1604 the Protestants of Hungary, having raised the standard of freedom under Stephen Bocskay, defeated the generals of Rudolph in several engagements, and on the 23d June 1606 they forced him to conclude peace at Vienna, thus securing to themselves for a time their religious liberties. In 1608 Rudolph resigned the kingdom to his brother Matthias, who during his short reign showed great toleration towards the adherents of the Reformed creeds. He died 20th March 1619, leaving the crown to his cousin Ferdinand II., the hero of the "Thirty Years' War." The accession of this monarch was signalized by the insurrection of the Protestants of Bohemia, and the renewal of persecutions in Hungary, fomented by the Jesuit prelate Peter Pázmán. But the victories of the Transylvanian prince Bethlen Gábor (Gabriel Bethlen) over the imperialist troops forced Ferdinand to conclude the treaty of Nikolsburg, 31st December 1621. By this compact the privileges of the Protestants were declared inviolate,

[1] The world-famed Bibliotheca Corvina is variously estimated to have contained from 5000 to 10,000 volumes, chiefly manuscripts, many of which were bought from Greek scholars who had fled from Constantinople, or had been copied in different parts of Italy.

[2] In the Map Department of the British Museum there is a curious old print by H. van Schoel (1602), taken from an engraving by A. Lafrery (1566), which represents one of the Turkish attacks upon this fortress.

and Bethlen's claim to the principality of Transylvania and seven counties of Hungary Proper was established. The infringement of this treaty on the part of Ferdinand brought about a renewal of hostilities, which resulted in a second peace, concluded at Pozsony (Pressburg) in 1626. After the death of Bethlen in 1629, the Jesuits succeeded in gaining over several powerful families to the Roman Church, and the religious persecutions were renewed by Ferdinand III., who succeeded his father in 1637. The Transylvanians had elected George Rákóczy as their prince, who proclaimed himself the protector of Protestantism and of Hungarian liberty. Having drawn up a statement of grievances—those of the Protestants in particular—he laid the document before Ferdinand, who, however, paid no attention to it. Rákóczy thereupon collected troops and gained several successes over the imperialists (1644), and in the next year formed a league with the Swedes. This coalition brought Ferdinand into desperate straits, and he therefore soon entered into a treaty of peace with Rákóczy at Linz (16th December 1645). By this treaty, confirmed at the diet held in 1647, Rákóczy was formally recognized as the legitimate prince of Transylvania. He died the year afterwards (1648), and was succeeded by his son George II. Rákóczy. The year 1657 witnessed the death of Ferdinand III., who was succeeded by his second son Leopold I.[1]

During the long reign of this monarch, so injurious to the cause of Hungarian liberty, Hungary was the theatre of intestine wars, insurrections, and the most tragic events. Shortly after his accession, Leopold became involved in war with the Turks, who had created Michael Apaffi prince of Transylvania in the place of his own partisan John Kemény. The Turks, although at first successful, were ultimately defeated by the imperialists at St Gotthard, 1st August 1664. This victory enabled Leopold to conclude a hasty and disadvantageous peace at Vasvár (10th August) with the infidels, and to direct his whole energies against the Protestants. The irritation consequent upon this harsh treatment resulted in a conspiracy,[2] which was organized by the Croatian ban Peter Zrinyi, Count Frangepan, Francis Rákóczy, and the chief justice Nádasdi, and had for its object the separation of Hungary from the house of Hapsburg. The plot having been discovered, the leaders were surprised, conveyed to Vienna, and, with the exception of Rákóczy, executed (30th April 1671). Although an amnesty was proclaimed on the 6th of June of the same year, Leopold in February 1673 appointed a bigoted Catholic, John Caspar Ambringen, governor-general of the kingdom, and made every effort to extirpate the Protestant religion. The oppression becoming at last intolerable, the Protestants again rose in arms under Michael Teleki and Emeric Tökölyi (1678), and were subsequently supported by the grand vizier Kara Mustapha, who in 1683 marched straight to Vienna with a large force. The valour of Sobieski, king of Poland, delivered the city (12th September 1683), and saved Austria from the threatened destruction. In 1686 Buda was taken from the Turks by Charles of Lorraine, and these troublesome foes were at length driven out of most of the provinces and towns of Hungary where they had been settled for about a century and a half. The glory of these achievements was, however, tarnished by the emperor's revengeful treatment of the Hungarians, hundreds of whom, on suspicion of complicity with the enemy, were put to death upon the scaffold erected in the market-place of Eperies by order of General Caraffa, which remained standing from March 1687 till the end of the year. Leopold at length granted a general amnesty, but obliged the diet to declare the throne hereditary in the house of Austria, and to abrogate the clause of the Golden Bull which allowed the right of armed resistance to tyranny (31st October 1687). The victories of Prince Eugene, which completed the conquests over the Turks, resulted in the peace of Carlowitz, January 26, 1699, by which the Porte abandoned Hungary and Transylvania to the emperor. On the 5th May 1705 Leopold died, and was succeeded by his eldest son Joseph I. In the year 1703 Francis Rákóczy II. headed a new revolution, which lasted till May 1711, when peace was concluded at Szatmár by Károly, the chief of the Hungarian generals. The emperor Joseph I. died on the 17th April of the same year, and was succeeded by his brother the archduke Charles. From this time until 1848 no open rupture occurred between Hungary and her Hapsburg rulers.

By the treaty of Passarowitz, concluded 21st July 1718, Temesvár, the last of the Turkish possessions, reverted to Hungary. In 1722 Charles received the adhesion of the diet to the Pragmatic Sanction, which secured the right of succession to the throne in the female line. At the instigation of Russia hostilities were renewed against the Turks, but Prince Eugene being now dead, and no other leader of equal ability appearing in his place, the Austrians were subjected to a series of disgraceful defeats. These misfortunes were consummated by the humiliating treaty of Belgrade (18th September 1739), in accordance with which the emperor was forced to cede the fortress of Belgrade, with Servia and Austrian Wallachia. On the 20th October of the following year Charles died, leaving the throne to his daughter Maria Theresa. Her claims to the imperial dignity were almost immediately called in question by Prussia, Saxony, France, and Bavaria, and her hereditary dominions were invaded by hostile troops. Maria in despair fled to Pozsony (Pressburg), and summoned the Hungarian diet. Appearing before that assembly on the 11th September 1741, with her infant son Joseph in her arms, she appealed in Latin to the magnanimity and loyal spirit of the nobles. The result of her address was the unanimous declaration on their part: "Moriamur pro 'rege nostro' Maria Theresa." Nor was this an empty burst of enthusiasm, for the "insurrectio" or general rise of the nation was proclaimed, and a large army collected, and Hungarian blood was profusely shed in support of her cause. Maria repaid the devotion of her subjects by the zeal which she showed for their welfare, and the salutary changes which she effected in the country. Transylvania was raised into a grand principality (1765), and the town and district of Fiume declared a *corpus separatum* of the Hungarian crown (23d April 1779). Maria Theresa also created an Hungarian guard, established several schools, and enlarged the university at Nagyszombat (Tyrnau), which in 1777 was transferred to Buda, and seven years later to Pest. But her efforts to ameliorate the condition of the peasantry, and the reforms which she introduced under the name of the *Urbarium* (1765), which determined the rights of the tenant serfs in relation to the landowners, are among the chief merits of her reign. She died on the 29th November 1780, and was succeeded by her son Joseph II.

This philosophic monarch was wholly carried away by his zeal for reforms, which were both subversive of the constitution and opposed to the will of the nation. He refused to be crowned in Hungary, and thus avoided the obligations of the usual coronation oath. In defiance of ancient custom he carried the crown of St Stephen to Vienna, dispensed altogether with the use of diets, and governed the country autocratically by decrees. He issued

[1] The elder son of Ferdinand III., who in 1647 had been designated Ferdinand IV., died in 1654.

[2] Known as "Palatine Wesselényi's Plot." The palatine, however, died in 1667, prior to the failure of the movement.

a general edict of toleration in religious matters (October 1781), but forced upon the people heavy taxes and foreign officials; he moreover enjoined the exclusive use of the German language in the schools, courts of justice, and public administration. The general discontent at these measures was heightened by the unfavourable issue of the war against Turkey; and Joseph, shortly before his death (1790), found himself compelled to revoke nearly all his edicts, and promise redress to his irritated subjects. His brother and successor, Leopold II., appeased the Hungarians by more definitely confirming the rights and liberties of the nation than any of his predecessors. After a reign of only two years Leopold died, and was succeeded by his eldest son Francis I. (1792). This monarch duly swore to maintain the laws and constitution of Hungary, but his efforts were eventually directed wholly against them. During the continuance of his war with France he repeatedly convoked the states, only, however, for the purpose of obtaining supplies of men and money to carry on the struggle. Through the whole of this crisis the Hungarians faithfully supported the Austrian cause, and disdainfully rejected the offers of Napoleon in his proclamation of the 15th May 1809, calling upon them to rise for national independence. But at the end of the great war the Hungarian nation received little gratitude for its devotion. Francis for several years discontinued the holding of the diet, and acted in direct violation of the constitution by levying troops and increasing the taxation to more than double. The opposition which these arbitrary measures provoked in the counties at length obliged him in 1825 to convene the states, and thus appease the widespread dissatisfaction.

To the holding of this diet, in which Count Stephen Széchenyi initiated the use of the Magyar instead of the accustomed Latin tongue, may be traced not only a reaction in favour of the native language, but also the commencement of the reform movement. The spirit of nationality was fully aroused, and liberal sentiments were diffused over the whole kingdom, notwithstanding the active opposition of the Viennese court influenced by Metternich, in the reigns of both Francis and his successor Ferdinand (1835). The diets of 1832, 1839, and 1843 passed several measures of reform, amongst which the most important were those demanding the official use of the Magyar language, the equality of the various Christian confessions, and the rights of the peasantry and of the non-ennobled citizens. Amongst the leaders of the liberal party the magnates were Count Louis Batthyányi and Barons Nicholas Wesselényi and Joseph Eötvös, and the deputies Deák, Klauzál, Fáy, Beöthy, Balogh, Szemere, and Louis Kossuth. In the hope of intimidating the advanced liberals, the Viennese court in 1839 imprisoned Wesselényi and Kossuth, but they were released in 1840 owing to the amnesty then proclaimed for political offenders. The publication of the *Pesti Hirlap* (Pest Gazette) was commenced in 1841 by Kossuth as the organ of the liberal party. This paper, the leading articles of which were written in a spirit directly opposed to the policy of the Government, gained an immense circulation, and considerably influenced the public mind. A pamphlet styled *A Kelet Népe* (The People of the East), written by Széchenyi in order to counteract the schemes of Kossuth, only served to add to the importance of the *Pesti Hirlap*. The conservative journal *Világ* (Light) was conducted by Count Aurél Dessewffy, who from 1833 until his death in 1842 was the leader of the conservative party.

Meanwhile intellectual and material improvement made rapid progress, especially in the Hungarian capital. Numerous works, literary and political, were published, the former due to the encouragement offered by the Hungarian academy and the Kisfaludy society, the latter the outcome of the great political excitement prevailing throughout the country. Clubs really if not avowedly political were established in most of the principal towns. Steam navigation of the Danube, the Budapest suspension bridge (commenced May 1840), and other improvements of the means of internal communication, which had received their first impulse from Count Széchenyi, were rapidly proceeded with. In order to encourage native trade and industry, long obstructed by toll and custom duties, Kossuth called into existence the *Védegylet* (Protection Union), the members of which pledged themselves to abstain from the use of Austrian manufactures until the tariff should be reformed. This association soon overspread the country, and affected Austrian trade so seriously that some manufacturers had to transport their factories into Hungary in order to save themselves from ruin. The establishment of this association, the liberal measures of the late diets, and the unanimity of national feeling in Hungary Proper and Transylvania embarrassed the Government of Vienna, which could reckon only on the support of the Conservatives, whose numbers and moral influence were comparatively small. Metternich therefore determined to annihilate the municipal independence of the counties, in whose assemblies lay the real strength of the Liberals, by the appointment of "administrators" paid by the court to fill the places of all absent lord-lieutenants. This measure raised the political excitement of the nation to the highest pitch. The Liberals were soon divided into two parties, the so-called "municipalists," with Kossuth at their head, who urged the reaffirmation of the county institutions, and the "centralists," led by Szalay and Eötvös, who insisted upon the nomination of a responsible ministry. On the approach of the elections for the diet of 1847 these two parties agreed upon a common course of action. In November the diet was summoned, when Kossuth appeared as a candidate for the county of Pest, and after a warm contest was elected. On the 12th November the diet was opened at Pozsony (Pressburg) by Ferdinand V. in person, who by addressing the assembled states in the Magyar language instead of Latin produced a very favourable impression. The first act of the diet was the unanimous election of a successor to the late palatine Joseph in the person of his son the archduke Stephen. Thus far all was well, but the address to the throne containing clauses, inserted by Kossuth's party, deprecatory of unconstitutional measures by the Government, after passing the lower was rejected by the upper house, by which means the royal speech was practically ignored. At the commencement of the year 1848 an Act was carried through both houses, ordaining the exclusive use of the Magyar language in all branches of the administration, in legal documents, and in the schools and colleges. Certain provisions were, however, made respecting Croatia and Slavonia.

Upon the news of the French revolution the diet was powerfully impressed, and the Liberals assumed a more determined attitude. On the proposal of Kossuth it was unanimously resolved to send a deputation to Vienna demanding from the Government a responsible ministry, the abolition of all feudal burdens, the equalization of taxes, the extension of the franchise, freedom of the press, complete religious toleration, and several other measures of reform. On the 16th of March the address was presented to Ferdinand, who, by reason of the troubled state of his Italian provinces and the revolutionary aspect of Vienna, was compelled to yield his assent. The palatine archduke Stephen was nominated viceroy in Hungary, and Count Louis Batthyányi entrusted with the formation of a ministry. The irritation of the Viennese Government at this enforced compliance with the Hungarian demands was increased by the choice of Kossuth as minister of finance. On the 11th April Ferdinand repaired to Pozsony (Pressburg), and the diet was closed with a Magyar speech from the throne.

Events of 1848.

But the Austrian Government, although compelled to abandon for the present its position of open and direct hostility to the national will of the Hungarians, was determined by other means to prevent the new reforms from being carried out. The plan adopted was that of secretly encouraging the southern non-Magyar nationalities to assert their independence, and oppose by force of arms the consolidation of the new constitution. Croatia and Slavonia and the Bánát refused to submit to the Hungarian rule, and demanded separate rights and autonomous administration; while in Transylvania, the diet of which had proclaimed its reunion with Hungary Proper, the Wallachs and Saxons rose in arms against the Magyars. The whole of the south and south-west of the country was soon in a state of revolt, and a war of races was carried on with indescribable fury. Representations to the court of Vienna remained virtually unheeded, the emperor contenting himself with hypocritical proclamations against the rebels, and with placing at the disposal of the Hungarian ministry a few regiments of soldiers, whose officers were disaffected to the Hungarian cause.

It now became evident that the Hungarians, in order to retain their national existence, must rely entirely upon their own resources, and make an immediate and vigorous effort, more especially as Jellachich, the newly-appointed ban of Croatia, was making preparations to march upon Pest. Ferdinand, who still professed his determination to defend the integrity of the Hungarian monarchy, convoked the diet for the 5th of July, when it was opened by the palatine Stephen, as viceroy. At the suggestion of Kossuth a levy of 200,000 men and ample supplies for the purposes of national defence were unanimously voted; but to these measures Ferdinand withheld his assent. On the 6th of September a deputation of a hundred members arrived at Vienna in order to urge upon the emperor the necessity of taking immediate and decisive steps to oppose the Croatian invasion. On the 9th of September they were admitted to an audience, but, receiving only an evasive answer, they straightway returned to Pest. The abortive result of the deputation, and an official report that Jellachich had crossed the Drave, were announced to the diet on the 11th September, and brought matters to a crisis. A few days later the palatine archduke Stephen, who at the demand of the diet had set out for the camp, but failed in his efforts at mediation, fled to Austria. The emperor thereupon nominated Count Lamberg royal commissioner and commander-in-chief of all the military forces in Hungary (September 25), but the diet pronounced his appointment illegal and invalid, and he was murdered on the Budapest bridge of boats by the infuriated populace (September 28). The Batthyányi ministry now resigned, and a committee of national defence was formed under the presidency of Kossuth. On the 29th September, Jellachich, who had advanced to within 25 miles of Buda, was defeated at Velencze, whence he fled towards Vienna during a three days' armistice that was granted to him by General Móga. Ferdinand now declared openly against the Hungarians, annulled the decrees of the diet, and nominated Jellachich generalissimo of the forces to be employed for the reduction of Hungary. While the Austrian Government, still further exasperated at the march of a Hungarian force to Schwechat (30th October), was preparing for a general invasion, the Hungarian diet hastily equipped a large army to resist it. In the meantime a new Austrian ministry was formed at Vienna, and on the 2d December Ferdinand was induced to resign the imperial throne. He was succeeded by his nephew archduke Francis Joseph, son of Francis Charles, the heir-apparent, who refused to accept the crown. The Hungarian diet, however, protested against this dynastic change as unconstitutional.

Revolution.

Revolutionary war (1848–49).

On the 15th of December the main body of the Austrian army under Prince Windischgrätz began to cross the western frontier of Hungary near Bruck on the Leitha, while the Hungarian army of the Upper Danube, commanded by Görgei, who had succeeded Móga, retreated in the direction of Moson (Wieselburg). On the 18th December the second Austrian army corps occupied Pozsony (Pressburg), which the Hungarian troops had evacuated, and upon the same day Jellachich, who commanded the first army corps, occupied Moson, compelling Görgei to withdraw towards Györ (Raab). Upon the occupation of this town by the Austrians, on the 27th December, Görgei removed to Bábolna, where he hoped to effect a junction with Perczel, who had been ordered to reinforce him. But Perczel being overtaken and defeated at Móor on the 29th December by the troops of the ban, was obliged to beat a hasty retreat towards Székesfehérvár (Stuhlweissenburg). These reverses having rendered Budapest insecure, the diet and the committee of national defence on the 1st January 1849 transferred their seat to Debreczen, and on the night of the 4th and 5th the Hungarian troops marched out of the capital, which on the following day was taken possession of by Windischgrätz. Perczel, who had gathered together the remains of his corps at Budapest, followed the Government by way of Szolnok, while Görgei made a flank movement to the north, and led his corps by a circuitous route through the Carpathians to join the army on the Theiss. Windischgrätz, mindful of Schwechat, and, regarding the Hungarians as rebels, had refused to listen to a deputation headed by Count Batthyányi making proposals of peace, and Batthyányi himself was arrested. While the Austrian generals were making this rapid progress in Hungary Proper, the Polish general Bem had succeeded in organizing a large force in Transylvania, by means of which he reduced the refractory Wallachs to subjection, and drove the Austrians out of the principality, which had been forced to submit to General Puchner.

In the diet now held at Debreczen Kossuth declared that the nation was on the verge of destruction, and could only be saved by extraordinary measures. But the inactivity of Windischgrätz, who, instead of hastening onwards to the Theiss, remained for several weeks at Pest, gave the committee of national defence time to concentrate its forces, procure war material, and make other provisions for a determined resistance. On the 12th of February Görgei arrived at Kassa (Kaschau), and the two Hungarian armies could now act in concert. Meanwhile the national cause made little progress in the south, a great portion of which was in the hands of the enemy. On the 14th February the fortress of Eszék in Slavonia was lost to the Hungarians; that of Lipótvár (Leopoldstadt) in the north had already fallen on the 2d of the same month.

At length the main body of the Austrians under Windischgrätz advanced, and attacked the Hungarians under the Polish general Dembinski on the 26th and 27th February at Kápolna. The battle, though obstinately contested, proved indecisive, and the Hungarians were obliged to retire beyond the Theiss in order to recruit their forces. A few days later, however, an Hungarian corps, withdrawn from the lower Danube, and commanded by Damjanics, routed the Austrians under Grammont at Szolnok (5th March). Meanwhile the Russians, coming to the aid of the Austrians, had penetrated into Transylvania and occupied Nagyszeben (Hermannstadt) and Brassó (Kronstadt), but the Hungarians under Bem regained these fortresses on the 11th and 20th March, and drove the Russians into Wallachia.

By the middle of March an army of 120,000 men, provided with excellent generals and ample artillery, was concentrated on the Theiss. Towards the end of the month the Hungarians crossed the river at various points, and advanced on the road to Pest, under the command of Görgei, Damjanics, Aulich, Klapka, and others,—Guyon having been nominated to the commandership of Komárom (Komorn), the relief of which was the ultimate object of the campaign. The leadership of the Hungarian forces had meanwhile passed from Dembinski to Vetter, on account of whose ill-health it was provisionally transferred on the 31st March to Görgei. From this time the Austrians had to endure a rapid succession of defeats,—at Hatvan (April 2), Tápió-Bieske (April 4), Isaszeg (April 6), Gödöllö (April 7), and Vácz or Waitzen (April 10). In consequence of these reverses Windischgrätz was recalled, and the chief command of the Austrian troops was given to Baron Welden (April 12). In order to prevent the relief of Komárom, Welden opposed the advance of Görgei with a force under Wohlgemuth, which was, however, defeated by Damjanics on the 19th April at Nagy-Sarló, so that on the 22d the relief of the fortress of Komárom was effected upon the left bank of the Danube, Guyon having previously succeeded in passing through the hostile lines. The subsequent rout of the besieging forces at Uj-Szöny on the 26th April completed the discomfiture of the Austrians, and forced them to fly to the frontier. The ban Jellachich meanwhile retreated to Croatia, and nearly the whole country was once more in the hands of the Hungarians.

In the midst of these victories Kossuth proposed in the diet at Debreczen the dethronement of the Hapsburg dynasty, and upon the 14th April an act to that effect was almost unanimously passed, although afterwards unfavourably received by Görgei and a large portion of the army. The chief provocation to the passing of this extreme and, as it eventually proved, unfortunate measure was the promulgation of the new constitution on the 4th March by the emperor Francis Joseph, which made a *tabula rasa* of all the time-honoured laws, rights, and privileges of Hungary. The substance of the declaration of independence was as follows: "That the house of Hapsburg, having violated the integrity of the kingdom, treacherously levied war against the nation, and called in the aid of a foreign power to accomplish its aims, has trampled under foot all the treaties that united it to Hungary, and is therefore declared for ever excluded from the Hungarian throne." The form of government was to be settled afterwards by the diet, but in the meantime Kossuth was nominated governor, the committee of national defence was dissolved, and a new responsible ministry formed under the presidency of Szemere.

It is generally admitted that, had the Hungarians followed up their victories by an immediate march upon Vienna, they would have been able to force the Austrian Government to terms, and thus have warded off the Russian invasion, the preparations for which were now being conducted upon an enormous scale. Instead, however, of acting on the offensive across the Austrian frontier, the Hungarian commander-in-chief, Görgei, after a few days delay at Komárom, made a retrograde movement towards the Hungarian capital. On the 4th May he arrived before Buda, which was still in the possession of the Austrians, but it was in vain that he summoned the commander Hentzi to surrender. On the 15th began the regular bombardment of the fortress, and on the 21st it was taken by assault. On the 5th of June Kossuth made his entry into Pest, and the diet having adjourned its sittings at Debreczen, the Government returned to the capital. Every preparation was now set on foot for a desperate defence against the combined armies of Russia and Austria, which by the middle of the month had completed their arrangements, and had begun to invade the country at various points. Prince Paskewitch advanced from Galicia at the head of the main body of the Russian army, consisting of over 100,000 men, while Haynau crossed the western frontier with an Austrian force of 60,000, supported by a Russian division of 12,000 under Paniutin. On the Drave and the Styrian frontier Nugent commanded 12,000, and near Eszék was Jellachich with 25,000 men. In Transylvania the combined Austrian and Russian forces under Puchner and Lüders amounted to 60,000; so that, including the garrisons of the fortresses in their hands, the allied forces were in all not less than 275,000 men with 600 guns. The whole available forces of Hungary did not amount to more than half this number, the army of the Upper Danube under Görgei being 50,000, that of Perczel and Vécsey in the south 30,000, the army of the north under Dembinski 12,000; while there were about 32,000 men under

Bem in Transylvania, and a few thousands under Kazinczy in the county of Máramaros. On the 19th of June the Russian corps under Lüders burst through the Red Tower Pass into Transylvania, and, having defeated the Hungarians, took the fortress of Nagy-Szeben, whilst in the following month Brassó in like manner surrendered to the Austrians. Jellachich was, however, defeated on the 14th July at Hegyes, and forced to retire from the Bácska. In the meantime Haynau's operations on the Danube met with general success, while the Russian main army advanced over Eperies and Kassa into the interior of the country. These disasters to the Hungarian cause were aggravated by the want of unanimity between the Hungarian commander-in-chief and the Government, which, being again obliged to leave Pest, transferred its seat to Szeged (July 11). After various sanguinary engagements with the invading forces in the vicinity of Komárom, Görgei on the night of the 12th July left the fortress under the charge of Klapka. On the 15th and 17th Görgei encountered the Russians at Vácz, and proceeded thence over Vadkert, Losoncz, and Rimaszombat, where on the 21st the Russian offers of truce were refused. Görgei, closely followed, finally crossed the Theiss on the 28th July near Tokay, whence he proceeded in the direction of Nagyvárad (Grosswardein) by routes to the east of Debreczen. There on the 2d August his first army corps under Nagy Sándor was defeated by the troops of Paskewitch. The Government had meanwhile removed to Arad, which fortress, having previously surrendered to the Hungarians, was made the last point of general concentration. In Transylvania the army of Bem had been overpowered on the 31st July at Segesvár (Schässburg); and in Hungary Proper Dembinski retreated first to Szeged and Szöreg, whence he was repulsed on the 5th August by Haynau, and afterwards to Temesvár. There on the 9th he suffered an overwhelming defeat. Upon the news of this catastrophe reaching Arad on the night of the 10th to 11th, Görgei, who had already arrived there on the 9th by forced marches from Nagyvárad, induced Kossuth and the few ministers who were with him to lay down their authority, and upon the 11th received from them the supreme civil and military command. On the evening of the same day, after the departure of Kossuth for Lugos, the new dictator, believing further resistance hopeless, communicated with the Russian general Rüdiger, offering to surrender at discretion. The sally of Klapka from Komárom, and his signal victory over the besieging Austrian army (August 3), were unknown at Arad. On August 13 Görgei surrendered his army, consisting of some 24,000 men with 140 guns, to Rüdiger at Szöllös near Világos; on the 16th Kazinczy followed with his troops, and on the 17th Damjanics gave up the fortress of Arad, and on the 5th September a similar fate befell Peterwardein.

A few thousand men followed Bem and Guyon to Turkey, whither Kossuth and the late ministers Szemere, Casimir Batthyányi, and Mészáros, and the military leaders Dembinski, Vetter, Perczel, Kmetty, and Wysocki also escaped. On the 2d to 5th October Komárom capitulated on honourable terms, General Klapka having refused to surrender until an amnesty and free passports had been granted by the Austrians. On the 6th October Aulich, Damjanics, Dessewffy, Kiss, Knézich, Lahner, Lázár, Leiningen, Nagy-Sándor, Pöltenberg, Schweidel, Török, and Vécsey met their end at Arad. On the same day Count Louis Batthyányi, and subsequently Prince Woronieczki, Baron Jeszenak, Csányi, Perényi, and others suffered at Pest. By a decree of Haynau, to whom the Russians had delivered up the prisoners of war, all officers below the rank of a general, if not consigned to prison, were pressed as privates into the Austrian service. The Hungarian commander-in-chief Görgei, however, was pardoned, and interned at Klagenfurt in Carinthia.

Hungary now lay entirely prostrate, and was treated as a conquered country. The Russians retreated to the north and east, leaving the Austrians with their commander Haynau, who availed himself of the summary powers conferred on him by the state of siege to inflict the greatest cruelties on the vanquished people. Many of the Hungarian nobility were condemned to long terms of imprisonment; the estates of the richer patriots were confiscated; and numerous Austrian and Bohemian officials were thrust upon the exhausted country. A rigorous censorship of the press was at the same time enforced. At length, in July 1850, Haynau was removed from the chief authority. A milder régime was inaugurated by the archduke Albrecht, who arrived at Pest on the 14th October 1851 as the new civil and military governor. But it was only after the visit of the emperor to Hungary (5th June to 14th August 1852) that the military courts were closed. The whole country, now reduced to a province of the Austrian empire, was placed under the direct control of the central Government at Vienna. On the 1st May 1853 the new organization was carried into effect, and the Austrian civil code made applicable to Hungary. On the 8th September the Hungarian insignia of royalty, which had disappeared from Arad at the time of Kossuth's flight, were discovered in the neighbourhood of Orsova; they were conveyed on the 19th to Vienna, but were afterwards transferred to Buda. On the 17th April 1854 the state of siege was abolished, and on the 12th July 1856 an amnesty was proclaimed. On the 4th May of the following year the emperor visited Hungary, and on the 9th of the same month granted the restoration of their confiscated estates to late political offenders. In August he commenced a second progress through his Hungarian dominions, and availed himself of the opportunity to express his sentiments of consideration for the people.

Indeed, from this time (1857) both the emperor and the Government of Vienna seemed desirous of making the Hungarians forget the troubles of 1848 and 1849 by concessions to the national will, whilst the encouragement given to improvements in the means of communication, and to the new projects for the regulation of the Theiss, as also the schemes for the colonization of sparsely populated districts, are well worthy of notice. During the year the railways from Szeged to Temesvár and from Szolnok to Debreczen were opened. By an imperial decree issued at the end of 1858 agricultural colonists, if of one nationality and creed, were allowed to settle in various parts of Hungary, with special exemptions from taxation. By a ministerial order of the 8th August 1859 the language used in the higher schools was for the future to be regulated according to circumstances of nationality, the predominance of German being thereby abolished. On the 21st of the same month the absolutist minister Bach was dismissed, in consequence of the ill-success of the Italian war, which was attributed to his ill-advised policy against the various nationalities of the realm. The so-called "Protestant patent" of September 1st, which ostensibly granted the communes the free administration of their own educational and religious matters, was, however, the cause of much dissatisfaction, and more than 2,800,000 Protestants petitioned for its withdrawal. In April 1860 the archduke Albrecht was at his own desire removed from the civil and military governorship of Hungary, and the master of the ordnance, Benedek, a native Magyar, was appointed in his stead. The Hungarian members in the Reichsrath, specially summoned for the purpose of finding a definite form of settlement for the whole empire, now put forward claims for the autonomy of their country, and by an imperial diploma of the 20th October their wishes were partly met. Benedek was removed from the general governorship of the kingdom, whilst the Hungarian court chancellery was restored, and Baron Vay nominated chancellor. At the same time the *curia regia* (supreme court of judicature) and the county assemblies were reinstituted, and the Magyar recognized as the official language. Furthermore, the emperor on the 27th December granted the reannexation of the Temesvár Bánát to Hungary Proper. In the following February it was decreed that their former constitutions should be restored to Hungary, Transylvania, and Croatia and Slavonia, and on the 6th of April the diet met at Buda, afterwards removing to Pest. But as the address sent to Vienna in June demanded the fullest autonomy for Hungary, and the Hungarians refused to yield their claims, in spite of the emperor's declared inability to accede, the diet was dissolved by imperial decree on the 22d August. Meanwhile a new Hungarian court chancellor had been appointed in the person of Count Forgách. Stringent measures were taken by the Government of Vienna to counteract the organized passive resistance of the counties, and in many places the payment of the taxes was enforced by military aid. On the 27th October the holding of all public county meetings was forbidden, and administrators or coadjutors were in many counties thrust upon the lord-lieutenants, who were forced to submit to the authority of the newly-appointed Government superintendent Count Pálffy de Erdöd. On the 18th November 1862 a general amnesty was granted to those who were implicated by their hostility to the late Government measures. In the summer of 1863 Hungary suffered from a severe famine, but the Reichsrath voted 20 million florins to alleviate the distress. On the 22d April 1864 Count Forgách was replaced by Count Arminius Zichy, who, on account of his unpopularity, was on the 26th June 1865 removed for Count George Majláth, a Conservative. In a visit to Budapest on the 6th to 9th June 1865, the emperor declared his willingness to do justice to the constitutional demands of the Hungarians, as far as was consistent with the integrity of the empire. On the 18th July Count Pálffy de Erdöd was replaced by Baron Sennyey, one of the leaders of the old Conservative party. On the 14th December the diet was opened by the emperor in person, who assented to the principle of self-government for Hungary, and agreed to recognize the Pragmatic Sanction as the basis of a settlement of the questions involved. The diet, however, demanded also an acknowledgment of the continuity of the constitutional rights of 1848. After the outbreak of the war between Austria and Prussia the diet was prorogued (26th June 1866). Upon its reopening on the 19th November an imperial rescript was read in which the emperor acquiesced in the Hungarian demands for constitutional self-government, and promised to appoint a responsible ministry. The result of the "compromise" effected by Baron Beust between the Austrian Government and the committee, headed by Deák, empowered by the Hungarian diet, was the dualistic system of the Austrian-Hungarian monarchy, as finally sanctioned on the 18th February 1867. This arrangement secured to Hungary the restoration of the constitutional, legal, and administrative autonomy of 1848, while the supreme command

and direction of the army were assigned to the emperor-king. A responsible ministry, including Barons Wenckheim and Eötvös, Count Mikó, Melchior Lónyay, and others, was formed on the 20th February 1867, under the presidency of Count Andrássy. On the 8th of the following June the emperor and empress were crowned king and queen of Hungary at Budapest, and a complete pardon was proclaimed to all political offenders both at home and abroad.

The reconciliation of the Magyars with the Hapsburg dynasty being thus complete, both parties sought to throw a veil over the past by mutual concessions. Transylvania was incorporated with Hungary Proper, and a joint commercial contract was entered upon between Hungary and Austria. In like manner foreign affairs and joint finance were assigned to "common ministries." On the 8th of August 1868 the Hungarian house of representatives accepted the dual Government military scheme, by which the standing army remained under the direction of the imperial ministry of war. The *Honvéd* (home defence) army obtained its own special organization and commander-in-chief. The long-existing misunderstanding between Hungary and Croatia was at length settled by the agreement concluded in September, which placed the relations of Croatia to the Hungarian crown on a more equable footing than hitherto. After the passing of various other measures of reform, including the emancipation of the Jews, a compulsory education act, and a special act (November 29) for the consolidation of all nationalities under the crown of St Stephen, the session of the Hungarian diet was closed on the 10th December 1868. In the elections for the next session (1869–72) the Deák party, which had taken the lead in the previous diet, were returned by a large majority, and in the new diet, opened April 23, 1869, the policy of conciliation still prevailed. The ministry from time to time underwent certain modifications, owing to the death of Baron Eötvös, the minister of education (February 1871), the appointment of Count Lónyay (May 1870) to the imperial ministry of finance, and his subsequent nomination to the presidency of the Hungarian council in the place of Count Andrássy, who in November 1871 succeeded Beust as foreign minister of Austria-Hungary. Meanwhile the finances of Hungary were becoming rapidly embarrassed owing to the repeated contraction since 1867 of enormous loans for state railways and costly public works. The elections of 1872 were, however, again favourable to the Deák faction. At the end of November Lónyay retired from the presidency of the ministry, and on the 1st December was succeeded by Szlávy, who in March 1873 obtained the consent of the diet to some additional taxes. In August the Military Frontier districts were placed under civil jurisdiction, the eastern portion or the Servian-Bánát frontier being incorporated with Hungary Proper. The new cabinet was not more fortunate than that which had preceded it in a solution of the financial question, and in March 1874 made room for a coalition ministry under Bittó, with Ghyczy as finance minister. Upon its resignation in February 1875, in consequence of the refusal of the house to grant further taxation, a strong liberal combination was formed by Tisza from members of the left and of the former Deák party. The new ministry, under the presidency of Wenckheim (3d March), was supported by an overwhelming majority in the elections for the new session (1875–78). On the 16th October Tisza, minister of the interior, was nominated president, and the financial difficulty was met by an advance in the income tax, and a fresh loan. The death of Deák on the 29th January 1876 cast a gloom over the whole country. For some time previously he had withdrawn from the field of politics, where less moderate but more distinctly Magyarizing tendencies now prevailed. By its resolutions of the 24th and 27th March 1876 the diet deprived of their former privileges the so-called "Saxon" sees and districts in Transylvania. From these new counties were formed on the system adopted for the rest of Hungary, and were placed under the general administration. The number of royal free towns in Hungary was, moreover, much reduced, especially in the Transylvanian circle. The insurrectionary state of the Slavic provinces of Turkey excited the apprehensions of the Magyars with regard to the Slav races of southern Hungary, and aroused a strong feeling of sympathy for the Porte. This was still further increased by the attitude of Russia, and the cordiality towards the Magyars evinced by the sultan Abdul Hamid II., who in 1877 presented the university of Budapest with a portion of the remains of the library of Matthias Corvinus. During the course of the war between Turkey and Russia the Magyars were with difficulty restrained from open manifestations in favour of the former and against the latter power. Nevertheless, after the conclusion of peace, Hungary had, in conformity with the requirements of Art. XXV. of the Berlin Treaty (July 1878), to furnish her quota of troops for the occupation of Bosnia and the Herzegovina, a task effected only with a considerable loss of men, and an additional burden on the state finances. The diet having been closed by the king on the 30th June, the new elections were held at the time the struggle for the occupation of Bosnia was progressing. The popular excitement in Hungary Proper was very great, both on account of the losses suffered by the Hungarian troops and the destruction by a violent thunderstorm of the town of Miskolcz. On the 3d October Széll, minister of finance, resigned office; other ministers also tendered their resignations, but were induced to retain their posts for a time. In the elections the majority of votes had fallen to the Liberal or Government party. On the 20th October the Hungarian parliament was opened, and at the beginning of December the reconstruction of the ministry was completed, the only new members being, for finance Count Szapáry, and for commerce Baron Kemény. On the 14th a sum of 20,000,000 florins was granted for the occupation expenses of the following year.

Early in the spring of 1879 the attention of all parties was for a time distracted from political matters by the disastrous inundation of Szeged. At the beginning of May the friendly relations of the non-Magyar nationalities of Hungary, and more particularly of the Roumanians of Transylvania, towards the Magyars seemed to be endangered by the passing of the amended education bill ordering the state language to be taught in all the non-Magyar primary schools. The new law, as affecting many nationalities, is likely to have an important bearing on the future of Hungary. The urgent necessity for more extended river embankments and a better system of dykes and dredging in the water-coursed levels of the midland Trans-Tisian counties became more than ever apparent in December, when inundations of the triple Körös and the Maros submerged many villages, farms, and pasturages, devastated large portions of Nagyvárad (Grosswardein), Arad, and other low-lying communes, and rendered thousands of persons homeless. In March 1880 a loan of 40,000,000 florins was raised for the purposes of regulating the Theiss and the Maros, and of rebuilding and securing the town of Szeged.

Bibliography.—Besides the great historical works in the native language, by Szalay, Jászay, Szilágyi, Count Teleki, and Michael Horváth, noticed under LITERATURE below, and the useful summary by Gideon Ladányi, *Magyarország Törtenelme* (Debreczen, 1867), we mention for those who are unacquainted with Hungarian—Engel, *Geschichte des ungrischen Reichs* (Vienna, 1813-14, 5 vols.); Fessler, *Geschichte der Ungarn und ihrer Landsassen* (3d ed., Leipsic, 1867-68, 5 vols.); Mailáth, *Geschichte der Magyaren* (2d ed., Ratisbon, 1852-53, 5 vols); the German edition of Szalay, by Wögerer (Pest, 1870-75, 3 vols.); Horváth, *Kurzgefasste Geschichte Ungarns* (Pest, 1863, 2 vols.), and *Fünfundzwanzig Jahre aus der Geschichte Ungarns*, 1823-48 (Leipsic, 1867, 2 vols.), both translated from the Hungarian; and Rogge, *Oesterreich von Világos bis zur Gegenwart* (Leipsic, 1872-73, 3 vols.). To these may be added—E. Szabad, *Hungary Past and Present* (Edinburgh, 1854); E. L. Godkin, *History of Hungary and the Magyars* (London, 1853); Sayous, *Histoire Générale des Hongrois* (Paris, 1876, 2 vols.), and *Histoire des Hongrois et de leur littérature politique de 1790 à 1815* (Paris, 1872). For the revolutionary period see Genl. Görgei, *My Life and Acts in Hungary* (London, 1852, 2 vols.), and Genl Klapka, *Memoirs* (London, 1850, 2 vols.), both translated from the German; and Szemere, *Hungary from 1848 to 1860* (London, 1860). See also A. J. Patterson, *The Magyars, their Country and Institutions* (London, 1869, 2 vols.), and the anonymous *Francis Deák, a Memoir* (London, 1880).

III. Language.

The Magyar or native Hungarian language is of Asiatic origin, belonging to the northern or Ural-Altaic (Finnic-Tataric) division of the Turanian Family, and forming along with the Ugro-Ostiakian and Vogul dialects the Ugric branch of that family. The affinity existing between the Magyar and the Finnic languages, first noticed by John Amos Comenius (Komensky) in the middle of the 17th century,[1] and later by Olav Rudbeck[2], Leibnitz[3], Strahlenberg,[4] Eccard, Sajnovics[5], and others, has been proved "grammatically" by Samuel Gyarmathi, in his work entitled *Affinitas linguæ Hungaricæ cum linguis Finnicæ originis grammatice demonstrata* (Göttingen, 1799). The Uralian travels of Anthony Reguly (1843–45), and the philological labours of Paul Hunfalvy and Joseph Budenz, may be said to have established it as an almost incontrovertible fact. The chief points of resemblance to Turco-Tataric and Mongolic dialects have been specially treated by Arminius Vámbéry (1870) and Gabriel Bálint (1877), the well-known recent travellers in Central Asia. Körösi-Csoma for many years zealously but unsuccessfully sought after traces of the origin of the nation and the language in Tibet. His grammar and dictionary of Tibetan, published by the Asiatic Society in 1834, have, however, earned for him a lasting name. The theory of Paul Beregszászi that the Magyar is related to many of the so-called "Oriental" languages[6] has now few supporters.

Although for nearly a thousand years established in Europe and subjected to Aryan influences, the Magyar language has yet retained its essential Turanian features, and the etymology and syntax still preserve these as their chief characteristics. The grammatical forms are expressed, as in Turkish, by means of affixes modulated according to the high or low vowel power of the root or chief syllables of the word with which they are connected,—the former being represented

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[1] See Hunfalvy's "Die ungarische Sprachwissenschaft," *Literarische Berichte aus Ungarn*, Budapest, 1877, pp. 80-87.

[2] *Specimen usus linguæ Gothicæ in eruendis atque illustrandis obscurissimis quibusdam Sacræ Scripturæ locis; addita analogia linguæ Gothicæ cum Sinica, necnon Finnicæ cum Ungarica*, Upsala, 1717.

[3] Hunfalvy, p. 81.

[4] *Id.*, pp. 82-86.

[5] *Demonstratio Idioma Ungarorum et Lapponum idem esse*, Copenhagen und Tyrnau, 1770.

[6] *Ueber die Aehnlichkeit der hungarischen Sprache mit den Morgenländischen*, Leipsic, 1796.

by *e*, *ö*, *ő*, *ü*, *ű*, the latter by *a*, *á*, *o*, *ó*, *u*, *ú*; the sounds *é*, *i*, *í* are regarded as neutral. Since the number of consonants exceeds that of the Latin alphabet which represents them, the following combinations, forming single articulations, and inseparable as consonants, are used to make up the deficiency:—*cs*, *cz*, *gy*, *ly*, *ny*, *sz*, *ty*, *zs*, and in a few words *dzs*. Among the striking peculiarities of the language are the definite and indefinite forms of the active verb, *e.g.*, *látom*, "I see" (definite, viz., "him," "her," "the man," &c.), *látok*, "I see" (indefinite); the insertion of the causative, frequentative, diminutive, and potential syllables after the root of the verb, *e.g.*, *ver*, "he beats"; *veret*, "he causes to beat"; *veroget*, "he beats repeatedly"; *verint*, "he beats a little"; *verhet*, "he can beat"; the mode of expressing possession by the tenses of the irregular verb *lenni*, "to be" (viz., *van*, "is"; *vannak*, "are"; *volt*, "was"; *lesz*, "will be," &c.), with the object and its possessive affixes, *e.g.*, *nekem vannak könyveim*, literally, "to me are books—my" = "I have books"; *neki volt könyve*, "to him was book—his" = "he had a book." Other characteristic features are the use of the singular substantive after numerals, and adjectives of quantity, *e.g.*, *két ember*, literally, "two man"; *sok szó*, "many word," &c.; the position of the Christian name and title after the family name, *e.g.*, *Ólmosy Károly tanár ur*, "Mr Professor Charles Ólmosy"; and the possessive forms of the nouns, which are varied according to the number and person of the possessor and the number of the object in the following way: *tollam*, "my pen"; *tollaim*, "my pens"; *tollad*, "thy pen"; *tollaid*, "thy pens"; *tollunk*, "our pen"; *tollaink*, "our pens," &c. But, although presenting no auxiliary verb "to have," no primitive possessive pronouns, no gender nor even separate pronominal forms and terminations for the distinction of the sexes, and (suffixed syllables or postpositions being used instead) hardly any true declension for objective terms, the Magyar far surpasses every Teutonic, Slavonic, Italic, and other Indo-European or Aryan language in the wealth of its verbal formations, as also in the power of harmonizing and assimilating the determinatives to the roots. Logical in its derivatives and in its grammatical structure, the Magyar language is, moreover, copious in idiomatic expressions, rich in its store of words, and almost musical in its harmonious intonation. It is, therefore, admirably adapted for both literary and rhetorical purposes.

The first Hungarian grammar known is the *Grammatica Hungaro-Latina* of John Erdösi *alias* Sylvester Pannonius, printed at Sárvár-Ujsziget in 1539. Among the grammatical works of recent date are the posthumous treatises of Nicholas Révai (Pest, 1809); the *Magyar nyelvmester* of Samuel Gyarmathi, published at Klausenburg in 1794; and the various grammars for the use of Germans, by J. Farkas (9th ed., Vienna, 1816), Mailáth (2d ed., Pest, 1832), Kis (Vienna, 1834), Márton (8th ed., Vienna, 1836), Maurice Ballagi or (in German) Bloch (5th ed., Pest, 1869), Töpler (Pest, 1854), Riedl (Vienna, 1858), Schuster (Pest, 1866), Charles Ballagi (Pest, 1868), Remélc (Pest and Vienna, 1869), Roder (Budapest, 1875), Führer (Budapest, 1878), and Ney (20th ed., Budapest, 1879). One of the best modern grammars for the French is that of C. E. De Ujfalvy (Paris, 1876). Two Hungarian grammars have also appeared in English by S. Wékey (London, 1852), and J. Csink (London, 1853).

The earliest lexicon is that of Gabriel (Mizsér) Pesti *alias* Pestinus Pannonius, *Nomenclatura sex linguarum, Latinæ, Italicæ, Gallicæ, Bohemicæ, Ungaricæ, et Germanicæ* (Vienna, 1538), which was several times reprinted. The *Vocabula Hungarica* of Bernardino Baldi (1583), the original MS. of which is in the Biblioteca Nazionale at Naples, contains 2899 Hungarian words with renderings in Latin or Italian.[1] In the *Dictionarium undecim linguarum* of Calepinus (Basel, 1590) are found also Polish, Hungarian, and English words and phrases. This work continued to be reissued until 1682. The *Lexicon Latino-Hungaricum* of Albert Molnár first appeared at Nuremberg in 1604, and with the addition of Greek was reprinted till 1708. Of modern Hungarian dictionaries the best is that of the Academy of Sciences, containing 110,784 articles in 6 vols., by Czuczor and Fogarasi (Pest, 1862–74). The next best native dictionary is that of Maurice Ballagi, *A Magyar nyelv teljes szótára*, (Pest, 1868–73). In addition to the above may be mentioned the work of Kresznerics, where the words are arranged according to the roots (Buda, 1831–32); the *Etymologisches Wörterbuch...aus chinesischen Wurzeln*, of Podhorszky (Paris, 1877); the *Magyar-ugor összehasonlító szótár* (Magyar-Ugrian Comparative Dictionary) of Budenz (Budapest, 1872, &c.); and that of new words, with German and Latin equivalents, by Kunoss (Pest, 1843). Other and more general dictionaries for German scholars are those of Márton (*Lexicon trilingue Latino-Hungarico-Germanicum*, Vienna, 1818–23), A. F. Richter (Vienna, 1836), E. Farkas (Pest, 1848–51), Fogarasi (4th ed., Pest, 1860), Loos (Pest, 1869), and M. Ballagi (Budapest, 3d ed. 1872–74). There are, moreover, Hungarian-French dictionaries by Kiss and Karády (Pest and Leipsic, 1844–48) and Babos and Molé (Pest, 1865), and English-Hungarian dictionaries by Dallos (Pest, 1860) and Bizonfy (Budapest, 1878).

IV. Literature.

The comparatively restricted and unobtrusive character of the Magyar or native Hungarian literature is partly owing to the fact that there are so many other languages current in Hungary, but it is chiefly to be attributed to the almost exclusive recognition, through many centuries, of Latin as the vehicle of cultured thought. The Romish ecclesiastics who settled in Hungary during the 11th century, and who found their way into the chief offices of the state, were mainly instrumental in establishing Latin as the predominant language of the court, the higher schools, and public worship, and of eventually introducing it into the administration. Having thus become the tongue of the educated and privileged classes, Latin continued to monopolize the chief fields of literature until the revival of the native language at the close of the 18th century.

Early Latin chronicles.

Amongst the earliest Latin works that claim attention are the "Chronicle" (*Gesta Hungarorum*), by the "anonymous notary" of King Béla, probably Béla II. (see Podhradczky,[2] *Béla király névtelen jegyzője*, Buda, 1861, p. 48), which describes the early ages of Hungarian history, and may be assigned to the middle of the 12th century; the *Carmen Miserabile* of Rogerius; the *Liber Cronicorum* of Simon Kézai, belonging to the end of the 13th century, the so-called "Chronicon Budense," *Cronica Hungarorum*, printed at Buda in 1473 (Eichhorn, *Geschichte der Litteratur*, ii. 319); and the *Chronicon Rerum Hungaricarum* of John Thuróczi.[3] An extraordinary stimulus was given to literary enterprise by king Matthias Corvinus, who attracted both foreign and native scholars to his court. Foremost amongst the Italians was Antonio Bonfini, whose work, *Rerum Hungaricarum Decades IV.*, comprising Hungarian history from the earliest times to the death of King Matthias, was published with a continuation by Sambucus (Basel, 1568).[4] Marzio Galeotti, the king's chief librarian, wrote an historical account of his reign. The most distinguished of the native scholars was John Cesinge *alias* Janus Pannonius, who composed Latin epigrams, panegyrics, and epic poems. The best edition of his works was published by Count S. Teleki at Utrecht in 1784.

Magyar literature. Earliest relics.

As there are no traces of literary productions in the native or Magyar dialect before the 12th century, the early condition of the language is concealed from the philologist. It is, however, known that the Hungarians had their own martial songs, and that their princes kept lyre and lute players who sang festal odes in praise of the national heroes. In the 11th century Christian teachers introduced the use of the Roman letters, but the employment of the Latin language was not formally decreed until 1114 (see Bowring, *Poetry of the Magyars*, Introd. xix.). It appears, moreover, that up to that date public business was transacted in Hungarian, for the decrees of King Coloman the Learned (1095–1114) were translated from that language into Latin. Among the literary relics of the 12th century are the "Latiatuc" or *Halotti Beszéd* funeral discourse and prayer in Hungarian, to which Döbrentei in his *Régi Magyar Nyelvemlékek* assigns as a probable date the year 1171 (others, however, 1182 or 1183). From the *Margit-Legenda*, or "Legend of St Margaret," composed in the early part of the 14th century,[5] it is evident that from time to time the native language continued to be employed as a means of religious edification.

Arpadian period (1000–1301).

Anjou-Sigismond period (1301–1437).

Under the kings of the house of Anjou, the Magyar became the language of the court. That it was used also in official documents and ordinances is shown by copies of formularies of oaths, the import of which proves beyond a doubt that the originals belonged to the reigns of Louis I. and Sigismond; by a statute of the town of Sajó-St-Peter (1403) relating to the wine trade; by the testament of Kazzai-Karácson (1413); and by other relics of this period published by Döbrentei in vol. ii. of the *R. M. Nyelvemlékek*. To the early part of the 15th century may be assigned also the legends of "St Francis" and of "St Ursula," and possibly the original of the *Ének Pannónia megvételéről*, an historical "Song about the Conquest of Pannonia." But not until the dawn of the Reformation did Magyar begin in any sense to replace Latin for literary purposes. The period placed by Hungarian authors between 1437 and 1530 marks the first development of Magyar literature.

Matthias or pre-Reformation period (1437–1530).

About the year 1437 two Hussite monks named Tamás and Bálint (*i.e.*, Thomas and Valentine) adapted from older sources a large portion of the Bible for the use of the Hungarian refugees in Moldavia. To these monks the first extant Magyar version of part of the Scriptures (the *Vienna* or *Révai Codex*[6]) is directly assigned

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[1] See Count Géza Kuun's "Lettere Ungheresi," *La Rivista Europea*, anno vi., vol. ii. fasc. 3, pp. 561–62, Florence, 1875.

[2] So also Jámbor (*A Magyar Irod. Tört.*, Pest, 1864, p. 104). Környel, Imre, and others incline to the belief that it was Béla I., and that consequently the "anonymous notary" belongs rather to the 11th than to the 12th century.

[3] An example of this work, printed on vellum in Gothic letter (Augsburg, 1488), and formerly belonging to the library of Matthias Corvinus, king of Hungary, may be seen in the British Museum. Of the three first-mentioned chronicles Hungarian translations by Charles Szabó appeared at Budapest in 1860, 1861, and 1862.

[4] Both this and the later editions of Frankfort (1581), Cologne (1690), and Pressburg (1744) are represented in the British Museum.

[5] The only copy existing at the present time appears to have been transcribed at the beginning of the 16th century. Both this and the *Halotti Beszéd* (Pray Codex) are preserved in the National Museum at Budapest.

[6] This codex contains Ruth, the lesser prophets, and part of the Apocrypha. According to Toldy, it is copied from an earlier one of the 14th century.

by Döbrentei, but the exact date either of this copy or of the original translation cannot now be ascertained. With approximate certainty may be ascribed also to Tamás and Bálint the original of the still extant transcript, by George Németi, of the Four Gospels, the *Jászay* or *Munich Codex* (finished at Tátros in Moldavia in 1466). Amongst other important codices are the *Jordánszky Codex* (1516–19), an incomplete copy of the translation of the Bible made by Ladislaus Bátori, who died about 1456; and the *Döbrentei* or *Gyulafehérvár Codex* (1508), containing a version of the Psalter, Song of Solomon, and the liturgical epistles and gospels, copied by Bartholomew Halabori from an earlier translation (Környei, *A Magyar nemzeti irodalomtörténet vázlata*, 1861, p. 30). Other relics belonging to this period are the oath which John Hunyady took when elected governor of Hungary (1446); a few verses sung by the children of Pest at the coronation of his son Matthias (1458); the *Siralomének Both János veszedelmén* (Elegy upon John Both), written by a certain "Gregori," as the initial letters of the verses show, and during the reign of the above-mentioned monarch; and the *Emlékdal Mátyás király halálára* (Memorial Song on the Death of King Matthias, 1490). To these may be added the rhapsody[1] on the taking of "Szabács" (1476); the *Katalin-Legenda*, a metrical "Legend of St Catherine of Alexandria," extending to over 4000 lines; and the *Feddöének* (Upbraiding Song), by Francis Apáthi.

Reformation period (1530–1606).

In the next literary period (1530–1606) several translations of the Scriptures are recorded. Among these there are—versions of the Epistles of St Paul, by Benedict Komjáti (Cracow, 1533); of the Four Gospels, by Gabriel (Mizsér) Pesti (Vienna, 1536); of the New Testament, by John Erdösi (Ujsziget, 1541; 2d ed., Vienna, 1574[2]), and by Thomas Félegyházi (1586); and the translations of the Bible, by Caspar Heltai (Klausenburg, 1551–65), and by Caspar Károli (Vizsoly, near Göncz, 1589–90). The last, considered the best, was corrected and re-edited by Albert Molnár at Hanau in 1608.[3] Heltai published also (1571) a translation, improved from that by Blasius Veres (1565), of the *Tripartitum* of Verböczy, and *Chronika* (1575) adapted from the *Decades* of Bonfini. Karádi in 1569 brought to light the earliest national drama, *Balassi Menyhért*. Among the native poets, mostly mere rhyming chroniclers of the 16th century, were Csanádi, Tinódi, Nagy-Báczai, Bogáti, Ilósvay, Istvánfi, Görgei, Temesvári, and Valkai. Of these the best and most prolific writer was Tinódi. Székely wrote in prose, with verse introduction, a "Chronicle of the World" under the title of *Cronica ez világnac yeles dolgairól* (Cracow, 1559). Csáktornya and Kákony imitated the ancient classical poets, and Erdösi introduced the hexameter. Andrew Farkas and the homilist Peter Melius (Juhász) attempted didactic verse; and Batizi busied himself with sacred song and Biblical history. During the latter part of the 16th century and the beginning of the 17th two poets of a higher order appeared in Valentine Balassa, the earliest Magyar lyrical writer, and his contemporary John Rimay, whose poems are of a contemplative and pleasing character.

17th century period (1606–1711)

The melancholy state of the country consequent upon the persecutions of Rudolph I., Ferdinand II., and Leopold I., as also the continual encroachment of Germanizing influences under the Hapsburgs, were unfavourable to the development of the national literature during the next literary period, dating from the Peace of Vienna (1606) to that of Szatmár (1711). A few names were, however, distinguished in theology, philology, and poetry. In 1626 a Hungarian version of the Vulgate was published at Vienna by the Jesuit George Káldi,[4] and another complete translation of the Scriptures, the so-called *Komáromi Biblia* (Komorn Bible) was made in 1685 by the Protestant George Csipkés, though it was not published till 1717 at Leyden, twenty-nine years after his death.[5] On behalf of the Catholics the Jesuit Peter Pázmán, eventually primate, Nicholas Eszterházy, Sámbár, Balásfi, and others were the authors of various works of a polemical nature. Especially famous was the *Hodægus, kalauz* of Pázmán, which first appeared at Pozsony (Pressburg) in 1613. Among the Protestants who exerted themselves in theological and controversial writings were Németi, Alvinczy, Alexander Felvinczy, Mártonfalvi, and Melotai, who was attached to the court of Bethlen Gábor. Telkibányai wrote on "English Puritanism" (1654). The Calvinist Albert Molnár, already mentioned, was more especially remarkable for his philological than for his theological labours. Párispápai compiled an Hungarian-Latin Dictionary, *Dictionarium magyar és deák nyelven* (Löcse, 1708), and Apáczai-Csere, a *Magyar Encyclopædia* (Utrecht, 1653). John Szalárdi, Paul Lisznyai, Gregory Pethö, John Kemény, and Benjamin Szilágyi, which last, however, wrote in Latin, were the authors of various historical works. In polite literature the heroic poem *Zrinyiász* (1651), descriptive of the fall of Sziget, by Nicholas Zrinyi, grandson of the defender of that fortress, marks a new era in Hungarian poetry. Of a far inferior character was the monotonous *Mohácsi veszedelem* (Disaster of Mohács), in 13 cantos, produced two years afterwards at Vienna by Baron Liszti. The lyric and epic poems of Stephen Gyöngyösi, who sang the deeds of Maria Széchy, the heroine of Murány, *Murányi Venus* (Kassa, 1664), are samples rather of a general improvement in the style than of the purity of the language. As a didactic and elegiac poet Stephen Kohári is much esteemed, though his poems are of a very serious and contemplative turn. More fluent but not less gloomy are the sacred lyrics of Nyéki-Veres first published in 1636 under the Latin title of *Tintinnabulum Tripudiantium*. The songs and proverbs of Peter Beniczky, who lived in the early part of the 17th century, are not without merit, and have been several times reprinted. We may here mention that, from the appearance of the first extant printed Magyar work[6] at Cracow in 1531 to the end of the period we have just been treating of, more than 1800 publications in the native language are known.[7]

Period of decline (1711–1772).

The period comprised between the peace of Szatmár (1711) and the year 1772 is far more barren in literary results than even that which preceded it. The exhaustion of the nation from its protracted civil and foreign wars, the extinction of the court of the Transylvanian princes where the native language had been cherished, and the prevalent use of Latin in the schools, public transactions, and county courts, all combined to bring about a complete neglect of the Magyar language and literature. Among the few prose writers of distinction were Andrew Spangár, whose "Hungarian Bookstore," *Magyar Könyvtár* (Kassa, 1738), is said to be the earliest work of the kind in the Magyar dialect; George Bárányi, who translated the New Testament (Lauba, 1754); the historians Michael Cserei and Matthew Bél, which last, however, wrote chiefly in Latin; and Peter Bod, who besides his theological treatises compiled a history of Hungarian literature under the title *Magyar Athénás* (Szeben, 1766). But the most celebrated writer of this period was the Jesuit Francis Faludi, the translator, through the Italian, of William Darrell's works. On account of the classic purity of his style in prose Faludi was known as the "Magyar Cicero." Not only as a philosophic and didactic writer, but also as a lyric and dramatic poet he surpassed all his contemporaries. Another pleasing lyric poet of this period was Ladislaus Amade, the naturalness and genuine sentiment of whose lightly running verses are suggestive of the love songs of Italian authors. Of considerable merit are also the sacred lyrical melodies of Paul Rádai in his *Lelki hódolás* (Spiritual Homage), published at Debreczen in 1715. Among the didactic poets may be mentioned Lewis Nagy, George Kálmár, John Illey, and Paul Bertalanfi, especially noted for his rhymed "Life of St Stephen, first Hungarian king," *Dicsöséges Sz. István elsö magyar királynak élete* (Vienna, 1751).

The remaining three literary periods stand in special relationship to one another, and are sometimes regarded as the same. The first two, marking respectively the progress of the "Regeneration of the Native Literature" (1772–1807) and the "Revival of the Language" (1807–1830), were introductory to and preparatory for the third or "Academy" period, which dates from the year 1830, and comprises the results of the native language and literature in the highest state of cultivation.

Regeneration of the literature (1772–1807).

In consequence of the general neglect of the Magyar language during the reigns of Maria Theresa and her successor Joseph II., the more important prose productions of the latter part of the 18th century, as for instance the historical works of George Pray, Stephen Katona, John Engel, and Ignatius Fessler, were written either in Latin or in German. The reaction in favour of the native literature manifested itself at first chiefly in the creation of various schools of poetry. Foremost among these stood the so-called "French" school, founded by George Bessenyei, the author of several dramatic pieces, and of an imitation of Pope's "Essay on Man," under the title of *Az embernek próbája* (Vienna, 1772). Bessenyei introduced the use of rhymed alexandrines in place of the monotonous Zrinian measure. Other writers of the same school were Laurence Orczy and Abraham Barcsay, whose works have a striking resemblance to each other, and were published together by Révai (1789). The songs and elegies of the short-lived Paul Ányos, edited by Bacsányi in 1798, show great depth of feeling. Versifiers and adapters from the French appeared also in Counts Adam and Joseph Teleki, Alexander Báróczi, and Joseph Péczeli, known also as the translator of Young's "Night Thoughts." The chief representatives of the strictly "classical" school, which adopted the ancient Greek and Latin authors as its models, were David Baróti Szabó, Nicholas Révai, Joseph Rájnis, and Benedict Virág. Among the most noteworthy works of Baróti are the *Uj mértékre vett külömb versek* (Kassa, 1777), comprising hexameter verses, Horatian odes, distiches, epistles, and epigrams; the *Paraszti Majorság* (Kassa, 1779–80), an hexameter version of Vanière's *Prædium rusticum*; and an abridged version of "Paradise Lost," contained in the *Költeményes munkaji* (Komárom, 1802). Baróti, moreover, published (1810–13) a translation of Virgil's *Æneid* and *Eclogues*. Of Baróti's

[1] First made known by Coloman Thaly (1871) from a discovery by MM. E. Nagy and D. Véghelyi in the archives of the Csicsery family, in the county of Ung.

[2] One of the only seven perfect copies extant of the Vienna (1574) edition is in the British Museum library.

[3] A copy, with the autograph of the editor, is in the British Museum.

[4] A copy is in the British Museum library.

[5] There are two copies of this edition in the British Museum library.

[6] The earliest, styled "Song on the Discovery of the right hand of the Holy King Stephen," and printed at Nuremberg by Anton Koburger in 1484. is lost.

[7] See Chas. Szabó's *Régi Magyar Könyvtár*, Budapest, 1879. *Cf.* also *Lit. Ber. aus Ungarn* for 1879, Bd. iii. Heft 2, p. 433–434.

purely linguistic works the best known are his *Ortographia és Prosodia* (Komárom, 1800); and the *Kisded Szótár* (Kassa, 1784 and 1792) or "Small Lexicon" of rare Hungarian words. As a philologist Baróti was far surpassed by Révai, whose linguistic labours have already been alluded to (see above, LANGUAGE); but as a poet he may be considered superior to Rájnis, translator of Virgil's *Bucolics* and *Georgics*, and author of the *Magyar Helikonra vezetö kalauz* (Guide to the Magyar Helicon, 1781). The "classical" school reached its highest state of culture under Virág, whose poetical works, consisting chiefly of Horatian odes and epistles, on account of the perfection of their style, obtained for him the name of the "Magyar Horace." The *Poetai Munkai* (Poetical Works) of Virág were published at Pest in 1799, and again in 1822. Of his prose works the most important is the *Magyar Századok* or "Pragmatic History of Hungary" (Buda, 1808 and 1816). Vályi-Nagy, the first Magyar translator of Homer, belongs rather to the "popular" than the "classical" school. His translation of the *Iliad* appeared at Sárospatak in 1821. The establishment of the "national" or "popular" school is attributable chiefly to Andrew Dugonics, though his earliest works, *Troja veszedelme* (1774) and *Ulysses* (1780), indicate a classical bias. His national romances, however, and especially *Etelka* (Pozsony, 1787) and *Az arany pereczek* (Pest and Pozsony, 1790), attracted public attention, and were soon adapted for the stage. The most valuable of his productions is his collection of "Hungarian Proverbs and Famous Sayings," which appeared in 1820 at Szeged, under the title of *Magyar példabeszédek és jeles mondások*. The most noteworthy follower of Dugonics was Adam Horváth, author of the epic poems *Hunniász* (Györ, 1787) and *Rudolphiász* (Vienna, 1817). Joseph Gvadányi's tripartite work *Falusi notárius* (Village Notary), published between 1790 and 1796, as also his *Rontó Pál és gr. Benyowszky történetcik* (Adventures of Paul Rontó and Count Benyowski), are humorous and readable, but careless in style. As writers of didactic poetry may be mentioned John Endrödy, Caspar Göböl, Joseph Takács, and Barbara Molnár, the earliest distinguished Magyar poetess.

Of a more general character, and combining the merits of the above schools, are the works of the authors who constituted the so-called "Debreczen Class," which boasts the names of the naturalist and philologist John Földi, compiler of a considerable part of the *Debreczeni magyar grammatica*; Michael Fazekas, author of *Ludas Matyi* (Vienna, 1817), an epic poem, in 4 cantos; and Joseph Kovács. Other precursors of the modern school were the poet and philologist Francis Verseghy, whose works extend to nearly forty volumes; the gifted didactic prose writer, Joseph Kármán; the metrical rhymster, Gideon Ráday; the lyric poets, Szentjóbi Szabó, John Bacsányi, and the short-lived Gabriel Dayka, whose posthumous "Verses" were published in 1813 by Kazinczy. Still more celebrated were Michael Csokonai and Alexander Kisfaludy. The former is one of the most original and genial of poets, his style somewhat resembling that of Petöfi. The best edition of Csokonai's works was published by Toldy (Pest, 1844). The first volume of Alexander Kisfaludy's *Himfy*, a series of short lyrics of a descriptive and reflective nature, appeared at Buda in 1801, under the title of *Kesergö szerelem* (Unhappy Love), and was received with such applause as but few books have ever met with; nor was the success of the second volume *Boldog szerelem* (Happy Love), which appeared in 1807, inferior. The *Regék*, or "Tales of the Past," were published at Buda from 1807 to 1808, and still further increased Kisfaludy's fame; but in his dramatic works he was not equally successful. Journalistic literature in the native language begins with the *Magyar Hirmondó* (Harbinger) started by Matthias Ráth at Pozsony in 1780. Among the magazines the most important was the *Magyar Muzeum*, established at Kassa (Kaschau) in 1788 by Baróti, Kazinczy, and Bacsányi. The *Orpheus* (1790) was the special work of Kazinczy, and the *Urania* (1794) of Kármán and of Pajor.

[Rev]ival [of th]e [Lang]uage (1807–1830).

Closely connected with the preceding period is that of the "Revival of the Language" (1807–1830), with which the name of Francis Kazinczy is especially associated. To him it was left to perfect that work of restoration begun by Baróti and amplified by Révai. Poetry and belles lettres still continued to occupy the chief place in the native literature, but under Kazinczy and his immediate followers Berzsenyi, Kölcsey, Fáy, and others, a correctness of style and excellence of taste hitherto unknown soon became apparent. Kazinczy, in his efforts to accommodate the national language to the demands of an improved civilization, availed himself of the treasures of European literature, but thereby incurred the opposition of those who were prejudiced by a too biased feeling of nationality. The opinions of his enemies were ventilated in a lampoon styled *Mondolat*. His belletristic works, or *Szép Literatura* (Pest, 1814–16), extend to 9 vols., consisting in great part of translations. His *Eredeti Mukái* (Original Works), in 5 vols., appeared at Pest in 1836–45, under the joint editorship of Bajza and Toldy. Daniel Berzsenyi, whose odes are among the finest in the Hungarian language, was the correspondent of Kazinczy, and like him a victim of the attacks of the *Mondolat*. But the fervent patriotism, elevated style, and glowing diction of Berzsenyi soon caused him to be recognized as a truly national bard. A too frequent allusion to Greek mythological names is a defect sometimes observable in his writings. His collective works were published at Buda by Döbrentei in 1842. Those of John Kis, the friend of Berzsenyi, cover a wide range of subjects, and comprise, besides original poetry, many translations from the Greek, Latin, French, German, and English, among which last may be mentioned renderings from Blair, Pope, and Thomson, and notably his translation, published at Vienna in 1791, of Lowth's "Choice of Hercules." The style of Kis is unaffected and easy. As a sonnet writer none stands higher than Paul Szemere, known also for his rendering of Körner's drama *Zrinyi* (1818), and his contributions to the *Elet és Literatura* (Life and Literature). The articles of Francis Kölcsey in the same periodical are among the finest specimens of Hungarian æsthetical criticism. The lyric poems of Kölcsey can hardly be surpassed, whilst his orations, and markedly the *Emlék beszéd Kazinczy felett* (Commemorative Speech on Kazinczy), exhibit not only his own powers, but the singular excellence of the Magyar language as an oratorical medium. Andrew Fáy, sometimes styled the "Hungarian Æsop," was an industrious writer in almost every branch of literature during both this and the following period, but is now chiefly remembered for his *Eredeti Mesék* (Original Fables). The dramatic works of Charles Kisfaludy, brother of Alexander, won him enthusiastic recognition as a regenerator of the drama. His plays, moreover, bear a distinctive national character, the subjects of most of them referring to the golden era of the country. His genuine simplicity as a lyrical writer is shown by the fact that several of his shorter pieces have passed into popular song. As the earliest Magyarizer of Servian folk-song, Michael Vitkovics did valuable service. Not without interest to Englishmen is the name of Gabriel Döbrentei, the translator of Shakespeare's "Macbeth," represented at Pozsony in 1825, and of Sterne's "Letters from Yorick to Eliza," *Yorick és Eliza levelei* (Pest, 1828). But his chief merit in the eyes of his fellow-countrymen were his editorship of the Kolozsvár *Erdélyi Muzeum* (1814–18, vol. x.), and his laborious compilation of the *Régi Magyar Nyelvemlékek* (Memorials of the Magyar Language), which works are among the most important contributions to the literary history of the nation. An historical poem of a somewhat philosophical nature was produced in 1814 by Andreas Horváth under the title of *Zircz emlékezete* (Reminiscence of Zirez); but his *Árpád*, in 12 books, finished in 1830, and published at Pest in the following year, is a great national epic. Among other poets of this period were Alois Szentmiklóssy, George Gaal, Emil Buczy, Joseph Szász, Ladislaus Tóth, and Joseph Katona, author of the much-extolled historical drama *Bánk Bán*.[1] Izidore Guzmics, the translator of Theocritus into Magyar hexameters, is chiefly noted for his prose writings on ecclesiastical and philosophical subjects. As authors of special works on philosophy, we find Samuel Köteles, John Imre, Joseph Ruszek, Daniel Eresei, and Paul Sárvári; as a theologian and Hebraist John Somossy; as an historian and philologist Stephen Horváth, who endeavoured to trace the Magyar descent from the earliest historic times; as writers on jurisprudence Alexander Kövy and Paul Szlemenics. (For an account of the historian George Fejér, the laborious compiler of the *Codex Diplomaticus*, see FEJÉR, vol. ix. pp. 64, 65.)

Academy period (commencing 1830).

The establishment of the Hungarian Academy of Sciences[2] (17th November 1830) marks the commencement of a new period, in the first eighteen years of which gigantic exertions were made as regards the literary and intellectual life of the nation. The language, nursed by the academy, developed rapidly, and showed its capacity for giving expression to almost every form of scientific knowledge.[3] By offering rewards for the best original dramatic productions, the academy provided that the national theatre should not suffer from a lack of classical dramas. During the earlier part of its existence the Hungarian academy devoted itself mainly to the scientific development of the language and philological research. Since its reorganization in 1869 the academy has, however, paid equal attention to the various departments of history, archæology, national economy, and the physical sciences. The encouragement of polite literature was more especially the object of the Kisfaludy Society, founded in 1836.[4]

[1] The subject is similar to that of Grillparzer's tragedy, *Ein treuer Diener seines Herrn*.

[2] It was founded in 1825 through the generosity of Count Széchenyi, who devoted his whole income for one year (60,000 florins) to the purpose. It was soon supported by contributions from all quarters except from the Government.

[3] Among the earlier publications of the academy were the *Tudománytár* (Treasury of Sciences, 1834–44), with its supplement *Literatura*; the *Külföldi játékszin* (Foreign Theatres); the *Magyar nyelv rendszere* (System of the Hungarian language, 1846; 2d ed., 1847); various dictionaries of scientific, mathematical, philosophical, and legal terms; an Hungarian-German dictionary (1835–38); and a Glossary of Provincialisms (1838). The *Nagy-Szótár* (Great Dictionary), begun by Czuczor and Fogarasi in 1845, was not issued till 1862–74. Among the regular organs of the academy are the "Transactions" (from 1840), in some 60 vols., and the "Annuals."

[4] Among its earlier productions were the *Nemzeti könyvtár* (National Library), published 1843–47, and continued in 1852 under the title *Ujabb Nemzeti könyvtár*, a repository of works by celebrated authors; the *Külföldi Regénytár* (Treasury of Foreign Romances), consisting of translations; and some valuable collections of proverbs, folk-songs, traditions, and fables. Of the many later publications of the Kisfaludy society the most important as regards English literature is the *Shakspere Minden Munkái* (Complete Works of Shakespeare), in 19 vols. (1864–78)

Polite literature had received a great impulse in the preceding period (1807–30), but after the formation of the academy and the Kisfaludy society it advanced with accelerated speed towards the point attained by other nations. Foremost among epic poets, though not equally successful as a dramatist, was Michael Vörösmarty, who, belonging also to the close of the last period, combines great power of imagination with elegance of language. His historical tragedy *Salamon Király* (King Solomon, 1821), though deficient in dramatic force, attracted considerable attention. As fine specimens of epic poetry the *Zalán futása* (Flight of Zalán, 1824) and *Cserhalom* (1826) are unrivalled. His lyrical poems are exquisite both in taste and style; his *Szózat* (Appeal) is the Magyar national anthem. Vörösmarty is also celebrated as the translator of Shakespeare's "Julius Cæsar" and "King Lear." Generally less varied and romantic, though easier in style, are the heroic poems *Augsburgi ütközet* (Battle of Augsburg) and *Aradi gyülés* (Diet of Arad) of Gregory Czuczor, who was, moreover, very felicitous as an epigrammatist. Martin Debreczeni was chiefly famed for his *Kiövi csata* (Battle of Kieff), published at Pest in 1854 after his death by Count Emeric Mikó. The laborious John Garay in his *Szent László* shows considerable ability as an epic poet, but his greatest merit was rather as a romancist and ballad writer, as shown by the "Pen Sketches" or *Tollrajzok* (1845), and his legendary series *Árpádok* (1847). Joseph Bajza was a lyricist of a somewhat melancholy cast, but his *Borének* (Wine Song), *Sohajtás* (Sigh), *Ébresztö* (Awakening), and *Apotheosis* are much admired. He is known further as the translator of F. C. Dahlmann's *Geschichte der englischen Revolution.* As generally able writers of lyrical poetry during the earlier part of this period may be mentioned among others Francis Császár, Joseph Székács, and Andrew Kunoss,—also Lewis Szakál and Alexander Vachott, whose songs and romances are of an artless and simple character, and the sacred lyricist Béla Tárkányi. As an original but rather heavy lyric and didactic poet we may mention Peter Vajda, who was, moreover, the translator of Bulwer's "Night and Morning." Of a more distinctly national tendency are the lyrics of John Kriza[1] and John Erdélyi, but the reputation of the latter was more especially due to his collections of folk-lore made on behalf of the Kisfaludy society. More popular than any of the preceding, and well-known in England through Sir John Bowring's translation, are the charming lyrics of Alexander Petöfi, the "Burns" of Hungary. His poems, embodying as they do the national genius, have passed into the very life of the people; particularly is he happy in the pieces descriptive of rural life. In his verse "Folk-tales," *Népregék* (1846), and "Ballads," *Regék* (1852), may Michael Tompa, another popular poet, be regarded as sometimes hardly less felicitous. The most diversely gifted Magyar singer, however, is John Arany, whose talents have been displayed, not only in ballads and lyrical effusions, but in almost every branch of poetry except the dramatic. Especially famous is the Toldi trilogy, of which the first part *Toldi*, in 12 cantos, relating to the youth of the hero, was published at Pest in 1847; the third part, *Toldi Estéje* (Toldi's Eve), describing his fall and death, in 1854; and the middle part, *Toldi Szerelme* (Toldi's Love), in 1879. The *Nagyidai czigányok* (Eida Gipsies), a fine humorous epic poem in 4 cantos, appeared in 1852. A collective edition of Arany's poetical works was published at Pest and Vienna in 1867.

Among recent lyricists who have attracted attention are the following:—Coloman Tóth, who is also the author of several epic and dramatic pieces; John Vajda, whose *Kisebb Költemények* (Minor Poems), published by the Kisfaludy society in 1872, are partly written in the mode of Heine, and are of a pleasing but melancholy character; Joseph Lévay, known also as the translator of Shakespeare's *Titus Andronicus, Taming of the Shrew*, and *Henry IV.*; and Paul Gyulai, who, not only as a faultless lyric and epic poet, but as an impartial critical writer, is highly esteemed, and whose *Romhányi* is justly prized as one of the best Magyar poems that has appeared in modern times. To the above may be added the names of Charles Berecz, Joseph Zalár, Samuel Nyilas, Joseph Vida, Lewis Tolnai, the sentimental Ladislaus Szelestey, and the talented painter Zoltán Balogh, whose romantic poem *Alpári* was published in 1871 by the Kisfaludy society. The lyrics of Anthony Várady (1875, 1877) are somewhat dull and unequal in tone; both he and Baron Ivor Kaas, author of *Az itélet napja* (Day of Judgment, 1876), have shown skill rather in the art of dramatic verse. The poems of Count Géza Zichy and Victor Dalmady, those of the latter published at Budapest in 1876, are mostly written on subjects of a domestic nature, but are conceived in a patriotic spirit. Emil Ábrányi adopts a rather romantic style, but his *Nagypéntek* (Good Friday) is an excellent descriptive sketch. Alexander Endrödy, author of *Tücsök dalok* (Cricket Songs, 1876), is a glowing writer, with great power of conception, but his metaphors, following rapidly one upon the other, become often confused. Joseph Kiss in 1876 brought out a few lyric and epic poems of considerable merit. The *Mesék* of Augustus Greguss (1878), a collection of verse "Fables," belonging to the school of Gay, partake more of a didactic than lyrical nature. This feature is noticeable also in the *Költemények* (1873) of Ladislaus Torkos, and the *Modern Mesék* (1874) of Ladislaus Névy. An energetic satirical poet has recently appeared in Lewis Bartók.

As one of the latest remarkable productions of Magyar poetry, we must not omit to draw attention to the *Salamon* (1878) of Charles Szász, which poem was rewarded with the prize of the academy. The subject, taken from the age of Hungarian chivalry, is artistically worked out from mediæval legends, and gives an excellent description of the times of St Ladislaus of Hungary. Charles Szász is generally better known as a metrical translator than as an original poet. He is the Magyarizer of Shakespeare's *Anthony and Cleopatra, Othello, Macbeth, Henry VIII., Winter's Tale, Romeo and Juliet*, and *Tempest*, as also of some of the best pieces of Burns, Moore, Byron, Shelley, Milton, Béranger, Lamartine, Victor Hugo, Goethe, and others. A translator from Byron and Pope appeared also in Maurice Lukács.[2]

Meanwhile dramatic literature has found many champions, of whom the most energetic is the late Edward Szigligeti, *proprie* Joseph Szathmáry, who has enriched the Hungarian stage with more than a hundred pieces. Of these the most popular are comedies and serio-comic national dramas. His recently produced tragedy *Béla IV.* is also much admired. A less prolific but more classical writer appeared in Charles Obernyik, whose *George Brankovics* is, next to Katona's *Bánk Bán*, one of the best historical tragedies in the language. Several of the already mentioned lyric and epic poets were, as we have shown in the case of Vörösmarty, occasional writers also for the drama. To these we may add the gifted but unfortunate Sigismund Czakó, Lewis Dobsa, Joseph Szigeti, Ignatius Nagy, Joseph Szenvey (a translator from Schiller), Joseph Gaal, Charles Hugo, Lawrence Tóth (the Magyarizer of the *School for Scandal*), Emeric Vahot, Alois Degré (equally famous as a novelist), Stephen Toldy, and Lewis Dóczi, author of the popular prize drama *Csók* (The Kiss). *Az ember tragoediája* (The Tragedy of Man), by Emeric Madách (1861), is a dramatic poem of a philosophical and contemplative character, and is not intended for the stage. Among the latest most successful dramatic pieces may be mentioned the *Falu rossza* (Village Scamp) of the late Edward Tóth (1875), which represents the life of the Hungarian peasantry, and shows both poetic sentiment and dramatic skill; *A szerelem harcza* (Combat of Love), by Count Géza Zichy; *Iskáriot* (1876) and the prize tragedy *Tamora* (1879), by Anthony Várady; *Jánus* (1877), by Gregory Csiky; and the dramatized romance *Szép Mikhal* (Handsome Michal), by Maurice Jókai (1877). The principal merit of this author's drama *Milton* (1876) consists in its brilliance of language. The *Szerelem iskolája* (School of Love), by Eugene Rákosy, although in some parts exquisitely worded, did not meet with the applause accorded to his *Ripacsos Pista Dolmánya* (1874). The *Gróf Dormándi Kálmán* (Count Coloman Dormándi) of Béla Bercsényi (1877) is a social tragedy of the French school. Among the most recent writers of comedy we single out Árpád Berczik for his *A házasitók* (The Matchmakers); Ignatius Súlyovsky for his *Nöi diplomatia* (Female Diplomacy); and the above-mentioned Gregory Csiky for his *Ellenállhatatlan* (The Irresistible), produced on the stage in 1878. As popular plays the *Sárga csikó* (Bay Foal) and *A piros bugyelláris* (The Red Purse) by Francis Csepreghy, have their own special merit, and were often represented in 1878 and 1879 at Budapest and elsewhere.

Original romance writing, which may be said to have commenced with Dugonics and Kármán at the close of the 18th, and to have

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to which a supplementary vol., *Shakspere Pályája* (1880), containing a critical account of the life and writings of Shakespeare, has been added by Professor A. Greguss. Translations from Molière, Racine, Corneille, Calderon, and Moreto have also been issued by the Kisfaludy society. The *Évlapok új folyama*, or "New Series of Annuals," from 1860 (Budapest, 1868, &c.), is a chrestomathy of prize orations, and translations and original pieces, both in poetry and prose.

[1] Late Unitarian bishop of Transylvania, author of *Vadrózsák*, or "Wild-Roses" (1863), a collection of Szekler folk-songs, ballads, and sayings.

[2] Besides the various translators from the English, as for instance William Györi, Augustus Greguss, Ladislaus Arany, Sigismond Ács, Stephen Fejes, and Eugene Rákosy, who, like those already incidentally mentioned, have assisted in the Kisfaludy society's version of Shakespeare's complete works, metrical translations from foreign languages have, during the last few years, been successfully made by Emil Ábrányi, Dr Ignatius Barna, Anthony Várady, Andrew Szabó, Charles Bérczy, Julius Greguss, Lewis Dóczi, Béla Erödi, Emeric Gáspár, and many others. A Magyar version, by Ferdinand Barna, of the *Kalewala* was published at Pest in 1871. Faithful renderings by Lewis Szeberényi, Theodore Lehoczky, and Michael Fincicky of the popular poetry of the Slavic nationalities appeared in vols. i and ii. of the *Hazai nép költészet tára* (Treasury of the Country's Popular Song), commenced in 1866, under the auspices of the Kisfaludy society. In vol. iii. Roumanian folk-songs have been Magyarized by George Ember, Julian Grozescu, and Joseph Vulcanu, under the title *Román népdalok* (Budapest, 1877). The *Rózsák* (Zombor, 1875) is a translation by Eugene Pavlovits from the Servian of Jovan Jovanovits. Both the last-mentioned works are interesting from an ethnographical point of view. Versions from the English appear from time to time in the *Budapesti Szemle* (Budapest Review), conducted by Paul Gyulai. We may here note that for foreigners unacquainted with Hungarian there are, besides several special versions of Petöfi and of Arany, 21 anthologies of Magyar poetry in German, by Count Majláth (1825), J. Fenyéry and F. Toldy (1828), G. Steinacker (1840, 1875), G. Stier (1850), K. M Kertbeny (1854, 1860), A. Dux (1854), Count Pongrácz (1859–61), A. M. Riedl (1860), J. Nordheim (1872), G. M. Henning (1874), A. von der Heide (1879), and others. Selections have also been published in English by Sir John Bowring (1830), S Wékey in his grammar (1852), and E. D. Butler (1877), and in French by H. Desbordes-Valmore and C. E. De Ujfalvy (1873).

found a representative in Francis Verseghy at the beginning of the 19th century, was afterwards revived by Fáy in his *Bélteky ház* (1832), and by the contributors to certain literary magazines, especially the *Aurora*, an almanack conducted by Charles Kisfaludy, 1821-30, and continued by Joseph Bajza to 1837. Almost simultaneously with the rise of the Kisfaludy society, works of fiction assumed a more vigorous tone, and began to present just claims for literary recognition. Far from adopting the levity of style too often observable in French romances, the Magyar novels, although enlivened by touches of humour, have generally rather a serious historical or political bearing. Especially is this the case with Nicholas Jósika's *Abafi* (1836), *A csehek Magyarországon* (The Bohemians in Hungary), and *Az utolsó Bátori* (The Last of the Báthoris), published in 1847. In these, as in many other of the romances of Jósika, a high moral standard is aimed at. The same may be said of Baron Joseph Eötvös's *Karthausi* (1839), and *Falu Jegyzője* (Village Notary), published in 1845, and translated into English (1850) by O. Wenckstern (see Eötvös, vol. viii. p. 455). The *Árvizkönyv* or "Inundation Book," edited by Eötvös, 1839-41, is a collection of narratives and poems by the most celebrated authors of the time. Of the novels produced by Baron Sigismond Kemény the *Gyulai Pál* (1847), in 5 vols., is, from its historical character, the most important. His *Férj és nö* (Husband and Wife) appeared in 1853 (latest ed., 1878), the *Rajongók* (Fanatics), in 4 vols., in 1858-59. The graphic descriptions of Hungarian life in the middle and lower classes by Lewis Kuthy won for him temporary renown; but his style, though flowery, is careless. Another popular writer of great originality was Joseph Radákovics *alias* Vas-Gereben. The romances of Baron Frederick Podmaniczky are simpler, and rather of a narrative than colloquial character. The fertile writer Paul Kovács excels more particularly in humorous narration. Fáy's singular powers in this direction were well shown by his *Jávor orvos és Bakator Ambrus szolgája* (Doctor Jávor and his servant Ambrose Bakator), brought out at Pest in 1855. The *Beszélyek* (Tales) of Ladislaus Beöthy were produced in the same year, his *Puszták fia* (Son of the Pusztas) in 1857. Pleasing humorous sketches are contained also in Ignatius Nagy's *Beszélyek* (1843) and "Caricatures" or *Torzképek* (1844); in Caspar Bernát's *Fresko képek* (1847-50); in Gustavus Lauka's *Vidék*, and his *A jó régi világ* (The Good Old World), published respectively in 1857 and 1863; and in Alexander Balázs's *Beszélyei* (1855) and *Tükördarabok* (1865). Among authors of other historical or humorous romances and tales which have appeared from time to time are Francis Márton *alias* Lewis Abonyi, Joseph Gaal, Paul Gyulai, William Győri, Lazarus Horváth, the short-lived Joseph Irinyi, translator of "Uncle Tom's Cabin," Francis Ney, Albert Pálffy, Alexander Vachott and his brother Emeric (Vahot), Charles Szathmáry, Desider Margittay, Victor Vajda, Joseph Bodon, Atala Kisfaludy, John Krátky, and the several writers whose names and latest works are noticed at the end of this paragraph. But by far the most prolific and talented novelist that Hungary can boast of is Maurice Jókai, whose power of imagination and brilliancy of style, no less than his true representations of Hungarian life and character, have earned for him a European reputation. His earlier romances, published before the revolution of 1848, are chiefly of a social or political tendency. Of his more recent productions the best known are *Egy magyar nábob* (A Magyar Nabob), with its continuation *Kárpáthy Zoltán*, published in 1853 and 1854 respectively; *Szerelem bolondjai* (The Fools of Love, 1867); *Az új földesur* (The New Landlord), translated into English by A. J. Patterson (1868); *Fekete gyémántok* (Black Diamonds, 1870); *A jövö század regénye* (The Romance of the Coming Century, 1873); *Az élet komédiásai* (The Comedians of Life, 1876); the historical romance *Szép Mikhál* (1876) already referred to; and his justly admired and vividly interesting work *Egy az isten* (God is One, 1877). The events of the last-mentioned novel, in which the Unitarians play an important part, are supposed to take place between the years 1848 and 1859, and the scenes are laid partly in Transylvania, partly in Italy. In his *A névtelen vár* (Nameless Castle, 1878), the author connects an epoch of French history with Hungarian, and gives an account of the Hungarian army employed so unsuccessfully against Napoleon in 1809. *Rab Ráby* (Captive Ráby), produced in 1879, is a tale of the times of Joseph II. Defects occasionally observable in Jókai's works are want of unity, consistency, and probability. Of the novels produced by other authors since 1870, we may mention *A hol az ember kezdödik* (Where the Man Begins), by Edward Kavassy (1871), in which he severely lashes the idling Magyar nobility; *Az én ismerőseim* (My Acquaintances), by Lewis Tolnai (1871); and *Anatol*, by Stephen Toldy (1872); the versified romances *Déli bábok hőse* (Hero of the Fata Morgana), generally ascribed to Ladislaus Arany, but anonymously published, *A szerelem hőse* (Hero of Love), by John Vajda (1873), and *Találkozások* (Rencounters) by the same (1877), and *A Tündéröv* (The Fairy Zone), by John Bulla (1876), all four interesting as specimens of narrative poetry; *Kálozdy Béla* (1875), a tale of Hungarian provincial life, by Zoltán Beöthy, a pleasing writer who possesses a fund of humour, and appears to follow the best English models; *Edith története* (History of Edith) by Joseph Prém (1876); *Nyomorúság iskolája* (School of Misery), by the prolific author Arnold Vértesi (1878); *Titkolt szerelem* (Secret Love), by Cornelius Ábrányi (1879), a social-political romance of some merit; and *Uj idők, avult emberek* (Modern Times, Men of the Past), by L. Véka (1879). In the *Itthon* (At Home), by Alois Degré (1877), the tale is made the medium for a satirical attack upon official corruption and Hungarian national vanity; and in the *Álmok álmodója* (Dreamer of Dreams), by John Ásbóth (1878), other national defects are aimed at. *A rosz szomszéd* (The Bad Neighbour), by Charles Vadnay (1878), is a felicitous representation of the power of love. The *Az utolsó Bebek* (The Last of the Bebeks), by the late Charles Pétery, is a work rich in poetic invention, but meagre in historical matter. The reverse is the case with the *Lajos pap* (Priest Lewis), by Charles Vajkay (1879), the scene of which is placed at Pest, in the beginning of the 14th century. In this romance the interest of the narrative is weakened by a superabundance of historical and archæological detail.

As regards works of a scientific character, the Magyars until recently were confessedly behind hand as compared with many other European nations. Indeed, before the foundation of the Hungarian academy in 1830, but few such works claiming general recognition had been published in the native language. Even in 1847 astronomy, physics, logic, and other subjects of the kind had to be taught in several of the lyceums through the medium of Latin. The violent political commotions of the next few years allowed but little opportunity for the prosecution of serious studies; the subsequent quieter state of the country, and gradual re-establishment of the language as a means of education, were, however, more favourable to the development of scientific knowledge.

In the department of philosophy, besides several writers of dissertations bearing an imitative, didactic, or polemical character, Hungary can boast a few authors of independent and original thought. Of these one of the most notable is Cyril Horváth, whose treatises published in the organs of the academy display a rare freedom and comprehensiveness of imagination. John Hetényi and Gustavus Szontagh must be rather regarded as adopters and developers of the ethical teaching of Samuel Köteles in the previous period. Hyacinth Rónay in his *Mutatrány* (Representation) and *Jellemisme* (Characteristics) endeavoured to popularize psychological studies. The philosophical labours of the already mentioned John Erdélyi and of Augustus Greguss won for them well-deserved recognition, the latter especially being famous for his æsthetical productions, in which he appears to follow out the principles of Vischer. The *Tanulmányok* (Studies) of Greguss were brought out at Pest in 1872. The reputation of John Szilasy, John Varga, Fidelius Beély, and Francis Ney arose rather from their works bearing on the subject of education than from their contributions to philosophy.

The labours of Stephen Horváth in the preceding period had prepared the way for future workers in the field of historical literature. Specially meritorious among these are Michael Horváth, Ladislaus Szalay, Paul Jászay, and Count Joseph Teleki. The *Magyarok története* (History of the Magyars), in 4 vols., first published at Pápa (1842-46), and afterwards in 6 vols. at Pest (1860-63), and in 8 vols. (1871-73), is the most famous of Michael Horváth's numerous historical productions. Ladislaus Szalay's *Magyarország története* (History of Hungary), vols. i.-iv. (Leipsic, 1852-54), vols. v.-vi. (Pest, 1856-61), second edition, i.-v. (1861-66), is a most comprehensive work, showing more particularly the progress of Hungarian legislative development in past times. His style is elevated and concise, but somewhat difficult. Magyar history is indebted to Paul Jászay for his careful working out of certain special periods, as, for instance, in his *A Magyar nemzet napjai a legrégibb idötöl az arany bulláig* (Days of the Hungarian nation from the earliest times to the date of the Golden Bull). Count Joseph Teleki is famed chiefly for his *Hunyadiak kora Magyarországon* (The Times of the Hunyadys in Hungary), vols. i.-vi. (Pest, 1852-63), x.-xii. (1853-57), the result of thirty years' labour and research. In particular departments of historical literature we find George Bartal, author of *Commentariorum . . . libri XV.*, tom. i.-iii. (Pozsony, 1847), John Czech, Gustavus Wenczel, Frederick Pesty, and Paul Szlemenics, as writers on legal history; Joseph Bajza, who in 1845 commenced a "History of the World," Alexander Szilágyi, some of whose works, like those of Ladislaus Kövary, bear on the past of Transylvania, others on the Hungarian revolution of 1848-49; Charles Lányi and John Pauer, authors of treatises on Roman Catholic ecclesiastical history; John Szombathi, Emeric Révész, and Balogh, writers on Protestant church history; William Fraknói, biographer of Cardinal Pázmán, and historian of the Hungarian diets; and Anthony Gévay, Aaron Sziládi, Joseph Podhradczky, Charles Szabó, John Jerney, and Francis Salamon, who have investigated and elucidated many special historical subjects. For the mediæval history of Hungary the *Mátyáskori diplomatikai emlékek* (Diplomatic Memorials of the Time of Matthias Corvinus), issued by the academy under the joint editorship of Ivan Nagy and Baron Albert Nyáry, affords interesting material. As a masterly production based on extensive investigation, we note the *Wesselényi Ferencz . . . összeesküvése* (The Secret Plot of Francis Wesselényi, 1664–71), by Julius Pauler (1876). Among the many historians of Magyar literature Francis Toldy *alias* Schedel holds the foremost place. As compilers of useful manuals may be mentioned also Joseph Szvorényi, Zoltan Beöthy, Alexander Imre, Paul Jámbor, Ladislaus Névy, John Környei, and Joseph Szinnyei, junior. For philological and ethnographical research into the origin and growth of the language none excels Paul Hunfalvy. He is, moreover, the warm advocate of the theory of its Ugrio-Finnic origin, as established by the late Uralian traveller Anthony Reguly, the result of whose labours Hunfalvy published in 1864, under the title *A Vogul föld és nép* (The Vogul Land and People). Between 1862 and 1866 valuable philological studies bearing on the same subject were published by Joseph Budenz in the *Nyelvtudományi közlemények* (Philological Transactions). This periodical, issued by the academy, has during the last decade (1870–80) contained also comparative studies, by Arminius Vámbéry and Gabriel Bálint, of the Magyar, Turkish-Tatar, and Mongolian dialects.

As compilers and authors of works in various scientific branches allied to history, may be particularly mentioned—in statistics and geography, Alexius Fényes, Emeric Palugyay, Alexander Konek, John Hunfalvy, Charles Galgóczy, Charles Keleti, Leo Beöthy, Joseph Körösi, Charles Ballagi, and Paul Király, and, as regards Transylvania, Ladislaus Kőváry; in travel, Arminius Vámbéry, Ignatius Goldziher, Ladislaus Magyar, John Xantus, John Jerney, Count Andrássy, Ladislaus Podmaniczky, Paul Hunfalvy; in astronomy, Nicholas Konkoly; in archæology, Bishop Arnold Ipolyi, Florian Rómer, Emeric Henszlmann, John Érdy, Baron Albert Nyáry, Francis Pulszky, and Francis Kiss; in Hungarian mythology, Bishop Ipolyi, Anthony Csengery,[1] and Árpád Kerékgyártó; in numismatics, John Erdy and Jacob Rupp; and in jurisprudence, Augustus Karvassy, Theodore Pauler, Gustavus Wenczel, Emeric Csacskó, John Fogarasi, and Ignatius Frank. Since 1867 great activity has been displayed in history and its allied branches, owing to the direct encouragement given by the Hungarian Historical Society, and by the historical, archæological, and statistical committees of the academy.

Notwithstanding the exertions of Paul Bugát to arouse an interest in the natural sciences by the establishment in 1841 of the "Hungarian Royal Natural Science Association," no general activity was manifested in this department of knowledge, so far as the native literature was concerned, until 1860, when the academy organized a special committee for the advancement of mathematical and natural science.[2] The principal contributors to the "Transactions" of this section of the academy have been—for anatomy and physiology, Coloman Balogh, Eugene Jendrassik, Joseph Lenhossék, and Lewis Thanhoffer; for zoology, John Frivaldszky, John Kriesch, and Theodore Margó; for botany, Frederick Hazslinszky, Lewis Jurányi, and Julius Klein; for mineralogy and geology, Joseph Szabó, Max Hantken, Joseph Krenner, Anthony Koch, and Charles Hoffmann; for physics, Baron Lorando Eötvös, Coloman Szily, and Joseph Sztoczek; for chemistry, Charles Than and Vincent Wartha; for meteorology, Guido Schenzl. As good text-books, for which the so-called "Ladies' Prize" was awarded by the academy, we may mention the *Természettan* (Physics) and *Természettani földrajz* (Physical Geography) of Julius Greguss.

Almost simultaneously with the formation of the above-mentioned committee of the academy, the "Natural Science Association" showed signs of renewed animation, and soon advanced with rapid strides in the same direction, but with a more popular aim than the academy. This may be seen from the fact that between 1868 and 1878 the number of its members increased from some 600 to about 5000. Since 1872, in addition to its regular organs, it has issued Hungarian translations of several popular scientific English works, as, for instance, Darwin's *Origin of Species*; Huxley's *Lessons in Physiology*; Lubbock's *Prehistoric Times*; Proctor's *Other Worlds than Ours*; Tyndall's *Heat as a Mode of Motion*, &c. Versions have also been made of Cotta's *Geologie der Gegenwart* and Helmholtz's *Populäre Vorlesungen*. As important original monographs we note—*Az árapály a Fiumei öbölben* (Ebb and Flow in the Gulf of Fiume), by Emil Stahlberger (1874); *Magyarország pókfaunája* (The Arachnida of Hungary), by Otto Hermann (1876–78); *Magyarország vaskörei és vasterményei* (The Iron Ores and Iron Products of Hungary), by Anthony Kerpely (1877); *Magyarország nevezetesebb dohányfajainak chemiai . . . megvizsgálása* (Chemical Examination of the most famous Tobaccos of Hungary), by Dr Thomas Kosutány (1877).

In order to give a general idea of the dominant position that the native Hungarian literature has obtained during the last half century, we conclude our sketch with a few statistics of the number of books and periodicals issued from the press at various dates since the foundation of the academy. In the year 1831 there were 184 Magyar works published; in 1853 there were 336; this number in 1874 increased to 946; in 1877 to 1067; and in 1878 and 1879 to 1312 and 1154 respectively. In 1879 there appeared also 111 German works, and 185 in other non-Magyar languages. In 1830 the number of Magyar periodicals was 10; in 1848–49 it increased to 80, but fell in 1850 to 9. In 1867, after the restoration of the Hungarian constitution, the number was again 80, and increased so rapidly during the next twelve years that by 1879 it reached 324, and has in the present year (1880) risen to 368. There are now, moreover, 197 newspapers and journals of all kinds in the non-Magyar languages, viz., 114 German, 61 Slavonic, 16 Roumanian, 4 Italian, and 2 Hebrew; so that there are at this date altogether 565 periodicals published in Hungary.

If we take a retrospective glance at the depressed state of the native language and literature as it was a century ago, when the first Magyar newspaper was published at Pozsony, 1st January 1780,[3] and contrast its commanding position now,—or if we consider that, though constantly surrounded and pressed by foreign and antagonistic elements, the native language and literature have not only not been overpowered, but have even gained the mastery, —we cannot fail to admire the determined perseverance of the champions of Magyar literature, and believe that the state language is destined to be a common and enduring bond of union between the various nationalities comprised under the crown of St Stephen.

Bibliography.—The best authorities on Magyar literature are:—F. Toldy, *A Magyar nemzeti irodalom története a legrégibb időktől a jelenkorig* (Pest, 1864-65; 3d ed., 1872); S. Imre, *A Magyar irodalom és nyelv rövid története* (Debreczen, 1865; 4th ed., 1878); J. Szvorényi, *Magyar irodalmi szemelvények* (Pest, 1867), and *A Magyar irodalmi tanulmányok kézikönyve* (Pest, 1868); P. Jámbor, *A Magyar irodalom története* (Pest, 1864); J. Környei, *A Magyar nemzeti irodalomtörténet vázlata* (Pest, 1861; 3d ed., 1874); A. Lonkay, *A Magyar irodalom ismertetése* (Budán, 1855; 3d ed., Pest. 1864); J. Ferencz, *Magyar irodalom és tudományosság története* (Pest, 1854); J. Ferencz és J. Danielik, *Magyar Irók. Életrajz-Gyüjtemény* (2 vols., Pest, 1856–58); and the literary histories of L. Névy, Z. Beöthy, and B. Erödi. One of the most useful monographs on "Magyar Literary History Writing" is that of J. Szinnyei, junior, *A Magyar Irodalomtörténet-Irás ismertetése* (Budapest, 1878). For information as to the most recent literature see A. Dux, *Aus Ungarn* (Leipsic, 1880). (E. D. BU.)

[1] The translator of Macaulay.

[2] See, however, J. Szinnyei and Son's *Bibliotheca Hungarica historiæ naturalis et matheseos*, 1472-1875 (Budapest, 1878), where the number of Magyar works bearing on the natural sciences and mathematics printed from the earliest date to the end of 1875 is stated to be 3811, of which 106 are referred to periodicals.

[3] A Latin periodical, intended only for transmission abroad, and styled *Mercurius Veridicus ex Hungaria*, was issued weekly at Kassa as early as 1705. A German periodical was first published in Hungary about 1731.

INDEX.

HUNS. The authentic history of the Huns in Europe practically begins about the year 372 A.D.,[1] when under a leader named Balamir (or, according to some MSS., Balamber) they began a westward movement from their settlements in the steppes lying to the north of the Caspian. After crushing, or compelling the alliance of, various nations unknown to fame (Alpilzuri, Alcidzuri, Himari, Tuncarsi, Boisci), they at length reached the Alani, a powerful nation which had its seat between the Volga and the Don; these also, after a struggle, they defeated and finally enlisted in their service. They then proceeded, after a short interval, in 374 to invade the empire of the Ostrogoths (Greuthungi), ruled over by the aged Ermanaric, or Hermanric, who died (perhaps by his own hand) while the critical attack was still impending. Under his son Hunimund a section of his subjects promptly made a humiliating peace; under Withemir (Winithar), however, who succeeded him in the larger part of his dominions, an armed resistance was organized; but it resulted only in repeated defeat, and finally in the death of the king. The representatives of his son Witheric put an end to the conflict by accepting the condition of vassalage. Balamir now directed his victorious arms still further westward against that portion of the Visigothic nation (or Tervingi) which acknowledged the authority of Athanaric. The latter entrenched himself on the frontier which had separated him from the Ostrogoths, behind the "Greutung-rampart" and the Dniester; but notwithstanding all his precautions he was surprised by the enemy, who forded the river in the night, fell suddenly upon his camp, and compelled him to abandon his position. Athanaric next attempted to establish himself in the territory between the Pruth and the Danube, and with this object set about heightening the old Roman wall which Trajan had erected in north-eastern Dacia; before his fortifications, however, were complete, the Huns were again upon him, and without a battle he was forced to retreat to the Danube. The remainder of the Visigoths, under Alavivus and Fritigern, now began to seek and ultimately were successful in obtaining (376) the permission of the emperor Valens to settle in Thrace; Athanaric meanwhile took refuge in Transylvania, thus abandoning the field without any serious struggle to the irresistible Huns. For more than fifty years the Roman world was undisturbed by any aggressive act on the part of the new invaders, who contented themselves with overpowering various other tribes which lived to the north of the Danube. In some instances, in fact, the Huns actually lent their aid to the Romans against third parties; thus in 404–5 certain Hunnic tribes, under a chief or king named Uldin, assisted Honorius in the struggle with Radagaisus (Ratigar) and his Ostrogoths, and took a prominent part in the decisive battle which was fought in the neighbourhood of Florence. Once indeed, in 409, they are said to have crossed the Danube and invaded Bulgaria under perhaps the same chief (Uldis), but extensive desertions soon compelled a retreat. About the year 432, a noteworthy Hunnic king, Ruas or Rugulas, is mentioned, who made himself of such importance that he received from Theodosius II. an annual stipend or tribute of 350 pounds of gold (£14,000), along with the rank of Roman general. Quarrels soon arose, partly out of the circumstance that the Romans had sought to make alliances with certain Danubian tribes which Ruas chose to regard as properly subject to himself, partly also because some of the undoubted subjects of the Hun had sought and found refuge on Roman territory; and Theodosius, in reply to an indignant and insulting message which he had received about this cause of dispute, was preparing to send off a special embassy when tidings arrived that Ruas was dead, and that he had been succeeded in his kingdom by Attila and Bleda, the two sons of his brother Mundzuk (433). Shortly afterwards the treaty of Margus (not far from the modern Belgrade), where both sides negotiated on horseback, was ratified. By its stipulations the yearly stipendium or tribute payable to Attila by the Romans was doubled; the fugitives were to be surrendered, or a fine of £8 to be paid for each of those who should be missing; free markets, open to Hun and Roman alike, were to be instituted; and any tribe with which Attila might be at any time at war was thereby to be held as excluded from alliance with Rome. For eight years afterwards there was peace so far as the Romans were concerned; and during this period probably it was that the Huns proceeded to the extensive conquests to which the contemporary historian Priscus so vaguely alludes in the words:—"He (Attila) has made the whole of Scythia his own, he has laid the Roman empire under tribute, and he thinks of renewing his attacks upon Persia. The road to that eastern kingdom is not untrodden by the Huns; already they have marched fifteen days from a certain lake, and have ravaged Media." They also appear before the end of this interval to have pushed westward as far as to the Rhone, and to have come into conflict with the Burgundians. Overt acts of hostility, however, occurred against the Eastern empire when the town of Margus (by the treachery of its bishop) was seized and sacked (441), and against the Western when Sirmium was invested and taken. In 445 Bleda died, and two years afterwards Attila, now sole ruler, undertook one of his most important expeditions against the Eastern empire; on this occasion he pushed southwards as far as Thermopylæ, Gallipoli, and the walls of Constantinople; peace was cheaply purchased by tripling the yearly tribute (which accordingly now stood at 2100 pounds of gold, or £84,000 sterling) and by the payment of a heavy indemnity besides. In 448 again occurred various diplomatic negotiations, and especially the embassy of Maximin, of which many curious details have been recorded by Priscus his companion. Then followed, in 451, that westward movement across the Rhine which was only arrested at last, with terrible slaughter, on the Catalaunian plains (according to common belief, in the neighbourhood of the modern Châlons, but more probably at a point some fifty miles to the south-east, near Mery-sur-Seine). The following year (452), that of the Italian campaign, was marked by such events as the sack of Aquileia, the destruction of the cities of Venetia, and finally, on the banks of the Mincio, that historical interview with Pope Leo I. which resulted in the return of Attila to Pannonia, where in 453 he died (see ATTILA). Almost immediately afterwards, the empire he had amassed rather than consolidated fell to pieces. His too numerous sons began to quarrel about their inheritance, while Ardaric, the king of the Gepidæ, was placing himself at the head of a general revolt of the dependent nations. The inevitable struggle came to a crisis near the river Netad in Pannonia, in a battle in which 30,000 of the Huns and their confederates, including Ellak, Attila's eldest son, were slain. The nation, thus broken, rapidly dispersed; one horde settled under Roman protection in Little Scythia (the Dobrudscha), others in Dacia Ripensis (on the confines of Servia and

[1] In the existing text of Ptolemy (iii. 5, 25), who wrote about the end of the 2d century after the Christian era, a tribe of Chuni (*Χοῦνοι*) is placed between the Basternæ and the Roxolani on the Dnieper; Schafarik, however (*Slav. Alt.*, i. 322, 1842), suggests that this may be an interpolated passage. Dionysius Periegetes (*c.* 200 A.D.) is sometimes quoted as having named the Huns among the borderers on the Caspian in this order—Scyths, Huns (Οὖννοι), Caspiani, Albani; but the true reading appears to be Θοῦννοι or Θῦνοι (Zeuss, *Die Deutschen u. d. Nachbarstämme*, p. 727). Eratosthenes, as quoted by Strabo (p. 514), gives in the same connexion Albani, Caspiani, and Κουΐτιοι, Κουΐντιοι, or Οὐΐτιοι.

Bulgaria) or on the southern borders of Pannonia. The main body, however, appear to have resumed the position on the steppes of the river Ural which they had left less than a century before; soon afterwards they reappear in history as the Bulgari (see Zeuss, *Die Deutschen*, &c., p. 710), divided into two sections, the Kuturguri and the less formidable Uturguri, who for more than seventy years (485–557) were a constant source of annoyance and danger to the Eastern empire, until they themselves fell under the rising power of the Avars. About the year 630 they succeeded in regaining their independence, under the leadership of a chief named Krobat, or more properly Kubrat, a person of great consequence, who made a treaty with the emperor Heraclius. After his death his dominions, according to Theophanes (who wrote about 800 A.D.), were divided among his five sons, of whom the eldest, Batbaias, remained with his own people near the Mæotis, while the third, Asperuch, crossed the Danube. At a later period the first of these divisions came into close relations with the Khazars on the Volga, and their territory is spoken of as Great Bulgaria; for a brief account of the Danubian or "White" Bulgarians the article BULGARIA and the works there referred to may be consulted.

We have no adequate philological data for conclusively determining the ethnological position of the ancient Huns; and, in the attempt to solve the problem by other means, the student is at all points much hampered by the vagueness and inaccuracy with which designations, apparently ethnological, are applied by ancient writers. Since the publication of the *Histoire Générale des Huns, des Turcs, des Mongols, et des autres Tartares Occidentaux* of De Guignes (1756–58), it has been usual to identify the first mentioned with the Heungnoo or Hiungnu, a people who, about the end of the 3d century B.C., according to the Chinese annals, constituted a powerful empire extending from the Great Wall of China to the Caspian, but who, gradually falling into a state of anarchy, ultimately succumbed to the attacks of their enemies towards the close of the 1st Christian century. Their subsequent history is very obscure; but it appears that one section of them fled westward and settled in the neighbourhood of the Ural river, and the extremely tempting hypothesis of De Guignes is that these were the direct ancestors of the Huns, who three centuries afterwards began, under Balamir, to exercise so formidable an influence on the affairs of Europe. If so, then the Huns in all probability belonged to the Turkish branch of the great Turanian race.

According to the totally distinct line of investigation followed by Roesler, however, the Bulgarians, and therefore the Huns whose descendants they were, are to be regarded as of Finnic origin (see *Romänische Studien*, p. 231 *sqq.*). It has only to be added that by mediæval writers, both Byzantine and Western, the word Hun is used much as the word Scythian was used by the ancients, with the utmost generality. No very close connexion can be made out between the Huns and the Magyars (Οὔγγροι, Ugri, Wengri, Ungri, Ungări, Hungari), who first became prominent about the 9th century and who were undoubtedly Finns.

Literature.—The contemporary authorities upon the subject of the Huns during the period of their greatest ascendency in Europe are the fragments of the eight books of the rhetorician Priscus, *Concerning Byzantium and the Occurrences connected with Attila*, with the writings of Ammianus Marcellinus the Roman soldier, and of Jordanis the Gothic bishop. The account of the Huns given by the last-named must always be read in the light of the fact that as a Goth he could hardly avoid giving a somewhat exaggerated picture of the great military power in the presence of which his own people had been able to show so little resistance. The truth of the somewhat elaborate sketch of the Huns by Ammianus has sometimes been doubted, but careful examination tends rather to establish its claim to be regarded as trustworthy. After alluding to their portentous ugliness (of which, however, the only features he specifies are the round shoulders and the scarred beardless cheeks), he proceeds to mention some of the habits which in his opinion stamp them as surpassing all other barbarians in rudeness of life. Their food, in addition to such roots as they are able to find, consists of the half-raw flesh of any sort of animal, prepared for use by being carried for some time between their persons and the backs of the hardy little horses which are their almost inseparable companions. Houses they have none; and their clothing, which is made partly of linen and partly of the skins of field mice sewed together, continues to be worn until it falls to pieces. Their weapons are javelins or spears tipped with bone, and (for close combat) the sword and lasso. In warfare they seldom fight in rank, the method of attack they prefer being to throw the enemy into confusion by repeated onset made in loose array. They are wholly without religion or sense of moral obligation. For later information we are dependent on the writers of the Byzantine history (see Stritter, *Memoriæ populorum olim ad Danubium, Pontum Euxinum, Paludem Mæotidem, Caucasum, &c., incolentium, ex scriptoribus Byzantinis erutæ ac digestæ*, 1771–79, and the edition of the fragments of Menander Protector, published in the Bonn collection). For Chinese notices bearing or supposed to bear on the subject of the Huns, De Guignes, Visdelou, and De Mailla remain our chief authorities; to these should be added M. Stanislas Julien's series of papers on the Thukiu in the 6th series of the *Journal Asiatique*, and Mr Wylie's translations from the Hun annals in the *Journal of the Anthropological Institute*. Other materials on the general subject will be found in the admirable notes to Le Beau's *History of the Byzantine Empire*, and in the editions of the Armenian historians by St Martin, Langlois, and Brosset. See also the *History of Georgia* by the last of these authors; the *Chronicle of Nestor*, which is made available to Western students in the edition of M. Paris; the works of Zeuss, Pallmann, and Roesler already cited; Thierry, *Histoire d' Attila et de ses Successeurs*, 1864; Sayous, *Les Origines et l'Époque Païenne de l'Histoire des Hongrois*, 1874; Jirecek, *Gesch. der Bulgaren*, 1877; Hodgkin, *Italy and her Invaders*, vol. ii., 1880; Kruse's edition of *Al Bekhri*, with notes; the *Account of the Khazars* by M. Harkavy; that of the *Ephthalitæ or White Huns*, by M. Vivien St Martin; and a series of papers by Mr Howorth "On the Westerly Drifting of Nomades," published in the *Journal of the Anthropological Institute*.

HUNT, JAMES HENRY LEIGH (1784–1859), one of the most delightful of English essayists and miscellaneous writers, and especially remarkable for his connexion with the most eminent literati of his time, was born at Southgate, October 19, 1784. His father, the son of a West Indian clergyman, had settled as a lawyer in Philadelphia, and his mother was the daughter of a merchant of that city. Having embraced the loyalist side, Leigh Hunt's father was compelled to fly to England, where he took orders, and acquired some reputation as a popular preacher, but want of steadiness, want of orthodoxy, and want of interest conspired to prevent his obtaining any preferment. Leigh Hunt was educated at Christ's Hospital, of which school as it existed in his time he has left a lively account in his autobiography. An impediment in his speech, afterwards removed, prevented his being sent to the university. "For some time after I left school," he says, "I did nothing but visit my school-fellows, haunt the book stalls, and write verses." These latter were published in 1802 under the title of *Juvenilia*, and, although the mere literary exercises of a clever boy, contributed to introduce him into literary and theatrical society. He began to write for the newspapers, published a volume of theatrical criticisms in 1807, and in 1808 quitted the War Office, where he had for some time filled a situation as clerk, to assume the editorship of the *Examiner* newspaper, a speculation of his brother John. The new journal soon acquired a high reputation for independence, both in political and literary criticism. It was perhaps the only newspaper of the time which owed no allegiance to any political party, but assailed whatever seemed amiss, "from a principle of taste," as Keats happily expressed it. The taste of the attack itself, indeed, was not always unexceptionable; and one upon the prince regent, unseemly and imprudent without doubt, but the chief sting of which lay in its substantial truth, occasioned (1813) a prosecution and a sentence of two years' imprisonment in the Surrey jail. The effect was naturally to make Hunt a hero for the time being, and to give a political direction to the career of a man of letters. The position was an essentially false one, and led to an entire misunderstanding of Leigh Hunt's character and aptitudes alike on the part of his friends and his antagonists. For the time he was exceedingly popular; the cheerfulness and gaiety with which he bore his imprisonment, and his amusing devices to mitigate its severity, attracted general attention and sympathy, and brought him visits from Byron, Moore, Brougham, and others, whose acquaintance exerted much influence on his future destiny. In 1816 he made a permanent mark in English literature by the publication of his *Story of Rimini*. There is perhaps no other instance of a poem short of the highest excellence having produced so important and durable an effect in modifying the accepted standards of literary composition. The secret of Hunt's success consists less in superiority of genius than of taste. His refined critical perception had detected the superiority of Chaucer's versification, as adapted to the present state of our language by Dryden, over the sententious epigrammatic couplet of Pope which had superseded it. By a simple return to the old manner he effected for English poetry in the comparatively restricted domain of metrical art what Wordsworth had already effected in the domain of nature; his is an achievement of the same class, though not of the same calibre. His poem is also a triumph in the art of poetical narrative, abounds with verbal felicities, and is pervaded throughout by a free, cheerful, and animated spirit, notwithstanding the tragic nature of the subject. It has been remarked that it does not contain one hackneyed or conventional rhyme. Other characteristic traits are less commendable, and the writer's occasional flippancy and familiarity, not seldom degenerating into the ludicrous, made him a mark for ridicule and parody on the part of his opponents, whose animosity, however, was rather political than literary. These faults were still more conspicuous in other pieces published by him about this date. Ere long, however, Keats's "Lamia" and Shelley's "Julian and Maddalo" manifested the deliverance which he had wrought for English narrative poetry. Both these illustrious men belonged to the circle gathered around him at Hampstead, which also included Hazlitt, Lamb, Procter, Haydon, Cowden Clarke, Dilke, Coulson, Reynolds, and in general almost all the rising young men of letters of Liberal sympathies. He had now for some years been married to Marianne Kent, who seems to have been sincerely attached to him, but was not in every respect a desirable partner. His own affairs were by this time in the utmost confusion, and he was only saved from ruin by the romantic generosity of Shelley. In return he was lavish of sympathy to Shelley at the time of the latter's domestic distresses, and defended him with spirit in the *Examiner*, although he does not appear to have at this date appreciated his genius with either the discernment or the warmth of his generous adversary, Professor Wilson. Keats he welcomed with enthusiasm, and aided to the uttermost, though Keats seems to have subsequently felt that Hunt's example as a poet had been in some respects detrimental to him. After Shelley's departure for Italy (1818) Leigh Hunt's affairs became still more embarrassed, and the prospects of political reform less and less satisfactory. His health and his wife's failed, and he was obliged to discontinue his charming series of essays entitled the *Indicator*, having, he says, "almost died over the last numbers." These circumstances induced him to listen to a proposal, which seems to have originated with Shelley, that he should proceed to Italy and join Shelley and Byron in the establishment of a periodical work in which Liberal opinions should be advocated with more freedom than was possible at home. The project was injudicious from every point of view; it would have done little for Hunt or the Liberal cause at the best, and depended entirely upon the co-operation of Byron, the most capricious of allies, and the most parsimonious of paymasters. Byron's principal motive for acceding to it appears to have been the expectation of acquiring influence over the *Examiner*, and he was exceedingly mortified on discovering when too late that Hunt had parted, or was considered to have parted, with his interest in the journal. Leigh Hunt left England for Italy in November 1821, but storm, sickness, and misadventure retarded his arrival until June 1822, a rate of progress which Peacock appropriately compares to the navigation of Ulysses.

Hunt's arrival in Italy was almost immediately followed by the tragic death of Shelley, which destroyed every prospect of success for the *Liberal*. Hunt was now virtually a dependant upon Byron, whose least amiable qualities were called forth by the relation of patron to an unsympathetic dependant, burdened with a large and troublesome family, and who was moreover incessantly wounded in the most sensitive part by the representations of his friends that he was losing caste by the connexion. The *Liberal* lived through four quarterly numbers, containing contributions no less memorable than Byron's "Vision of Judgment" and Shelley's translations from *Faust*; but it produced little effect on the whole, and in 1823 Byron sailed for Greece, leaving his coadjutor at Genoa to shift for himself. The Italian climate and manners, however, were entirely to Hunt's taste, and he protracted his residence until 1825, producing in the interim his matchless translation of Redi's *Bacco in Toscana*, and the religious work subsequently published under the title of *The Religion of the Heart*. In 1825 an unfortunate litigation with his brother brought him back to England, and in 1827 he committed the greatest mistake of his life by the publication of his *Lord Byron and his Contemporaries*. The work is of considerable value as a corrective of merely idealized estimates of Lord Byron. But such a corrective should not have come from one who had lain under obligations to Byron, however trifling, or however they might seem to be cancelled by subsequent unkindness. Leigh Hunt should also have considered that the materials for his estimate of Byron were chiefly afforded by a residence under Byron's own roof. Apart from its obvious impropriety, the publication in itself is in general petty and carping. Hunt's attitude towards Byron is always that of the inferior; in proportion, therefore, as Byron is made to look small, Hunt appears still smaller. The book's reception was even more unfavourable than its deserts. British manliness and British cant were for once equally shocked, and the author especially writhed under the withering satire of Moore. For many years ensuing, the history of Hunt's life is that of a painful struggle with poverty and sickness. He worked unremittingly, but one effort failed after another. Two periodical ventures, the *Tatler* and the *London Journal*, were discontinued for want of subscribers, although in the latter Leigh Hunt had able coadjutors, and it contained some of his best writing. His editorship of the *Monthly Repository*, in which he succeeded W. J. Fox, was also unsuccessful. The adventitious circumstances which had for a time made the fortune of the *Examiner* no longer existed, and Hunt's strong and weak points, his refinement and his affectations, were alike unsuited to the general body of readers. *Sir Ralph Esher*, a romance of Charles the Second's period, was more successful, and *Captain Sword and Captain Pen*, a spirited contrast between the victories of peace and the victories of war, deserves to be ranked among his best poems. In 1840 his circumstances were improved by the successful representation of his *Legend of Florence*, a play of great merit, although it has not maintained itself upon the stage. *Lover's Amazements*, a comedy, was acted several years afterwards; and other plays are extant in MS. The pretty narrative poem of *The Palfrey* was published in 1842; and about this time he began to write for the *Edinburgh Review*. In 1844 he was further benefited by the generosity of Mrs Shelley and her son, the present baronet, who, on succeeding to the family estates, settled an annuity of £120 upon him; and in 1847 Lord John Russell procured him a civil list pension of £200. The fruits of the improved comfort and augmented leisure of these latter years were visible in the production of some charming volumes. Foremost among these are the companion books, *Imagination and Fancy* and *Wit and Humour*. In these Leigh Hunt shows himself as within a certain range the most refined, appreciative, and felicitous of critics. Homer and Milton may be upon the whole beyond his reach, though even here he is great in the detection of minor and unapprehended beauties; with Spenser and the old English dramatists he is perfectly at home, and his subtle and discriminating criticism upon them, as well as upon his own great contemporaries, is continually bringing to light beauties unsuspected by the reader, as they were probably undesigned by the writer. His companion volume on the pastoral poetry of Sicily, quaintly entitled *A Jar of Honey from Mount Hybla*, is almost equally delightful. *The Town* and *Men, Women, and Books* are partly made up from former material. The *Old Court Suburb* is an anecdotic sketch of Kensington, where he long resided before his final removal to Hammersmith. In 1850 he published his autobiography, a naive and accurate piece of self-portraiture, full of affectations, but on that very account free from the affectation of unreality. It is more chary of portraits of contemporaries than might have been expected, but contains very detailed accounts of some of the most interesting periods of the author's life, his education at Christ's Hospital, his imprisonment, and his residence in Italy. In 1855 his narrative poems, original and translated, were collected under the title of *Stories in Verse*, with an interesting preface. He died at Putney, on August 28, 1859.

The character of Leigh Hunt is not easy to delineate, not from any difficulty of recognizing or harmonizing its leading features, but from that of depicting the less admirable traits in a manner consistent with the affection and respect to which it is entitled on the whole. His virtues were charming rather than imposing or brilliant; he had no vices, but very many foibles. His great misfortune was that these foibles were for the most part of an undignified sort, and, though it may seem a paradox, that they were so harmless, and on so miniature a scale. Leigh Hunt's affectation, for example, is not comparable to Byron's, or his egotism to Wordsworth's, and therefore its very pettiness excites a sensation of the ludicrous which the colossal self-consciousness of his contemporaries does not produce. The very sincerity of his nature is detrimental to him; the whole man seems to be revealed in everything he ever wrote, and hence the most beautiful productions of his pen appear in a manner tainted by his really very pardonable weaknesses. Some of these, such as his helplessness in money matters, and his facility in accepting the obligations which he would have delighted to confer, were unfortunately of a nature to involve him in painful and humiliating embarrassments, which seem to have been aggravated by the mismanagement of those around him. The notoriety of these things has deprived him of much of the honour due to him for his fortitude under the severest calamities, for his unremitting literary industry under the most discouraging circumstances, and for his uncompromising independence as a journalist and an author. It was his misfortune to be involved in politics, for which he had little vocation, and which embroiled him with many with whom he would otherwise have been on good terms. "Though I was a politician," he says himself, "I had scarcely a political work in my library. Spensers and Arabian Tales filled up the shelves." He was in fact as thorough a man of letters as ever existed, and most of his failings were more or less incidental to that character. But it is not every consummate man of letters of whom it can be unhesitatingly affirmed that he was brave, just, and pious.

Leigh Hunt's character as an author was the counterpart of his character as a man. In some respects his literary position is unique. Few men have effected so much by mere exquisiteness of taste in the absence of high creative power; fewer still, so richly endowed with taste, have so frequently and conspicuously betrayed the want of it. As Wordsworth could never see where simplicity of poetic diction lapsed into mere prose, so Hunt was incapable of discovering where familiarity became flippancy. While Wordsworth, however, is at worst wearisome, Hunt is sometimes positively offensive to fastidious readers. This observation principally refers to his poetry, which, in spite of such vexatious flaws, nevertheless possesses a brightness, animation, artistic symmetry, and metrical harmony, which lift the author out of the rank of minor poets, particularly when the influence of his example upon his contemporaries is taken into account. He excelled especially in narrative poetry, of which, upon a small scale, there are probably no better examples in our language than "Abou ben Adhem" and "Solomon's Ring." He possessed every qualification for a translator, and it is to be regretted that his performances in that department are not more numerous and sustained. As an appreciative critic, whether literary or dramatic, he is hardly equalled; his guidance is as safe as it is genial. The no less important vocation of a censor was uncongenial to his gentle nature, and was rarely essayed by him.

The principal authorities for Leigh Hunt's life are his *Autobiography*, published in 1850, and reprinted since his death with additions and corrections, and the two volumes of his *Correspondence*, published with a connecting thread of biography by his son in 1862. The references to him in the writings and biographies of his contemporaries are innumerable. A full bibliography of his works, with excellent remarks, has been published by Mr Alexander Ireland. (R. G.)

HUNT, William Henry (1790–1864), water-colour painter, was born near Long Acre, London, March 28, 1790. Overcoming the usual parental objections, he was apprenticed about 1805 to John Varley, the landscape-painter, with whom he remained five or six years, exhibiting three oil pictures at the Royal Academy in 1807. He was early connected with the society of painters in water-colour, of which body, then in a transition state, he was elected associate in 1824, and full member in 1827. To its exhibitions he was until the year of his death one of the most prolific contributors. Many years of Hunt's uneventful and industrious life were passed at Hastings. He died of apoplexy, February 10, 1864.

Hunt was one of the creators of the English school of water-colour painting. His subjects, especially those of his later life, are extremely simple; but, by the delicacy, humour, and fine power of their treatment, they take rank second to works of the highest art only. Considered technically, his works exhibit all the resources of the water-colour painter's craft, from the purest transparent tinting to the boldest use of body-colour, rough paper, and scraping for texture. His sense of colour is perhaps as true as that of any English artist. "He was," says Ruskin, "take him for all in all, the finest painter of still life that ever existed." Several fine and characteristic examples of Hunt's work, as the Boy and Goat, Brown Study, and Plums, Primroses, and Birds' Nests, are in the water-colour galleries at South Kensington.

HUNTER, JOHN (1728–1793),—as physiologist and surgeon combined, unrivalled in the annals of medicine,—born February 13,[1] 1728, at Long Calderwood, in the parish of East Kilbride, Lanarkshire, was the youngest of the ten children of John and Agnes Hunter. His father, who died October 30, 1741,[2] aged 78, was descended from the old Ayrshire family of Hunter of Hunterston, and his mother was the daughter of a Mr Paul, treasurer of Glasgow. Hunter is said to have made but little progress at school, being averse to its restraints and pursuits, and fond of country amusements. When seventeen years old he repaired to Glasgow, where he for a short time assisted his brother-in law, Mr Buchanan, a cabinetmaker, who had involved himself in pecuniary difficulties. Being desirous at length of some settled occupation, he obtained from his brother William permission to aid, under Mr Symonds, in making dissections in his anatomical school, then the most celebrated in London, intending, should he be unsuccessful there, to enter the army. He arrived accordingly in the metropolis in September 1748, about a fortnight before the commencement of his brother's autumnal course of lectures. After succeeding beyond expectation with the dissection of the muscles of an arm, he was entrusted with a similar part injected, and from the excellence of his second essay Dr Hunter predicted that he would become a good anatomist. Seemingly John Hunter had hitherto received no instruction in preparation for the special course of life upon which he had entered. His brother, with whom he was now intimately associated, was one of the most brilliant exponents of medical science, and enjoyed the society of the best cultured men of the age; but that it was through this circumstance that, as stated by R. A. Stafford,[3] "he was taught to think," and that his mind, as has been surmised, had previous to his coming to London been "idle, heedless, and aimless," can hardly be concluded in the face of what the future revealed of the practical and inquiring turn and the originality of his mental disposition. Rather we may assume, with B. B. Cooper,[4] that Hunter was naturally gifted with powers of mind which rendered him to some extent independent of the training required by less extraordinary intellects. Dr J. Ridge,[5] speaking of Hunter's permitted truancy from the grammar school, argues that early tuition and attainments, at least of the kind imparted, being inconsistent with a natural education of the senses, are not favourable to the production of extraordinary genius. Hunter's power of estimating what was worth doing, and what could be done, is by Dr Moxon[6] ascribed in part to his being "a man who had a free youth, not over-taught, nor over-strained;" and, if it be true that "the early part of life, the school-time, has long been spent, and is spent, in pursuits which minister but little to the culture of the mind, or to the communication and reception of knowledge useful to any class of society in proportion to the time consumed,"[7] it is possible that his dislike to scholastic exercises may have served to protect Hunter from influences opposed to that very endowment which made him preeminent as a teacher, namely, the power of perceiving the relation of numerous individual facts as illustrations of general principles.

Hard-working, and singularly patient and skilful in dissection, Hunter had by his second winter in London acquired sufficient anatomical knowledge to be entrusted with the charge of his brother's practical class, with the members of which, as also with the resurrection men, he was a universal favourite. In the summer months of 1749–50, at Chelsea Military Hospital, he attended the lectures and operations of Cheselden, on whose retirement in the following year he became a surgeon's pupil at St Bartholomew's, where Pott was one of the senior surgeons. In the summer of 1752 he visited Scotland. Home and, following him, Ottley state that Hunter began in 1754 to assist his brother as his partner in lecturing; according, however, to the *European Magazine* for 1782, the office of lecturer was offered to Hunter by his brother in 1758, but declined by him on account of the "insuperable embarrassments and objections" which he felt to speaking in public. In 1754 he became a surgeon's pupil at St George's Hospital, where he was appointed house-surgeon in 1756.[8] During the period of his connexion with Dr Hunter's school he, in addition to other labours, solved the problem of the descent of the testis in the fœtus, traced the ramifications of the nasal and olfactory nerves within the nose, experimentally tested the question whether veins could act as absorbents, studied the formation of pus, and the nature of the placental circulation, and with his brother earned the chief merit of practically proving the function and importance of the lymphatics in the animal economy. On June 5, 1755,[9] he was induced to enter as a gentleman commoner at St Mary's Hall, Oxford, but his true instincts would not permit him, to use his own expression, "to stuff Latin and Greek at the university." Some three and thirty years later he thus significantly wrote of an opponent:—"Jesse Foot accuses me of not understanding the dead languages; but I could teach him that on the dead body which he never knew in any language dead or living."[10] Doubtless, however, linguistic studies would have served to correct in him what was perhaps a natural defect—a difficulty in the presentation of abstract ideas which was not wholly attributable to the novelty of his doctrines.

An attack of inflammation of the lungs in the spring of 1759, apparently caused by overwork, having produced symptoms threatening consumption, by which the promising medical career of his brother James had been cut short, Hunter, with a view to residence abroad for a season, obtained from Mr Adair in October 1760 the appointment of staff-surgeon in Hodgson and Keppel's expedition to Belleisle. With this he sailed in 1761. In the following year he served with the English forces on the frontier of Portugal. Whilst with the army he acquired the extensive knowledge of gunshot wounds embodied in his important treatise on that subject, published in 1794, in which, amongst other matters of moment, he insists on the rejection of the indiscriminate practice of dilating with the knife followed almost universally by surgeons of his time. When not engaged in the active duties of his profession, he occupied himself with physiological and other scientific researches. Thus, in 1761, off Belleisle, the conditions of

[1] The date is thus entered in the parish register, see Adams, *Memoirs*, Appendix, p. 203. The Hunterian Oration, instituted in 1813 by Dr Baillie and Sir Everard Home, is delivered at the Royal College of Surgeons on the 14th of February, which Hunter used to give as the anniversary of his birth.

[2] Ottley's date, 1738, is inaccurate, see Simmons, *Account of . . . W. Hunter*, p. 7. Hunter's mother died Nov. 3, 1751, aged 66.

[3] *Hunt. Orat.*, 1851, p. 6.

[4] *Hunt. Orat.*, 1853, p. 7.

[5] *Observations on the Life, Disease, and Death of J. Hunter*, p. 19, 1855.

[6] See Oration before Hunterian Society, *Med. Times and Gazette*, March 1877, p. 224.

[7] R. Quain, *Hunt. Orat.*, 1869, p. 19.

[8] So in Home's *Life*, p. xvi., and Ottley's, p. 15. Hunter himself (*Treatise on the Blood*, p. 62) mentions the date 1755.

[9] Ottley incorrectly gives 1753 as the date. In the buttery book for 1755 at St Mary's Hall his admission is thus noted: "Die Junii 5to 1755 Admissus est Johannes Hunter superioris ordinis Commensalis." Hunter apparently left Oxford after less than two months' residence, as the last entry in the buttery book with charges for battels against his name is on July 25, 1755. His name was, however, retained on the books of the Hall till December 10, 1756. The writer is indebted to Dr John Griffiths, Keeper of the Archives, Oxford University, for the following record of Hunter's matriculation:—"Ter° Trin. 1755.—Junii 5to Aul. S. Mar. Johannes Hunter 24 Johannis de Kilbride in Com. Clidesdale Scotiæ Arm. fil."

[10] Ottley, *Life of J. Hunter*, p. 22.

the coagulation of the blood were among the subjects of his inquiries.[1] Later, on land, he continued the study of human anatomy, and arranged his notes and memoranda on inflammation; he also ascertained by experiment that digestion does not take place in snakes and lizards during hibernation, and observed that enforced vigorous movement at that season proves fatal to such animals, the waste so occasioned not being compensated, whence he drew the inference that, in the diminution of the power of a part attendant on mortification, resort to stimulants which increase action without giving real strength is inadvisable.[2] A MS. catalogue by Hunter, probably written soon after his return from Portugal, shows that he had already made a collection of about two hundred specimens of natural and morbid structures.

On arriving in England early in 1763, Hunter, having retired from the army on half-pay, took a house in Golden Square, and commenced the career of a London surgeon. Most of the metropolitan practice at the time was held by Pott, C. Hawkins, Sharpe, Warner, Adair, and Tomkins; and Hunter sought to eke out his at first slender income by teaching practical anatomy and operative surgery to a private class. His leisure was devoted to the study of comparative anatomy, to procure subjects for which he obtained the refusal of animals dying in the Tower menagerie and in various travelling zoological collections. In connexion with his rupture of a tendo Achillis,[3] in 1767, he performed on dogs several experiments which, with the illustrations in his museum of the reunion of such structures after division, laid the foundation of the modern practice of cutting through tendons for the relief of distorted and contracted joints. In the same year he was made a fellow of the Royal Society. His first contribution to the *Philosophical Transactions*, with the exception of a supplement to a paper by J. Ellis in the volume for 1766, was an essay on post-mortem digestion of the stomach, written at the request of Sir J. Pringle, and read June 18, 1772, in which he first correctly explained that phenomenon as a result of the action of the gastric juice.[4] Hunter, on December 9, 1768, was elected a surgeon to St George's Hospital, and, soon after, a member of the Corporation of Surgeons. He now began to take house-pupils. Among these were Edward Jenner, who came to him in 1770, and until the time of Hunter's death corresponded with him on the most intimate and affectionate terms, W. Guy, Kingston, Dr Physick of Philadelphia, and Everard Home, his brother-in-law. Mr Lynn and Sir A. Carlisle, though not inmates of his house, were frequent visitors there. His pupils at St George's included Abernethy, Cline, James Earle, and Astley Cooper. From the high reputation in their profession which these one and all attained, some estimate may be formed of the weight and value of Hunter's personal influence and teaching. In 1770 he settled in Jermyn Street, in the house which his brother William had previously occupied; and in July 1771 he married Anne, the eldest daughter of Mr Robert Home, surgeon to Burgoyne's regiment of light-horse.[5]

From 1772 till his death Hunter resided during autumn at a house built by him at Earl's Court, Brompton, where most of his biological researches were carried on. There he kept for the purpose of study and experiment the fishes, lizards, blackbirds, hedgehogs, and other animals sent him from time to time by Jenner, tame pheasants and partridges, at least one eagle, toads, silkworms, and many more creatures obtained from every quarter of the globe. Bees he had under observation in his conservatory for upwards of twenty years; hornets and wasps were also diligently studied by him. On two occasions his life was in risk from his pets—once in wrestling with a young bull, and again when he fearlessly took back to their dens two leopards which had broken loose among his dogs. Choosing intuitively the only true method of philosophical discovery, Hunter, ever cautious of confounding fact and hypothesis, besought of nature the truth through the medium of manifold experiments and observations. "He had never read Bacon," says Babington, "but his mode of studying nature was as strictly Baconian as if he had."[6] To Jenner, who had offered a conjectural explanation of a phenomenon, he writes, August 2, 1775: "I think your solution is just; but why think? why not try the experiment? Repeat all the experiments upon a hedgehog[7] as soon as you receive this, and they will give you the solution." Perhaps no man busily engaged in professional practice has ever conducted so many physiological and pathological investigations in the animal world as Hunter; and yet it was with him an axiom "that experiments should not be often repeated which tend merely to establish a principle already known and admitted, but that the next step should be the application of that principle to useful purposes" ("Anim. Œcon.," *Works*, iv. 86). During fifteen years he kept a flock of geese simply in order to acquaint himself with the development of birds in eggs, with reference to which he remarked—"It would almost appear that this mode of propagation was intended for investigation." In his toxicological and other researches, in which his experience had led him to believe that the effects of noxious drugs are nearly similar in the brute creation and in man, he had already, in 1780, as he states, "poisoned some thousands of animals."[8]

By inserting shot at definite distances in the leg-bones of young pigs, and also by feeding them with madder, by which all fresh osseous deposits are tinged,[9] Hunter obtained evidence that bones increase in size, not by the intercalation of new amongst old particles, as had been

[1] *Treatise on the Blood*, p. 21.

[2] See Adams, *Memoirs*, pp. 32, 33. *Cf.* Hunter's *Treatise on the Blood*, p. 8, and *Works*, ed. Palmer, i. 604.—On the employment of Hunter's term "increased action" with respect to inflammation, see Paget, *Lect. on Surg. Path.*, 3d ed., p. 321 *sqq.*

[3] According to Hunter, as quoted in Palmer's edition of his lectures, p. 437, the accident was "after dancing, and after a violent fit of the cramp;" Clift, however, who says he probably never danced, believed that he met with the accident "in getting up from the dissecting table after being cramped by long sitting" (see W. Lawrence, *Hunt. Orat.*, 1834, p. 64).

[4] The subjects and dates of his subsequent papers in the *Transactions*, the titles of which give little notion of the richness of their contents, are as follows:—The torpedo, 1773; air-receptacles in birds, and the Gillaroo trout, 1774; the *Gymnotus electricus*, and the production of heat by animals and vegetables (supplemented in 1777), 1775; the recovery of people apparently drowned, 1776; the free martin, 1779; the communication of smallpox to the fœtus in utero, and the occurrence of male plumage in old hen pheasants, 1780; the organ of hearing in fishes, 1782; the anatomy of a "new marine animal" described by Home, 1785; the specific identity of the wolf, jackal, and dog (supplemented in 1789), the effect on fertility of extirpation of one ovarium, and the structure and economy of whales, 1787; observations on bees, 1793; and some remarkable caves in Bayreuth and fossil bones found therein, 1794. With these may be included a paper by Home, from materials supplied by Hunter, on certain horny excrescences of the human body.

[5] Mrs Hunter died January 7, 1821, in Holles Street, Cavendish Square, London, in her seventy-ninth year. She was a handsome and accomplished woman, and well fulfilled the social duties of her position. The words for Haydn's English canzonets were supplied by her, and were mostly original poems; of these the lines beginning "My mother bids me bind my hair" are, from the beauty of the accompanying music, among the best known. (See R. Nares in *Gent. Mag.*, xci., pt. 1, p. 89, quoted in Nichols's *Lit. Anec.*, 2d ser., vii. 638.)

[6] *Hunt. Orat.*, 1842, p. 15.

[7] The condition of this animal during hibernation was a subject of special interest to Hunter, who thus introduces it, even in a letter of condolence to Jenner in 1778 on a disappointment in love:—"But let her go, never mind her. I shall employ you with hedgehogs, for I do not know how far I may trust mine."

[8] See his evidence at the trial of Captain Donellan, *Works*, i. 195.

[9] On the discovery of the dyeing of bones by madder, see Belchier, *Phil. Trans.*, vol. xxxix., 1736, pp. 287 and 299.

imagined by Duhamel, but by means of additions to their extremities and circumference, excess of calcareous tissue being removed by the absorbents. Some of his most extraordinary experiments were to illustrate the relation of strength of constitution to sex. He exchanged the spurs of a young cock and a young pullet, and found that on the former the transplanted structure grew to a fair size, on the latter but little; whereas a spur from one leg of a cock transferred to its comb, a part well supplied with blood, grew more than twice as fast as that left on the other leg. Another experiment of his, which required many trials for success, was the engrafting of a human incisor on the comb of a cock.[1] The uniting of parts of different animals when brought into contact he attributed to the production of adhesive instead of suppurative inflammation, owing to their possession of "the simple living principle."[2] The effects of habit upon structure were illustrated by Hunter's observation that in a sea-gull which he had brought to feed on barley the muscular parietes of the gizzard became greatly thickened. A similar phenomenon was noticed by him in the case of other carnivorous birds fed on a vegetable diet.

It was in 1772 that Hunter, in order effectually to gauge the extent of his own knowledge, and also to correctly express his views, which had been repeatedly misstated or ascribed to others, commenced his lectures on the theory and practice of surgery, at first delivered free to his pupils and a few friends, but subsequent to 1774 on the usual terms, four guineas. Though Pott, indeed, had perceived that the only true system of surgery is that which most closely accords with the curative efforts of nature, a rational pathology can hardly be said to have had at this time any existence; and it was generally assumed that a knowledge of anatomy alone was a sufficient foundation for the study of surgery. Hunter, unlike his contemporaries, to most of whom his philosophic habit of thought was a mystery, and whose books contained little else than relations of cases, and modes of treatment, sought the reason for each phenomenon that came under his notice. The principles of surgery, he maintained, are not less necessary to be understood than the principles of other sciences; unless, indeed, the surgeon should wish to resemble "the Chinese philosopher whose knowledge consisted only in facts." In that case the science must remain unimproved until fresh facts arise. Too much attention, he remarked, cannot be paid to facts; yet a multitude of facts overcrowd the memory without advantage if they do not lead us to establish principles, by an acquaintance with which we learn the causes of diseases. Hunter's course, which latterly comprised eighty-six lectures, delivered on alternate evenings between the hours of seven and eight, lasted from October to April. Some teachers of his time were content to dismiss the subjects of anatomy and surgery in a course of only six weeks' duration. The task of lecturing is said to have been to Hunter so formidable that at the commencement of each course he was obliged to take half a drachm of laudanum. His class was usually small, and never exceeded thirty. Among its members at various times were Abernethy, Carlisle, Chevalier, Cline, Coleman, Astley Cooper, Home, Lynn, and Macartney. Hunter was deficient in the gifts of a good extempore speaker, being in this respect a remarkable contrast to his brother William; and he read his lectures, seldom raising his eyes from the manuscript. His manner with his auditory is stated to have been embarrassed and awkward, or, as Adams puts it (*Obs. on Morbid Pois.*, p. 272), "frequently ungraceful," and his language always unadorned; but that his "expressions for the explaining of his new theories rendered his lectures often unintelligible" is scarcely evident in his pupils' notes still extant. His own and others' errors and fallacies were exposed with equal freedom in his teaching. Occasionally he would tell his pupils, "You had better not write down that observation, for very likely I shall think differently next year;" and once to a question of Coleman's he replied, "Never ask me what I have said or what I have written; but, if you will ask me what my present opinions are, I will tell you." He was always much gratified when, in the conversations that he encouraged his hearers to hold with him at the end of his lectures, he found that what he said was understood and appreciated.

In January 1776 Hunter was appointed surgeon-extraordinary to the king. He commenced in the same year his Croonian lectures on muscular motion, continued annually, except in 1777, till 1782: they were never published by him, being in his opinion too incomplete. In 1778 appeared the second part of his *Treatise on the Natural History of the Human Teeth*, the first part of which was published in 1771. It was in the waste of the dental alveoli and of the fangs of shedding teeth that in 1754–55, as he tells us, he received his first hint of the use of the absorbents. Abernethy (*Phys. Lect.*, p. 196) relates that Hunter, being once asked how he could suppose it possible for absorbents to do such things as he attributed to them, replied, "Nay, I know not, unless they possess powers similar to those which a caterpillar exerts when feeding on a leaf." Hunter in 1780 read before the Royal Society a paper in which he laid claim to have been the first to make out the nature of the utero-placental circulation. His brother William, who had five years previously described the same in his *Anatomy of the Gravid Uterus*, thereupon wrote to the Society attributing to himself this honour. John Hunter in a rejoinder to his brother's letter, dated February 17, 1780, reiterated his former statement, viz., that his discovery, on the evening of the day in 1754 that he had made it in a specimen injected by a Dr Mackenzie, had been communicated by him to Dr Hunter. Thus arose an estrangement between the two Hunters, which continued until the time of William's last illness, when his brother obtained permission to visit him.

In 1783 Hunter was elected a member of the Royal Society of Medicine and of the Royal Academy of Surgery at Paris, and took part in the formation of "A Society for the Improvement of Medical and Chirurgical Knowledge."[3] It appears from a letter by Hunter that in the latter part of 1783 he, with Jenner, had the subject of colour-blindness under consideration. As in that year the lease of his premises in Jermyn Street was to expire, he purchased the twenty-four years' leasehold of two houses, the one on the east side of Leicester Square, the other in Castle Street, with intervening ground. Between the houses he built in 1783–85, at an expense of above £3000, a museum for his anatomical and other collections. These by 1782 had cost him £10,000, and contained preparations of numerous specimens presented by Sir Joseph Banks, the Honourable C. Greville, and Mr Walsh. The new edifice consisted of a hall 52 feet long by 28 feet wide, and lighted from the top, with a gallery all round, and having beneath it a lecture

[1] *Essays and Observations*, i. 55, 56. "May we not claim for him," says Sir Wm. Fergusson with reference to these experiments, "that he anticipated by a hundred years the scientific data on which the present system of human grafting is conducted?" (*Hunt. Orat.*, 1871, p. 17).

[2] *Essays and Observations*, i. 115; *cf. Works*, i. 391.

[3] The *Transactions* of the Society contain papers by Hunter on inflammation of veins (1784), intussusception (1789), a case of paralysis of the muscles of deglutition (1790), and a case of poisoning during pregnancy (1794), with others written by Home, from materials supplied by him, on Hunter's operation for the cure of popliteal aneurism, on loose cartilages in joints, on certain horny excrescences of the human body, and on the growth of bones.

theatre, and a room used subsequently for the meetings of the Lycæum Medicum, a society instituted by Hunter and Fordyce. In April 1785 Hunter's collections were removed into it under the superintendence of Home and Bell,[1] and another assistant, André. Among the foreigners of distinction that inspected the museum, which was now shown by Hunter twice a year,—in October to medical men, and in May to other visitors,—were Blumenbach, Camper, Poli, and Scarpa. In the acquisition of subjects for his varied biological investigations and of specimens for his museum, expense was a matter of small moment with Hunter. Thus at one time he endeavoured, at his own cost, to obtain information respecting the Cetacea by sending out a surgeon to the North in a Greenland whaler. He is said, moreover, to have given, in June 1783, no less than £500 for the body of O'Brien, or Byrne, the Irish giant, whose skeleton, 7 feet 7 inches high, is so conspicuous an object in the museum of the College of Surgeons of London.[2]

Hunter, who in the spring of 1769–72 had suffered from gout, in spring 1773 from spasm apparently in the pyloric region, accompanied by failure of the heart's action (Ottley, *Life*, p. 44), and in 1777 from vertigo with symptoms of angina pectoris, had in 1783 another attack of the last mentioned complaint, to which he was henceforward subject when under anxiety or excitement of mind.

In May 1785,[3] chiefly to oblige Sharp the engraver, Hunter consented to have his portrait taken by Sir Joshua Reynolds. He proved a bad sitter, and Reynolds made but little satisfactory progress, till one day Hunter, while resting his somewhat upraised head on his left hand, fell into a profound reverie—one of those waking dreams, seemingly, which in his lectures he has so well described, when "the body loses the consciousness of its own existence."[4] The painter had now before him the man he would fain depict, and, turning his canvas upside down, he sketched out the admirable portrait which, since most skilfully restored by Mr H. Farrar, is in the possession of the Royal College of Surgeons. A copy of the same, by Jackson, acquired from Lady Bell, is to be seen at the National Portrait Gallery in South Kensington. St Mary's Hall, Oxford, also possesses a copy. Sharp's engraving of the original, published in 1788, is one of the finest of his productions. The volumes seen in Reynolds's picture are a portion of the unpublished records of anatomical researches left by Hunter at his death, which, with other manuscripts, Sir Everard Home in 1812 removed from his museum, and eventually, in order, it has been supposed, to keep secret the source of many of his papers in the *Philosophical Transactions*, and of facts mentioned in his lectures, committed to the flames.[5]

[1] Bell lived with Hunter fourteen years, *i.e.*, from 1775 to 1789, and was employed by him chiefly in making and drawing anatomical preparations for the museum. He died in 1792 at Sumatra, where he was assistant-surgeon to the East India Company.

[2] O'Brien, dreading dissection by Hunter, had shortly before his death arranged with several of his countrymen that his corpse should be conveyed by them to the sea, and sunk in deep water; but his undertaker, who had entered into a pecuniary compact with the great anatomist, managed that while the escort was drinking at a certain stage on the march seawards, the coffin should be locked up in a barn. There some men he had concealed speedily substituted an equivalent weight of paving-stones for the body, which was at night forwarded to Hunter, and by him taken in his carriage to Earl's Court, and, to avoid risk of a discovery, immediately after suitable division boiled to obtain the bones. See Tom Taylor, *Leicester Square*, chap. xiv., 1874; *cf. Annual Register*, xxvi. 209, 1783.

[3] See C. R. Leslie and Tom Taylor, *Life and Times of Sir J. Reynolds*, ii. 474, 1865.

[4] *Works*, i. 265–266.

[5] A transcript of a portion of Hunter's MSS., made by Clift in 1793 and 1800, was edited by Professor Owen, in two volumes with notes, in 1861, under the title of *Essays and Observations in Natural History, Anatomy, Physiology, Psychology, and Geology*. On the destruction of Hunter's papers see Clift's "Appendix" in vol. ii. p. 497, also Prof. Flower, *Introd. Lect.*, 7–9, 1870.

Among the subjects of Hunter's physiological investigations in 1785 was the mode of growth of deer's antlers. As he possessed the privilege of making experiments on the deer in Richmond Park, he in July of that year had a buck there caught and thrown, and tied one of its external carotid arteries. He observed that the antler which obtained its blood supply therefrom, then half-grown, became in consequence cold to the touch. Hunter debated with himself whether it would be shed in due time, or be longer retained than ordinarily. To his surprise he found, on re-examining the antler a week or two later, when the wound around the ligatured artery was healed, that it had regained its warmth, and was still increasing in size. Had, then, his operation been in some way defective? To determine this question, the buck was killed and sent to Leicester Fields. On examination Hunter ascertained that the external carotid had been duly tied, but that certain small branches of the artery above and below the ligature had enlarged, and by their anastomoses had restored the blood supply of the growing part. Thus it was evident that under "the stimulus of necessity," to use a phrase of the experimenter, the smaller arterial channels are capable of rapid increase in dimensions to perform the offices of the larger.[6] It happened that, in the ensuing December, there lay in one of the wards of St George's Hospital a patient of Hunter's, admitted for popliteal aneurism. The disease must soon prove fatal unless by some means arrested. Should the surgeon, following the usual and commonly fatal method of treatment, cut down upon the tumour, and, after tying the artery above and below it, evacuate its contents? Or should he adopt the procedure, deemed by Pott generally advisable, of amputating the limb above it? It was Hunter's aim in his practice, even if he could not dispense with the necessity, at least to diminish the severity of operations, which he considered were an acknowledgment of the imperfection of the art of healing, and compared to "the acts of the armed savage, who attempts to get that by force which a civilized man would get by stratagem." Since, he argued, the experiment with the buck had shown that collateral vessels are capable of continuing the circulation when passage through a main trunk is arrested, why should he not, in his aneurism case, leaving the absorbents to deal with the contents of the tumour, tie the artery in the sound parts, where it is tied in amputation, and preserve the limb? Acting upon this idea, he ligatured his patient's femoral artery in the lower part of its course in the thigh, in the fibrous sheath enclosing the space since known as "Hunter's canal."[7] The leg was found, some hours after the operation, to have acquired a temperature even above the normal.[8] At the end of January 1786, that is, in six weeks' time, the patient was well enough to be able to leave the hospital. Thus it was that Hunter inaugurated an operation which has been the means of preserving to hundreds life with integrity of limb — an operation which, as the Italian Assalini, who saw it first performed, testifies, "excited the greatest wonder,

[6] In his *Treatise on the Blood*, p. 288, Hunter observes :—"We find it a common principle in the animal machine, that every part increases in some degree according to the action required. Thus we find . . . . vessels become larger in proportion to the necessity of supply, as for instance, in the gravid uterus; the external carotids in the stag, also, when his horns are growing, are much larger than at any other time."

[7] See Professor Owen, "John Hunter and Vivisection," *Brit. Med. Journ.*, February 22, 1879, p. 284. In the fourth of his operations for popliteal aneurism, Hunter for the first time did not include the vein in the ligature. His patient lived for fifty years afterwards. The results on the artery of this operation are to be seen in specimen 3472A (Path. Ser.) in the Hunterian Museum.

[8] Home, *Trans. of Soc. for Impr. of Med. and Chirurg. Knowl.*, i. 147, 1793. Excess of heat in the injured limb was noticed also in Hunter's second case on the day after the operation; and in his fourth case it reached 4°–5° on the first day, and continued during a fortnight.

and awakened the attention of all the surgeons in Europe."

Early in 1786 Hunter published his *Treatise on the Venereal Disease*, which, like some of his previous writings, was printed in his own house. Without the aid of the booksellers, 1000 copies of it were sold within a twelvemonth. Although certain views therein expressed with regard to the relationship of syphilis have been proved erroneous, the work is a valuable compendium of observations of cases and modes of treatment (*cf.* Hilton, *Hunt. Orat.*, p. 40). Towards the end of the year appeared his *Observations on certain parts of the Animal Œconomy*, which, besides the more important of his contributions to the *Philosophical Transactions*, contains nine papers on various subjects. By the death of Mr Middleton in 1786, Hunter became deputy surgeon-general to the army; his appointment as surgeon-general and as inspector-general of hospitals followed in 1790, on the death of Mr Adair. In 1787 he received the Royal Society's Copley medal as a testimony to the importance of his discoveries in natural history, and was also elected a member of the American Philosophical Society. On account of the increase in his practice and his impaired health, he now obtained the services of Home as his assistant at St George's Hospital. The death of Pott in December 1788 secured to Hunter the undisputed title of the first surgeon in England. He resigned to Home, in 1792, the delivery of his surgical lectures, in order to devote himself more fully to the completion of his *Treatise on the Blood, Inflammation, and Gunshot Wounds*, which was published by his executors in 1794. In this, his masterpiece, the application of physiology to practice is especially noticeable. Certain experiments described in the first part, pp. 62-64, which demonstrate that arterialization of the blood in respiration takes place by a process of diffusion of "pure air" or "vital air" (*i.e.*, oxygen) through membrane, were made so early as the summer of 1755.

Hunter in 1792 announced to his colleagues at St George's, who, he considered, neglected the proper instruction of the students under their charge, his intention no longer to divide with them the fees which he received for his hospital pupils. Against this innovation, however, the governors of the hospital decided in March 1793. Subsequently, by a committee of their appointing, a code of rules respecting pupils was promulgated, one clause of which, probably directed against an occasional practice of Hunter's, stipulated that no person should be admitted as a student of the hospital without certificates that he had been educated for the medical profession. In the autumn two young Scotchmen, ignorant of the new rule, came up to town and applied to Hunter for admission as his pupils at St George's. Hunter explained to them how he was situated, but promised to advance their request at the next board meeting at the hospital on the 16th October. On that day, having finished a difficult piece of dissection, he went down to breakfast in excellent spirits and in his usual health. After making a professional call, he attended the board meeting. There the interruption of his remarks in behalf of his applicants by a flat contradiction from a colleague brought on one of the old spasmodic heart attacks; he ceased speaking, and retired into an adjoining room only in time to fall lifeless into the arms of Dr Robertson, one of the hospital physicians. After an hour had been spent in vain attempts to restore animation, his body was conveyed to his house in a sedan chair.[1] Thus, in his sixty-fifth year, and in the height of his mental activity, died John Hunter, "whose range of thought nature alone could fill," and to whom, as to but few among all mankind, had been given wisdom to interpret the dark sayings of nature. His remains were interred privately on October 22, 1793, in the vaults of St Martin's in the Fields. Thence, on March 28, 1859, through the instrumentality of Mr Frank Buckland, they were removed to Abbot Islip's chapel in Westminster Abbey, to be finally deposited in the grave in the north aisle of the nave, close to the resting-place of Ben Jonson.

Hunter was of about medium height, strongly built, and high-shouldered and short-necked. He had an open countenance, and large features, eyes light-blue or grey, eyebrows prominent, and hair reddish-yellow in youth, later white, and worn curled behind; and he dressed plainly and neatly. He rose at or before six, dissected till nine (his breakfast hour), received patients from half-past nine till twelve, at least during the latter part of his life, and saw his outdoor and hospital patients till about four, when he dined, taking, according to Home, as at other meals in the twenty years preceding his death, no wine. After dinner he slept an hour; he then superintended experiments, read or prepared his lectures, and made, usually by means of an amanuensis, records of the day's dissections. "I never could understand," says Clift, "how Mr Hunter obtained rest: when I left him at midnight, it was with a lamp fresh trimmed for further study, and with the usual appointment to meet him again at six in the morning." Mr H. Leigh Thomas records[2] that, on his first arrival in London, having by desire called on Hunter at five o'clock in the morning, he found him already busily engaged in the dissection of insects. Rigidly economical of time, Hunter was always at work, and always he had in view some fresh enterprise. He was once heard by Adams to express regret that men must die at all. To his museum he gave a very large share of his attention, being fearful lest the ordering of it should be incomplete at his death, and knowing of none who could continue his work for him. "When I am dead," said he one day to Dr Garthshore, "you will not soon meet with another John Hunter." At the time of his death he had anatomized certainly over 500 different species of animals, some of them repeatedly, and had made numerous dissections of plants. The manuscript works by him appropriated and destroyed by Home, among which were his eighty-six surgical lectures, all in full, are stated to have been "literally a cartload"; and many pages of his records were written by Clift under his directions "at least half a dozen times over, with corrections and transpositions almost without end."

To Hunter, as he himself observed, to think was a delight. His mind was framed for systematic investigation, and hence, perhaps, arose the fatigue which, more particularly during the last ten years of his life, the desultory conversation of a mixed company would occasion him.[3] "My mind is like a bee-hive," was a remark of his to Abernethy, "a simile which struck me," says that writer, "on account of its correctness; for, in the midst of buzz and apparent confusion, there was great order, regularity of structure, and abundant food, collected with incessant industry from the choicest stores of nature."[4] Hunter was generally, though cheerfully, taciturn, and many a morning's labour with Clift was passed with scarcely a word of discourse. When, however, he spoke—as while resting himself, and standing upright from his dissection after stooping for hours as if nailed to the object under investigation—he evinced both shrewdness and wit. In conversation his words were well chosen, and his remarks often wonderfully forcible and pointed; and, when so disposed, he could put things in a very ludicrous point of view. He articulated slowly, and in consultation gave his opinion much as if lecturing, the enunciation of his not seldom novel doctrines being prefaced by some introductory illustration or history. A stranger to artifice and flattery, and open and unceremonious or even blunt in speech, he readily communicated what he knew and thought, and thus did not always inspire others with a higher opinion of their personal consequence. "We are but beginning to learn our profession," he would tell his friends; and he was wont to say that he was conscious of no peculiar talent, but that, if he had promoted professional knowledge, it seemed to him to have arisen chiefly from his disposition to distrust opinions, and to examine every subject for himself. What views of his he confidently offered for acceptance were such as he believed to have a solid foundation in facts; and the blind enunciation by his fellow-practitioners of time-honoured errors vexed

[1] The record of Hunter's death in the *St James Chronicle* for October 15-17, 1793, p. 4, col. 4, makes no allusion to the immediate cause of Hunter's death, but gives the following statement:—"JOHN HUNTER.—This eminent Surgeon and valuable man was suddenly taken ill, yesterday, in the Council-room of St George's Hospital. After receiving the assistance which could be afforded by two Physicians and a Surgeon, he was removed in a close chair to his house, in Leicester Fields, where he expired about two o'clock." Examination of the heart revealed disease involving the pericardium, endocardium, and arteries, the coronary arteries in particular showing ossific change.

[2] *Hunt. Orat.*, 1827, p. 5.

[3] Home, *Life*, p. lxv.

[4] *Hunt. Orat.*, 1819, p. 48.

his mind, which was naturally susceptible, and was rendered the more so by excess of exertion, with repeatedly the additional strain of bodily disease. "I know, I know," said he to Abernethy, "I am but a pigmy in knowledge, yet I feel as a giant when compared with these men." The charges that his language was frequently coarse, and that swearing was with him a habit, as with many of his contemporaries and successors, have been indignantly rebutted by Clift.[1] Leigh Thomas describes the impression left by his first early morning interview with Hunter as "a mingled feeling of profound respect, surprise, and admiration;" and by his assistants, pupils, and all with whom he had lived on intimate terms, he was both loved and venerated. His temper, Home states, was very warm and impatient, and when irritated not easily soothed. The hasty but not altogether illogical outburst of his anger when refused the post-mortem examination of a child, the victim of some obscure malady, in the words, "Then, sir, I heartily hope that yourself and all your family, nay all your friends, may die of the same disease, and that no one may be able to afford any assistance," is in amusing contrast with the acknowledged benevolence of his character. To the kindness of his disposition, his fondness for animals, his aversion to operations, his thoughtful and self-sacrificing attention to his patients, and especially his zeal to help forward struggling practitioners and others in any want abundantly testify. "Every man," said he, "should be an economist, for if he has ever more money than his wants require he can assist the poor." In a letter of his, introducing a patient to his brother William, we read: "He has no money, and you have plenty, so that you are well met." Pecuniary means he valued no further than they enabled him to promote his researches; and to the poor, to non-beneficed clergymen, professional authors, and artists his services were rendered without remuneration. His yearly income in 1763–74 was never £1000; it exceeded that sum in 1778, for several years before his death was £5000, and at the time of that event had reached above £6000. All his earnings not required for domestic expenses were, during the last ten years of his life, devoted to the improvement of his museum; and his property, this excepted, was found on his decease to be barely sufficient to pay his debts. By his contemporaries generally Hunter was respected as a master of the art and science of anatomy, and as a cautious and trustworthy if not an elegant or very dexterous operator. Few, however, perceived the drift of his biological researches. Although it was admitted, even by Foot,[2] that the idea after which his unique museum had been formed—namely, that of morphology as the only true basis of a systematic zoological classification—was entirely his own, yet his investigations into the structure of the lower orders of animals were regarded as, after all, works of unprofitable curiosity. One surgeon, of no inconsiderable repute, is said to have ventured the remark that Mr Hunter's preparations were "just as valuable as so many pig's pettitoes;"[3] and the president of the Royal Society, Sir Joseph Banks, writing in 1796, plainly expressed his disbelief as to the collection being "an object of importance to the general study of natural history, or indeed to any branch of science except to that of medicine." It was "without the solace of sympathy or encouragement of approbation, without collateral assistance,"[4] and careless of achieving fame—for he held that "no man ever was a great man who wanted to be one"—that Hunter laboured to perfect his designs, and established the science of comparative anatomy, and principles which, however neglected in his life-time, became the ground-work of all medical study and teaching.

In accordance with the directions given by Hunter in his will, his collection was offered for purchase to the British Government. But the prime minister, Mr Pitt, on being asked to consider the matter, exclaimed: "What! buy preparations! Why, I have not money enough to purchase gunpowder." He, however, consented to the bestowal of a portion of the king's bounty for a couple of years on Mrs Hunter and her two surviving children. In 1796 Lord Auckland undertook to urge upon the Government the advisability of acquiring the collection, and on June 13, 1799, parliament voted £15,000 for this purpose. Its custodianship, after refusal by the College of Physicians, was unanimously accepted by the Corporation of Surgeons on the terms proposed. These were in brief—that the collection be open four hours in the forenoon, two days every week, for the inspection and consultation of the fellows of the College of Physicians, the members of the Company of Surgeons, and persons properly introduced by them, a catalogue of the preparations and an official to explain it being at those times always at hand; that a course of not less than twenty-four lectures[5] on comparative anatomy and other subjects illustrated by the collection be given every year by some member of the Company; and that the preparations be kept in good preservation at the expense of the Corporation, and be subject to the superintendence of a board of sixteen trustees.[6] The fulfilment of these conditions was rendered possible by the receipt of fees for examinations and diplomas, under the charter by which, in 1800, the Corporation was constituted the Royal College of Surgeons. A board of curators was in that year appointed by the council of the college to provide for the management of the museum and the preparation of catalogues. In 1806 the collection was placed in temporary quarters in Lincoln's Inn Fields, and the sum of £15,000 was voted by parliament for the erection of a proper and commodious building for its preservation and extension. This was followed by a grant of £12,500 in 1807. The collection was removed in 1812 to the new museum, and opened to visitors in 1813. The greater part of the present edifice was built in 1835, at an expense to the college of about £40,000; and the combined Hunterian and collegiate collections, having been rearranged in what are now termed the western and middle museums, were in 1836 made accessible to the public. The erection of the eastern museum in 1852, on premises in Portugal Street bought in 1847 for £16,000, cost £25,000, of which parliament granted £15,000; it was opened in 1855.

Hunter's collection was estimated to contain 13,682 specimens, viz., in the physiological department, 3745 in spirit, 965 osteological, 617 dry, 1968 zoological—total 7295; and in the pathological, 1084 in spirit, 625 dry (including bones), 536 calculi and concretions, 218 monsters and malformations, and 215 microscopic—total 2678; and 3709 fossils. Since its acquisition by the college, it has been greatly increased, notably by presentations from Sir William Blizard (1811) and Sir S. L. Hammick (1851), and by purchase of specimens in the possession of Sir A. Lever (1806), Messrs Joshua Brookes (1828), Heaviside (1829), Langstaff, South (1835), Howship, Taunton (1841), Liston (1842), and Walker (1843), Sir Astley Cooper (1843), and Dr Barnard Davis (Jan. 1880). The histological collection, of which the 215 Hunterian specimens are the nucleus, is the result chiefly of the labours of Professor Quekett, and purchases from Dr Tweedy Todd, Mr Nasmyth, and Professor Lenhossek, and contained in July 1880 upwards of 12,000 specimens. The library, the formation of which commenced in 1801, consisted in July 1880 of 37,668 vols., comprising 14,882 separate works, and 39,021 tracts, pamphlets, essays, theses, and reports.[7] Mr William Clift, whom, on February 14, 1792, Hunter received into his house to train as an assistant in his museum,[8] had the exclusive charge of the collection from the date of its owner's death to that of its purchase by the state. During this period, with two gallons of spirit meted out occasionally, and the pittance of 7s. a week for his own support out of the limited funds at the disposal of Hunter's executors, he contrived to maintain the whole in good condition. He was conservator of the museum, as stated on the pedestal of his bust there, from 1800 to 1849. From 1825 to 1832 he was assisted by his son, William Home Clift. Professor Richard Owen held the office of assistant-conservator in 1832–35, and of conservator in 1836–55, and Professor J. T. Quekett that of assistant-conservator in 1843–51, and of conservator from 1852 till his death in 1861, when he was succeeded by Professor William Henry Flower.

The scope of Hunter's labours may be defined as the explication of the various phases of life exhibited in organized structures, both animal and vegetable, from the simplest to the most highly differentiated. By him, therefore, comparative anatomy was employed, not in subservience to the classification of living forms, as by Cuvier, but as a means of gaining insight into the principle animating and producing these forms, by virtue of which he perceived that, however different in form and faculty, they were all allied to himself. In what does life consist? is a question which in his writings he frequently considers, and which seems to have been ever present in his mind. Life, he taught, was a principle independent of structure,[9] most tenaciously held by the least highly organized beings, but capable of readier destruction as a whole, as, *e.g.*, by deprivation of heat or by pain, in young than in old animals. In life he beheld an agency working under the control of law, and exercising its functions in various modes and degrees. He perceived it, as Abernethy observes, to be "a great chemist," a power capable of manufacturing a variety of substances into one kind of generally distributed nutriment, and of furnishing from this a still greater variety of dissimilar substances. Like Harvey, who terms it the *anima vegetiva*, he regarded it as a principle of self-preservation, which keeps the body from dissolution. Life is shown, said he, in renovation and action; but, although facilitated in its working by mechanical causes, it can exist without action, as in an egg new-laid or undergoing incubation. It is not simply a regulator of temperature; it is a principle which resists cold, conferring on the structures which it endows the capacity of passing some degrees below the freezing-point of ordinary inanimate matter without suffering congelation. Hunter found, in short, that there exists in animals a latent heat of life, set free in the process of death (see *Treatise on*

[1] See Lawrence, *Hunt. Orat.*, p. 60.
[2] See p. 266 of his malicious so-called *Life of John Hunter*, 1794.
[3] *Cf.* J. H. Green, *Hunt. Orat.*, 1840, p. 27.
[4] Abernethy, *Physiological Lectures*, p. 11, 1817.
[5] Instituted in 1806.
[6] Increased to seventeen in 1856
[7] *Calendar of the Royal College of Surgeons*, July 8, 1880.
[8] See Sir Benj. C. Brodie, "Autobiography," *Works*, ed. C. Hawkins, i. 41, 1865.
[9] How clearly he held this view is seen in his remark (*Treatise on the Blood*, p. 28, *cf.* p. 46) that, as the coagulating lymph of the blood is probably common to all animals, whereas the red corpuscles are not, we must suppose the lymph to be the essential part of that fluid. Hunter was the first to discover that the blood of the embryos of red-blooded animals is at first colourless, resembling that of invertebrates. (See Owen, Preface to vol. iv. of *Works*, p. xiii.)

the Blood, p. 80). Thus he observed that sap if removed from trees froze at 32° Fahr., but within them might be fluid even at 15°; that a living snail placed in a freezing mixture acquired first a temperature of 28°, and afterwards of 32° ere it froze; and that, whereas a dead egg congealed immediately at 32°, a living egg did so only when its temperature had risen to that point after a previous fall to 29½°. The idea that the fluid and semifluid as well as the solid constituents of the body contain the vital principle diffused through them he formed in 1755–6, when, in making drawings illustrative of the changes that take place in the incubated egg, he noted specially that neither the white nor the yolk undergoes putrefaction. The blood he, with Harvey, considered to possess a vitality of its own, more or less independent of that of the animal in which it circulates. Life, he held, is preserved by the compound of the living body and the source of its solid constituents, the living blood. It is to the susceptibility of the latter to be converted into living organized tissue that the union of severed structures by the first intention is due. He even inclined to the belief that the chyle has life, and he considered that food becomes "animalized" in digestion. Coagulation of the blood he compared to the contraction of muscles, and believed to be an operation of life distinct from chemical coagulation, adducing in support of his opinion the fact that, in animals killed by lightning, by violent blows on the stomach, or by the exhaustion of hunting, it does not take place. "Breathing," said Hunter, "seems to render life to the blood, and the blood continues it in every part of the body."[1] Life, he held, could be regarded as a fire, or something similar, and might for distinction's sake be called "animal fire." Of this the process of respiration might afford a constant supply, the fixed life supplied to the body in the food being set free and rendered active in the lungs, whilst the air carried off that principle which encloses and retains the animal fire.[2] The living principle, said Hunter, is coeval with the existence of animal or vegetable matter itself, and may long exist without sensation. The principle upon which depends the power of sensation regulates all our external actions, as the principle of life does our internal, and the two act mutually on each other in consequence of changes produced in the brain. Something (the "materia vitæ diffusa") similar to the components of the brain (the "materia vitæ coacervata") may be supposed to be diffused through the body and even contained in the blood; between these a communication is kept up by the nerves (the "chordæ internunciæ").[3] Neither a material nor a chemical theory of life, however, formed a part of Hunter's creed. "Mere composition of matter," he remarked, "does not give life; for the dead body has all the composition it ever had; life is a property we do not understand; we can only see the necessary leading steps towards it."[4] As from life only, said he in one of his lectures, we can gain an idea of death, so from death only we gain an idea of life. Life, being an agency leading to, but not consisting of, any modification of matter, "either is something superadded to matter, or else consists in a peculiar arrangement of certain fine particles of matter, which being thus disposed acquire the properties of life." As a bar of iron may gain magnetic virtue by being placed for a time in a special position, so perhaps the particles of matter arranged and long continued in a certain posture eventually gain the power of life. "I enquired of Mr Hunter," writes one of his pupils,[5] "if this did not make for the Exploded Doctrine of Equivocal Generation; he told me perhaps it did, and that as to Equivocal Generation all we c^d have was negative Proofs of its not taking Place. He did not deny that Equivocal Generation happened; there were neither positive proofs for nor against its taking place."

To exemplify the differences between organic and inorganic growth, Hunter made and employed in his lectures a collection of crystallized specimens of minerals, or, as he termed them, "natural or native fossils." Of fossils, designated by him "extraneous fossils," because extraneous respecting the rocks in which they occur, he recognized the true nature, and he arranged them according to a system agreeing with that adopted for recent organisms. The study of fossils enabled him to apply his knowledge of the relations of the phenomena of life to conditions, as exhibited in times present, to the elucidation of the history of the earth in geological epochs. He observed the non-occurrence of fossils in granite, but with his customary scientific caution and insight could perceive no reason for supposing it to be the original matter of the globe, prior to vegetable or animal, or that its formation was different from that of other rocks. In water he recognized the chief agent in producing terrestrial changes (*cf. Treatise on the Blood*, p. 15, note); but the popular notion that the Noachian deluge might account for the marine organisms discovered on land he pointed out was untenable. From the diversity of the situations in which many fossils and allied living structures are found, he was led to infer that at various periods not only repeated oscillations of the level of the land, lasting thousands of centuries, but also great climatic variations, perhaps due to a change in the ecliptic, had taken place in geological times. Hunter considered that very few fossils of those that resemble recent forms are identical with them. He conceived that the latter might be varieties, but that if they are really different species, then "we must suppose that a new creation must have taken place." It would appear, therefore, that the origin of species in variation had not struck him as possible. That he believed varieties to have resulted from the influence of changes in the conditions of life in times past is shown by a somewhat obscure passage in his "Introduction to Natural History" (*Essays and Observations*, i. 4), in which he remarks, "But, I think, we have reason to suppose that there was a period of time in which every species of natural production was the same, there being then no variety in any species," and adds that "civilization has made varieties in many species, which are the domesticated." Modern discoveries and doctrines as to the succession of life in time are again foreshadowed by him in the observation in his introduction to the description of drawings relative to incubation (quoted in Pref. to *Cat. of Phys. Ser.*, i. p. iv., 1833) that:—

> "If we were capable of following the progress of increase of the number of the parts of the most perfect animal, as they first formed in succession, from the very first, to its state of full perfection, we should probably be able to compare it with some one of the incomplete animals themselves, of every order of animals in the creation, being at no stage different from some of those inferior orders; or, in other words, if we were to take a series of animals from the more imperfect to the perfect, we should probably find an imperfect animal corresponding with some stage of the most perfect."

In pathological phenomena Hunter discerned the results of the perturbation of those laws of life by which the healthy organism subsists. With him pathology was a science of vital dynamics. He afforded principles bearing not on single complaints only, but on the effects of injury and disease in general. To attempt to set forth what in Hunter's teaching was new to pathology and systematic surgery, or was rendered so by his mode of treatment, would be well-nigh to present an epitome of all that he wrote on those subjects. "When we make a discovery in pathology," says Adams, writing in 1818, "we only learn what we have overlooked in his writings or forgotten in his lectures." Surgery, which only in 1745 had formally ceased to be associated with "the art and mystery of barbers," he raised to the rank of a scientific profession. His doctrines were, necessarily, not those of his age: while lesser minds around him were still dim with the mists of the ignorance and dogmatism of times past, his lofty intellect was illumined by the dawn of a distant day.

See, besides the above quoted publications, *An Appeal to the present Parliament . . . . on the subject of the late J. Hunter's Museum*, 1795; Sir C. Bell, *A Lecture . . . . being a Commentary on Mr J. Hunter's preparations of the Diseases of the Urethra*, 1830; The President of the Royal College of Surgeons of England, *Address to the Committee for the Erection of a Statue of Hunter*, Lond., March 29, 1859; Professor Owen, "Sketch of Hunter's Scientific Character and Works," in Tom Taylor's *Leicester Square*, 1874, also in Hunter's *Works*, ed. by Palmer, vol. iv., 1837, and in *Essays and Observations*; the invaluable catalogues of the Hunterian Collection issued by the Royal College of Surgeons; and numerous Hunterian Orations. In the *Journal of a Voyage to New South Wales*, by John White, is a paper containing directions for preserving animals, printed separately in 1809, besides six zoological descriptions by Hunter; and in the *Natural History of Aleppo*, by A. Russell, are remarks of Hunter's on the anatomy of the jerboa and the camel's stomach. Notes of his lectures on surgery, edited by J. W. K. Parkinson, appeared in 1833 under the title of *Hunterian Reminiscences*. Hunter's *Observations and Reflections on Geology*, intended to serve as an introduction to the catalogue of his collection of extraneous fossils, was published in 1859, and his *Memoranda on Vegetation* in 1860. (F. H. B.)

HUNTER, WILLIAM (1718–1783), a celebrated physiologist and physician, and the first great teacher of anatomy in England, was born May 23, 1718, at East Kilbride, Lanark. He was the seventh child of his parents, and an elder brother of John Hunter, the distinguished surgeon. When fourteen years of age he was sent to the university of Glasgow, where he studied for five years. He had originally been intended for the church, but, scruples concerning subscription arising in his mind, he followed the advice of his friend William Cullen (see CULLEN, vol. vi. p. 694), and resolved to devote himself to physic. During 1737–40 he resided with Cullen at Hamilton, and then, with a view to increasing his medical knowledge before settling in partnership with his friend, he spent the winter of 1740–41 at Edinburgh, and thence went to London. There Dr James Douglas, an anatomist and obstetrician of some note, to whom he had been recommended, engaged his services as a tutor to his son, and as a dissector, and assisted him to enter as a surgeon's pupil at St George's Hospital, and to procure the instruction of the anatomist Dr Nicholls. Dr Douglas died in April 1742, but Hunter still continued to live with his family. In 1746 Hunter undertook in place of Mr Samuel Sharpe the delivery, for a society of

[1] *Treatise on the Blood*, p. 63.
[2] *Essays and Observations*, i. 113.
[3] *Treatise on the Blood*, p. 89.
[4] *Ib.*, p. 90.
[5] P. P. Staple, with the loan of whose volume of MS. notes of Hunter's "Chirurgical Lectures," dated, on the last page, Sept. 20, 1787, the writer has been favoured by Dr W. H. Broadbent.

naval practitioners, of a series of lectures on operative surgery, and so satisfactorily did he acquit himself of his task that he was requested to include anatomy in his course. It was not long before he attained considerable fame as a lecturer; for not only was his oratorical ability great, but he differed from his contemporaries in the fulness and thoroughness of his teaching, and in the care which he took to provide for his hearers the best possible practical illustrations of his discourses. We read that the syllabus of Mr Nourse, published in 1748, "totam rem anatomicam complectens," comprised only twenty-three lectures, exclusive of a short and defective "Syllabus Chirurgicus," and that at "one of the most reputable courses of anatomy in Europe," which Hunter had himself attended, the professor was obliged to demonstrate all the parts of the body, except the nerves and vessels (shown in a fœtus) and the bones, on a single dead subject, and for the explanation of the operations of surgery used a dog! In 1747 Hunter became a member of the Corporation of Surgeons. In the course of a tour through Holland to Paris with his pupil J. Douglas in 1728, he visited Albinus at Leyden, and inspected with admiration his injected preparations. By degrees Hunter renounced surgical for obstetric practice, in which he excelled. He was appointed a surgeon-accoucheur at the Middlesex Hospital in 1748, and at the British Lying-in Hospital in the year following. The degree of M.D. was conferred upon him by the university of Glasgow, October 24, 1750. About the same time he left his old abode at Mrs Douglas's, and settled as a physician in Jermyn Street. He became a licentiate of the College of Physicians, September 30, 1756. In 1762 he was consulted by Queen Charlotte, and in 1764 was made physician-extraordinary to her Majesty.

On the departure of his brother John for the army, Hunter engaged as an assistant Mr William Hewson, whom he subsequently admitted to partnership in his lectures. Hewson was succeeded in 1770 by Mr Cruikshank. Hunter became in 1767 a fellow of the Royal Society; in 1768 a fellow of the Society of Antiquaries, and third professor of anatomy to the Royal Academy of Arts; and in 1780 and 1782 respectively an associate of the Royal Medical Society and of the Royal Academy of Sciences of Paris. During the closing ten years of his life his health failed greatly. His last lecture, at the conclusion of which he fainted, was given, contrary to the remonstrances of friends, only a few days before his death, which took place March 30, 1783. He was buried in the rector's vault at St James's, Piccadilly.

Hunter had in 1765 requested of the Hon. Mr Grenville the grant of a plot of ground on which he might establish "a museum in London for the improvement of anatomy, surgery, and physic" (see "Papers" at end of his *Two Introductory Lectures*, 1784), and had offered to expend on its erection £7000, and to endow in perpetuity a professorship of anatomy in connexion with it. His application receiving no recognition, he after many months abandoned his scheme, and built himself a house, with lecture and dissecting-rooms, in Great Windmill Street, whither he removed in 1770. In one fine apartment in this house was accommodated his collection, comprising anatomical and pathological preparations, ancient coins and medals, minerals, shells, and corals. His natural history specimens were in part a purchase, for £1200, of the executors of his friend Dr John Fothergill (see vol. ix. p. 475). Hunter's whole collection, together with his fine library of Greek and Latin classics, and an endowment of £8000, by his will became, after the lapse of twenty years, the property of the university of Glasgow. His paternal estate of Long Calderwood was left to his brother-in-law, Dr James Baillie, by whom, as soon as the will was proved, it was made over to John Hunter. Hunter was never married, and was a man of frugal habits. Like his brother John, he was an early riser, and a man of untiring industry. He is described as being in his lectures, which were of two hours' duration, "both simple and profound, minute in demonstration, and yet the reverse of dry and tedious;" and his mode of introducing anecdotal illustrations of his topic was most happy. Lecturing was to him a pleasure, and, notwithstanding his many professional distractions, he regularly continued it, because, as he said, he "conceived that a man may do infinitely more good to the public by teaching his art than by practising it" (see "Memorial" appended to *Introd. Lect.*, p. 120).

Hunter was the author of several contributions to the *Medical Observations and Enquiries* and the *Philosophical Transactions*. In his paper on the structure of cartilages and joints, published in the latter in 1743, he anticipated what Bichat sixty years afterwards wrote concerning the structure and arrangement of the synovial membranes. His *Medical Commentaries* (pt. i., 1762, supplemented 1764) contains, among other like matter, details of his disputes with the Munros as to who first had successfully performed the injection of the *tubuli testis* (in which, however, both he and they had been forestalled by Haller in 1745), and as to who had discovered the true office of the lymphatics (*cf.* ANATOMY, vol. i. p. 815), and also a discussion on the question whether he or Pott ought to be considered the earliest to have elucidated the nature of *hernia congenita*, which, as a matter of fact, had been previously explained by Haller. In the *Commentaries* is exhibited Hunter's one weakness—an inordinate love of controversy. His impatience of contradiction he averred to be a characteristic of anatomists, in whom he once jocularly condoned it, on the plea that "the passive submission of dead bodies" rendered the crossing of their will the less bearable. His great work, *The Anatomy of the Gravid Uterus, exhibited in Figures*, fol. (see ANATOMY, vol. i. p. 816), was published in 1774. His posthumous works are *Two Introductory Lectures*, 1784, and *Anatomical Description of the Human Gravid Uterus*, 1794, which was re-edited by Dr Rigby in 1843.

See *Gent. Mag.*, liii. pt. 1, p. 364, 1783; S. F. Simmons, *An Account of the Life of W. Hunter*, 1783; Adams's and Ottley's Lives of J. Hunter; Sir B. C Brodie, *Hunterian Oration*, 1837; W. Munk, *The Roll of the Royal College of Physicians of London*, ii. 205, 1878; and the preceding article. (F. H. B.)

HUNTING. The circumstances which render necessary the habitual pursuit of wild animals, either as a means of subsistence or for self-defence, generally accompany a phase of human progress distinctly inferior to the pastoral and agricultural stages; resorted to as a recreation, on the other hand, the practice of the chase in most cases indicates a considerable degree of civilization, and sometimes ultimately becomes the almost distinctive employment of the classes which are possessed of most leisure and wealth. It is only in some of its latter aspects, viz., as a "sport," pursued on fixed rules and principles, that hunting requires notice here.

The information we possess as to the field sports of the ancients is in many directions extremely fragmentary. With regard to the ancient Egyptians, however, we learn that the huntsmen constituted an entire subdivision of the great second caste; they either followed the chase on their own account, or acted as the attendants of the chiefs in their hunting excursions, taking charge of the dogs, and securing and bringing home the game. The game was sought in the open deserts which border on both sides the valley of the Nile; but (by the wealthy) sometimes in enclosed spaces into which the animals had been driven, or in preserves. Besides the noose and the net, the arrow, the dart, and the hunting pole or *venabulum* were frequently employed. The animals chiefly hunted were the gazelle, ibex, oryx, stag, wild ox, wild sheep, hare, and porcupine; also the ostrich for its plumes, and the fox, jackal, wolf, hyæna, and leopard for their skins, or as enemies of the farm-yard. The lion was occasionally trained as a hunting animal instead of the dog. The sportsman appears, occasionally at least, in the later periods, to have gone to cover in his chariot or on horseback; according to Wilkinson, when the dogs threw off in a level plain of great extent, it was even usual for him "to remain in his chariot, and, urging his horses to their full speed, endeavour to turn or intercept them as they doubled, discharging a well-directed arrow whenever they came within its range."[1] The partiality for the chase which the ancient Egyptians manifested was shared by the Assyrians and Babylonians, as is shown by the frequency with which hunting scenes are found depicted on the walls of their temples and palaces, and also by the alleged fact that even their dresses and furniture were ornamented with similar subjects.[2] The game pursued included the lion, the wild ass, the gazelle, and the hare, and the implements chiefly employed seem to have been the javelin and the bow. There are indications that hawking was also known. The Assyrian kings also maintained magnificent parks, or "paradises," in which game of every kind was enclosed; and perhaps it was from them that the Persian sovereigns borrowed the practice mentioned both by Xenophon in the *Cyropædia*, and by Curtius. According to Herodotus, Cyrus devoted the revenue of four great towns to meet the expenses of his hunting establishments. The circumstances under which the death of the son of Crœsus is by the same writer (i. 34–45) related to have occurred incidentally show in what high estimation the recreation of hunting was held in Lydia. In Palestine game has always been plentiful, and the Biblical indications that it was much sought and duly appreciated are numerous. As means of capture, nets, traps, snares, and pitfalls are most frequently alluded to; but the arrow (Isa. vii. 24), the spear, and the dart (Job xli. 26–29) are also mentioned. There is no evidence that the use of the dog (Jos., *Ant.*, iv. 8, 10, notwithstanding) or of the horse in hunting was known among the Jews during the period covered by the Old Testament history; Herod, however, was a keen and successful sportsman, and is recorded by Josephus (*B. J.*, i. 21, 13, compare *Ant.*, xv. 7, 7; xvi. 10, 3) to have killed no fewer than forty head of game (boar, wild ass, deer) in one day. The sporting tastes of the ancient Greeks, as may be gathered from many references in Homer (*Il.*, ix. 538–545; *Od.*, ix. 120; xvii. 295, 316; xix. 429 *sq.*), had developed themselves at a very early period; they first found adequate literary expression in the work of Xenophon entitled *Cynegeticus*,[3] which expounds his principles and embodies his experience in his favourite art of hunting. The treatise chiefly deals with the capture of the hare; in the author's day the approved method was to find the hare in her form by the use of dogs; when found she was either driven into nets previously set in her runs, or else run down in the open. Boar-hunting is also described; it was effected by nets into which the animal was pursued, and in which when fairly entangled he was speared. The stag, according to the same work, was taken by means of a kind of wooden trap (ποδοστράβη) which attached itself to the foot. Lions, leopards, lynxes, panthers, and bears are also specially mentioned among the large game; sometimes they were taken in pitfalls, sometimes speared by mounted horsemen. As a writer on field sports Xenophon was followed by Arrian, who in his *Cynegeticus*, in avowed dependence on his predecessor, seeks to supplement such deficiencies in the earlier treatise as arose from its author's unacquaintance with the dogs of Gaul and the horses of Scythia and Libya. Four books of *Cynegetica*, extending to about 2100 hexameters, by Oppian have also been preserved; the last of these is incomplete, and it is probable that a fifth at one time existed. The poem contains some good descriptive passages, as well as some very curious indications of the state of zoological knowledge in the author's time. Hunting scenes are frequently represented in ancient works of art, especially the boar-hunt, and also that of the hare. In Roman literature allusions to the pleasures of the chase (wild ass, boar, hare, fallow deer, being specially mentioned as favourite game) are not wanting (Virg., *Georg.*, iii. 409–413; *Ecl.*, iii. 75; Hor., *Od.*, i. 1, 25–28); it seems to have been viewed, however, with less favour as an occupation for gentlemen, and to have been chiefly left to inferiors and professionals. The immense *vivaria* or *theriotropheia*, in which various wild animals, such as boars, stags, and roe-deer, were kept in a state of semi-domestication, were developments which arose at a comparatively late period; as also were the *venationes* in the circus, although these are mentioned as having been known as early as 186 B.C. The bald and meagre poem of Gratius Faliscus on hunting (*Cynegetica*) is modelled upon Xenophon's prose work; a still extant fragment (315 lines) of a similar poem with the same title, of much later date, by Nemesianus, seems to have at one time formed the introduction to an extended work corresponding to that of Oppian. That the Romans had borrowed some things in the art of hunting from the Gauls may be inferred from the name *canis gallicus* (Spanish *galgo*) for a greyhound, which is to be met with both in Ovid and Martial; also in the words (*canis*) *vertragus* and *segusius*, both of Celtic origin.[4] According to Strabo (p. 200) the Britons also bred dogs well adapted for hunting purposes. The addiction of the Franks in later centuries to the chase is evidenced by the frequency with which not only the laity but also the clergy were warned by provincial councils against expending so much of their time and money on hounds, hawks, and falcons; and we have similar proof with regard to the habits of other Teutonic nations subsequent to the introduction of Christianity.[5] Originally among the northern nations sport was open to every one[6] except to slaves, who were not permitted to bear arms; the growth of the idea of game-preserving was a gradual one, and kept pace with the development of feudalism. For its ultimate development in Britain see FOREST LAW, where also the distinction between beasts of forest or venery, beasts of chase, and beasts and fowls of warren is explained. See also GAME LAWS.

The English word "hunt" (from *henten*, "to capture," and thus nearly equivalent to "chase," which is the doublet of the verb "to catch"; compare Ital. *caccia*, Fr. *chasse*) has come specially to be applied to the pursuit of the stag, hare, and fox, especially of the last-named, with horse, hound, and horn, as distinguished from other modes of capturing game. It thus corresponds to the French *chasse au courre*, as distinguished from *chasse au tir*, *à l'oiseau* &c., and to the German *Hetzjagd* as distinguished from *Birsch*. The origin of the sport in Britain does not admit of being historically traced. Doubtless the early inhabitants shared to a large extent in the habits of the other Celtic peoples; the fact that at least they kept good hunting dogs is vouched for, as we have seen, by Strabo; and an interesting illustration of the manner in which these were used is given in the inscription quoted by Orelli (*n.* 1603)—"Silvano Invicto Sacrum—ob aprum eximiæ formæ captum, quem multi antecessores prædari non potuerunt." When the period of Alfred the Great is reached, we have it on the authority of Asserius, his biographer, that before he was twelve years of age he "was a most expert and

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[1] See on this whole subject ch. viii. of Wilkinson's *Ancient Egyptians* (ii. 78–92, ed. Birch, 1878).

[2] See Layard (*Nineveh*, ii. 431, 432), who cites Ammian. Marcell., xxvi. 6, and Athen., xii. 9.

[3] Engl. transl. by Blane.

[4] Hehn, *Kulturpflanzen u. Hausthiere*, p. 327.

[5] References will be found in Smith's *Dictionary of Christian Antiquities*, art. "Hunting."

[6] "Vita omnis in venationibus . . . consistit," Cæs., *B. G.*, vi. 21. "Quoties bella non ineunt, multum venatibus, plus per otium transigunt," Tacitus, *Germ.*, 15.

active hunter, and excelled in all the branches of that noble art, to which he applied with incessant labour and amazing success."[1] Of his grandson Athelstan it is related by William of Malmesbury that after the victory of Brunanburgh he imposed upon the vanquished king of Wales a yearly tribute, which included a certain number of "hawks and sharp-scented dogs fit for hunting wild beasts." According to the same authority, one of the greatest delights of Edward the Confessor was "to follow a pack of swift hounds in pursuit of game, and to cheer them with his voice." It was under the Anglo-Saxon kings that the distinction between the higher and lower chase first came to be made,—the former being expressly for the king or those on whom he had bestowed the pleasure of sharing in it, while only the latter was allowed to the proprietors of the land. To the reign of Cnut belong the "Constitutiones de Foresta," according to which four thanes were appointed in every province for the administration of justice in all matters connected with the forests; under them were four inferior thanes to whom was committed immediate care of the vert and venison [2] The severity of the forest laws which prevailed during the Norman period is sufficient evidence of the sporting ardour of William and his successors. The Conqueror himself, we are told by his contemporaries, "loved the high game as if he were their father;" and the penalty for the unauthorized slaughter of a hart or hind was loss of both eyes.

Stag hunting.

Stag Hunting.—Although at an early period stag hunting was a favourite recreation with royalty, it is difficult to say when the royal buckhounds were first established. It seems probable that in the reign of Henry VIII. the royal pack was kennelled at Swinley, where, in the reign of Charles II. (1684), a deer was found that went away to Lord Petre's seat in Essex; only five got to the end of this 70 miles' run, one being the king's brother, the duke of York. George III. was a great stag hunter, and met the royal pack as often as possible.

The Devon and Somerset staghounds are the only pack in England that now pursue the wild red deer. In his interesting work, *The Chase of the Wild Red Deer*, Mr Collyns says that the earliest record of a pack of staghounds in the Exmoor district is in 1598, when Hugh Polland, Queen Elizabeth's ranger, kept one at Simonsbath. The succeeding rangers of Exmoor forest kept up the pack until nearly 200 years ago, the hounds subsequently passing into the possession of Mr Walter of Stevenstone, an ancestor of the Rolle family. Successive masters continued the sport until 1825, when the fine pack, descended probably from the blood hound crossed with the old southern hound, was sold in London. It is difficult to imagine how the dispersion of such a pack could have come about in such a sporting country, but in 1827 the late Sir Arthur Chichester got a pack together, and the country has been hunted ever since, the present master being Mr Fenwick Bissett. Stag hunting begins on the 12th of August, and ends on the 8th of October; there is then a cessation until the end of the month, when the hounds are unkennelled for hind hunting, which continues up to Christmas; it begins again about Ladyday, and lasts till the 10th of May. The mode of hunting with the Devon and Somerset hounds is briefly this:—the whereabouts of a warrantable stag is communicated to the master by that important functionary the harbourer; two couple of steady hounds called tufters are then thrown into cover, and, having singled out a warrantable deer, follow him until he is forced to make for the open, when the body of the pack are laid on. Very often two or three hours elapse before the stag breaks, but a run over the wild country fully atones for the delay. With all other packs of staghounds, except one in the New Forest, which hunts fallow deer, the quarry is the carted deer; the animal is turned out from a vehicle resembling a prison van in appearance, and the hounds are laid on after a quarter of an hour's law.

Fox hunting.

Fox Hunting.—It is only within comparatively recent times that the fox has come to be considered as an animal of the higher chase. William Twici, indeed, who was huntsman-in-chief to Edward II., and who wrote in Norman French a treatise on hunting, which still exists in an English translation, mentions the fox as a beast of venery, but obviously as an altogether inferior object of sport. Strutt also gives an engraving, assigned by him to the 14th century, in which three hunters, one of whom blows a horn, are represented as unearthing a fox, which is pursued by a single hound. The precise date of the establishment of the first pack of hounds kept entirely for fox hunting cannot be accurately fixed. In the work of "Nimrod" (C. J. Apperley), entitled *The Chase*, there is (p. 4) an extract from a letter from Lord Arundel, dated February 1833, in which the writer says that his ancestor, Lord Arundel, kept a pack of foxhounds between 1690 and 1700, and that they remained in the family till 1782, when they were sold to the celebrated Hugh Meynell, of Quorndon Hall, Leicestershire. Lord Wilton again, in his *Sports and Pursuits of the English*, says that "about the year 1750 hounds began to be entered solely to fox." The *Field* of November 6, 1875, p. 512, contains an engraving of a hunting-horn then in the possession of the late master of the Cheshire hounds, and upon the horn is the inscription:—"Thomas Boothby, Esq., Tooley Park, Leicester. With this horn he hunted the first pack of foxhounds then in England fifty-five years. Born 1677. Died 1752. Now the property of Thomas d'Avenant, Esq., county Salop, his grandson." These extracts do not finally decide the point, because both Mr Boothby's and Lord Arundel's hounds may have hunted other game besides fox, just as in Edward IV.'s time there were "fox dogs" though not kept exclusively for fox. On the whole, it is probable that Lord Wilton's surmise is not far from correct. Since fox hunting first commenced, however, the system of the sport has been much changed. In our grandfathers' time the hounds met early, and found the fox by the drag, that is, by the line he took to his kennel on his return from a foraging expedition. Hunting the drag was doubtless a great test of nose, but many good runs must have been lost thereby, for the fox must often have heard the hounds upwind, and have moved off before they could get on good terms with him. At the present day, the woodlands are neither so large nor so numerous as they formerly were, while there are many more gorse covers; therefore, instead of hunting the drag up to it, a much quicker way of getting to work is to find a fox in his kennel; and, the hour of meeting being later, the fox is not likely to be gorged with food, and so unable to take care of himself at the pace at which the modern foxhound travels.

The maste[r]

On hunting days it is the master's duty to say what covers are to be drawn, and to request the field to take up such positions as will enable the fox to have fair play. The management of the field requires considerable firmness, but the very strong language one sometimes hears is better avoided. Where a professional huntsman is employed, he is responsible for the actual hunting, and the less he is interfered with by the master or anybody else the better. The country should be hunted fairly through-

[1] See Strutt, *Sports and Pastimes*, who also gives an illustration, "taken from a manuscriptal painting of the 9th century in the Cotton Library," representing "a Saxon chieftain, attended by his huntsman and a couple of hounds, pursuing the wild swine in a forest."

[2] See Lappenberg, *Hist. of England under the Anglo-Saxon Kings* (ii. 361, Thorpe's transl.).

out its length and breadth, not only for the sake of the subscribers living in the different districts, but with a view to sport. Woodlands of greater or less extent are to be found even in countries denominated open, and these places are generally strongholds for foxes, and should be regularly rattled throughout the season; if this be neglected, the foxes, instead of breaking quickly, will ring about the cover all day, and, what is worse, many small covers will be drawn blank by reason of their inhabitants seeking the quietude of the wood. The frequent hunting of woodlands, though conducive in the long run to sport, is not popular with the field. It is on the whole a matter for congratulation that most packs of hounds are now carried on by subscription. Little by little the expense attending a pack of hounds has increased until it has now assumed large proportions: the hounds must be of the best blood; at least five horses per hunting day (exclusive of the master's) must be allowed for the hunt servants; no makeshifts for kennel or stable will be tolerated; and the hunt servants must be men of known character. Under these circumstances, a master undertaking to keep hounds at his own expense incurs great cost for the benefit of others, or else, being judged by the standard of great establishments, lays himself open to a charge of only half doing what he has put his hand to. If hunting is as popular as it is supposed to be, it is for every reason advisable that those who derive amusement from it should contribute something towards the general expenses. In establishments conducted upon a liberal scale, the annual cost will amount to about £620 a year for each day in the week that the pack hunts; thus, a three days a week pack will cost about £1860 per annum, a four days a week pack £2480, and so on; but absolute efficiency cannot be maintained much under £520 per day.

[Th]e [Hun]ts[ma]n. The author of the *Diary of a Huntsman* says that, to be perfect, "a huntsman should possess the following qualifications—health, memory, decision, temper, patience, a good ear, voice, and sight, courage and spirits, perseverance and activity; and with these he will make a slow pack quick." Should the master be his own huntsman, he will save about £300 a year, but he should unite as many as possible of the above list of virtues to those he is possessed of in his capacity of master. The position of a huntsman is a peculiar one; he is the servant of the master, yet the latter must to a certain extent make a confidant of him, as in cases of breeding, drawing the hounds for a day's hunting, and other matters. A huntsman must be fond of his calling, or he will not be energetic in the pursuit of it; he must also be a bold horseman,—if a good one so much the better,—for nothing is more annoying to the master and the field than to see a huntsman refuse to cast his hounds in an obviously probable direction, because the doing so would necessitate jumping an ugly fence. Observation and decision are also indispensable. When hounds check, the proper course to pursue is very often suggested by some trifling incident which occurred perhaps ten minutes before, and which was noticed at the time without any particular weight being attached to it; for instance, some rooks might have been hovering on the left or right of the line the hounds were running; or again, some hound that can be depended on diverges for a moment from the rest of the pack. The huntsman remembers this when the check takes place, and tries in that direction, often with success. When once a check occurs, decision should be shown in acting promptly; right or wrong, the huntsman must do something, and must have a reason for what he does. Authorities are not wanting who reckon youth as one of a huntsman's qualities; but huntsmen, like hunters, are not at their best until half worn out. There is so much to learn in the nature of the fox, so many isolated cases must have been observed in order to deduce a principle from them, that a young man cannot possibly have the experience necessary to show the best sport, and our hunting records tell of men who have continued to ride boldly and to show no signs of age when fifty years old.

The method of hunting a pack of hounds varies somewhat in different countries. One of the most accepted canons is that the huntsman should not interfere with his hounds more than is necessary. So long as hounds can hunt, it is best to let them do so, for if their heads are once got up by hallooing and lifting, they will not so readily settle down again; while hounds that are in the habit of being lifted and galloped off to a distant point whenever a check occurs, will generally look for assistance, and will make but little use of their own noses on cold scenting days. Some countries are naturally bad-scenting ones, and, in order to kill a fox in them, hounds must be lifted more than in others.

Huntsmen are often much abused, when drawing a large cover, for not going away with the first fox. There is a difference of opinion whether, if hounds are running one fox in cover, they should be stopped and put on the line of one that has gone away. Something will depend upon whether the cover was well worked during cub hunting or not, and whether foxes are plentiful or scarce, but after the 1st of February the rule should be to go away with the first fox that breaks, or the hounds may get on a vixen.

The whipper-in. The whipper-in, to be a success, must be content to suppress himself for the public good. When a "good thing" occurs, and the huntsman is going as hard as he can, and many of the field harder than they like, the whip, or, if two be kept, the second whip, should wait in cover and come on with the tail hounds. A good whip can do more in the furtherance of sport than any huntsman; in the interest, therefore, of fox hunting, there must be no rivalry, or rather no manifestation of it, between the huntsman and the whip. A noisy fellow is an abomination; and the whip should carefully avoid rating a hound after seeing that his voice is entirely disregarded. If needs be a hound must be flogged and that soundly, but he should never be struck without knowing what it is for; thus, it is of no use, twenty minutes after a hound has ceased to run riot, to get alongside of him, bellow out his name, and then flog him; to warrant the use of the lash, he must be caught *flagrante delicto*, and must pay no heed to rating. Where, however, hounds have been properly entered and treated, they will require but little chastisement. On approaching a cover, one whip should go on in advance and station himself on the lee side of it, where he may often see a fox steal away as soon as the hounds are thrown in. Although some packs have only one whip, a second is very desirable, especially before Christmas, and in countries where there is much woodland. One whip can then go into cover and keep near the huntsman in readiness to obey any directions he may give, and the other is free to see to other matters.

The earth-stopper. The earth-stopper is an important functionary in countries where there are many earths, for if he neglects his business blank days will probably result with annoying frequency. When properly carried out, earth-stopping consists in a man going round and stopping all the earths in the district to be hunted over during the day, so that when foxes return from finding their food, which they do some hours before it is light, they shall find their own door barred against them. This involves the earth-stopper being astir shortly after 2 A.M., not the most pleasant hour of the twenty-four on a winter's day. If he gets to work late, he stops all the foxes in instead of out; and, when the cover is drawn, no one can understand how the fox which has been seen about for the last fortnight cannot be found at the moment when his presence is particularly desired.

Cub hunting. Cub hunting carried out on a proper principle is one of the secrets of a successful season. To the man who cares for hunting, as distinct from riding, September and October are not the least enjoyable months of the whole hunting season. As soon as the young entry have recovered from the operation of "rounding," arrangements for cub hunting begin. The hounds must have first of all walking, then trotting and fast exercise, so that their feet may be hardened, and all superfluous fat worked off by the last week in August. So far as the hounds are concerned, the object of cub hunting is to teach them their duty; it is a dress rehearsal of the November business. In company with a certain proportion of old hounds, the youngsters learn to stick to the scent of a fox, in spite of the fondness they have acquired for that of a hare, from running about when at walk. When cubbing begins, a start is made at 4 or 5 A.M., and then the system is adopted of tracking the cub by his drag. A certain amount of blood is of course indispensable for hounds, but it should never be forgotten that a fox cub of seven or eight months old, though tolerably cunning, is not so very strong; the huntsman should not therefore be over-eager in bringing to hand every cub he can find. It would be a move in the right direction if noses were not to be counted until the first of November.

Hare hunting. *Hare hunting*, which must not be confounded with COURSING (*q.v.*), is an excellent school both for men and for horses. It is attended with the advantages of being cheaper than any other kind, and of not needing so large an area of country. Hare hunting requires considerable skill; Beckford even goes so far as to say—"There is more of true hunting with harriers than with any other description of hounds. . . . . . In the first place, a hare, when found, generally describes a circle in her course which naturally brings her upon her foil, which is the greatest trial for hounds. Secondly, the scent of the hare is weaker than that of any other animal we hunt, and, unlike some, it is always the worse the nearer she is to her end." Hare hunting is essentially a quiet amusement; no hallooing at hounds nor whip cracking should be permitted; nor should the field make any noise when a hare is found, for, being a timid animal, she might be headed into the hounds' mouths. Capital exercise and much useful knowledge are to be derived by running with a pack of beagles. There are the same difficulties to be contended with as in hunting with the ordinary harrier, and a very few days' running will teach the youthful sportsman that he cannot run at the same pace over sound ground and over a deep ploughed field, up hill and down, or along and across furrows.

Otter hunting. *Otter hunting*, which is less practised now than formerly, begins just as all other hunting is drawing to a close. When the waterside is reached an attempt is made to hit upon the track by which the otter passed to his "couch," which is generally a hole communicating with the river, into which the otter often dives on first hearing the hounds. When the otter "vents" or comes to the surface to breathe, his muzzle only appears above water, and when he is viewed or traced by the mud he stirs up, or by air bubbles, the hounds are laid on. Notwithstanding the strong scent of the otter, he often escapes the hounds, and then a cast has to be made. When he is viewed an attempt is made to spear him by any of the field who may be within distance; if their spears miss, the owners must wade to recover them. Should the otter be transfixed by a spear, the person who threw it goes into the water and raises the game over his head on the spear's point. If instead of being speared, he is caught by the hounds, he is soon worried to death by them, though frequently not before he has inflicted some severe wounds on one or more of the pack.

Oth[er] kin[ds of] hun[ting]. Quitting the United Kingdom, we find that the elephant, hyæna, hunting leopard, and a small species of panther known as the ounce, are not only objects of chase, but are themselves trained to assist in the capture of other animals. The elephant has been found of great service in lion and tiger hunting, his size affording comparative safety to the hunters seated on his back. The hyæna, which resembles a dog in many particulars, is said to be as tractable, when properly trained, and to be of much use in the pursuit of game. The hunting leopard or cheetah and the ounce are used in hunting a species of antelope. They have hoods put over their heads, and are taken in a small waggon into the field; when the deer is seen the hood is taken off and the animal starts in pursuit, followed by the hunter; when the game is secured the hood is again put on. In India field sports are largely indulged in, owing partly to natural facilities, and partly to the taste for hunting characteristic of the English resident there. Tigers are sometimes caught in traps, and sometimes shot in the jungle from the back of an elephant; they seek to conceal themselves, and very rarely commence hostilities against mankind, but when severely wounded and brought to bay they fight courageously. Hunting the wild hog, or "pig sticking," as it is often termed, is a favourite sport in India; the ground is walked over by beaters, and when a hog is roused the two mounted huntsmen nearest to him start in pursuit, and endeavour to spear him. The riding requires judgment and very good nerves: hollows, ravines, and cracks in the ground caused by the sun are numerous, and, as they are hidden by the tall grass, the horse cannot avoid them; it is said that no horse can run down a hog in less than a mile, even over the best ground, while over a rough country the distance travelled amounts to three or four. The rider's aim is to blow the hog sufficiently before getting within spearing distance—for the charge of an untired hog is a dangerous affair; but when near a thick cover the sportsman must try to spear him at all hazards, or make up his mind to lose him. The proper management of the spear requires considerable practice. Besides the above mentioned animals, the fox, jackal, wolf, hyæna, buffalo, and four-horned antelope are also objects of the chase.

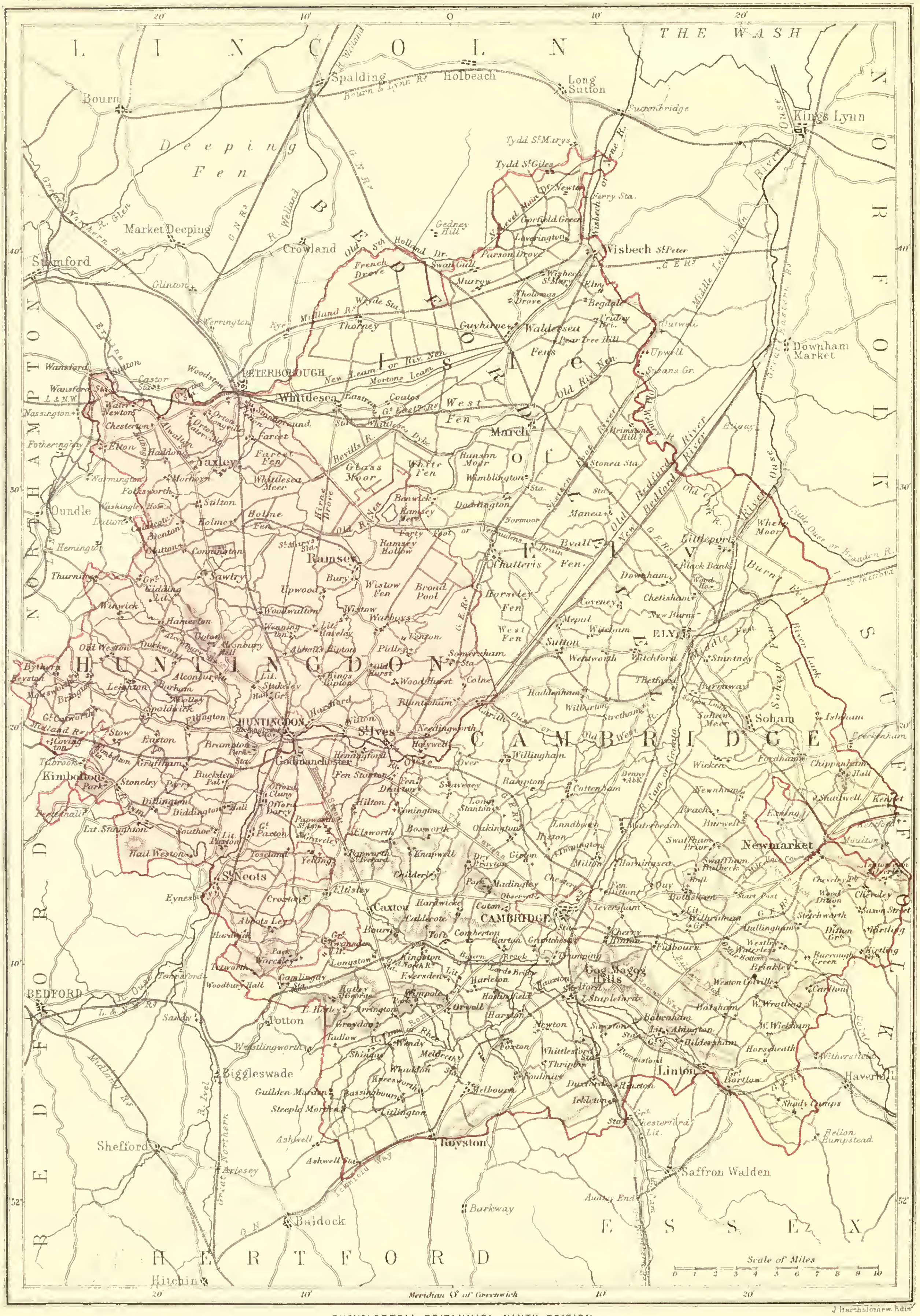
Australia was formerly the scene of a great deal of kangaroo hunting, but that animal is now comparatively scarce.

In Africa there is plenty of big-game hunting, the list including the elephant, lion, giraffe, hippopotamus, antelopes of various kinds, leopard, hyæna, buffalo, jackal, and ostrich. Of these the larger and more dangerous animals are killed as opportunity offers, but the jackal is hunted by English settlers like a fox. Ostrich hunting is somewhat peculiar; the bird is pursued by men on horseback, and, though over the ground it is swifter than a horse, it generally runs in a large circle, so that the riders, by describing a smaller circle and relieving one another, are enabled to keep tolerably near to it, and so to ride it down.

In North America the bison, an animal sometimes when full grown weighing as much as 142 stone, is pursued by the natives on horseback and then shot. The moose is chased towards a ravine or a snowdrift, and when he begins to flounder in the snow he is shot at by the hunters. The red deer is now hunted with staghounds upon the English principle. South America affords hunting after the puma, tapir, and wild bull, the lasso being the usual means of capture.

In Russia, bears, wolves, and wild boars are hunted. Wolves are found in Germany, where they are not only hunted by properly trained wolf-hounds, but are killed by any available means.

France offers facilities for hunting the wolf, wild boar,



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and deer, but the sport, though followed up with a considerable amount of enthusiasm, is not carried out in a manner strictly in accordance with English ideas. The weak point in French hunting is that the huntsmen do not seem to possess a particularly accurate knowledge of the habits and characteristics of the animal they pursue. Then again their system of kennel management is not what it might be. To show sport in the vast forests, the hounds should be in good health and well-trained, and there should be plenty of them. Of late years, however, more attention has been paid to hound breeding and kennel management, and with encouraging results. (E. D. B.)

te III. HUNTINGDON, or HUNTS, an inland county of England, situated between 52° 9′ and 52° 35′ N. lat. and 0° 3′ E. and 0° 30′ W. long., and bounded on the N. and W. by Northampton, S. by Bedford, and E. by Cambridge. Its extreme breadth is at the middle, from which it narrows gradually and irregularly towards its north and south ends. Its extreme length from north to south is about 30 miles, and its extreme breadth from east to west about 23 miles. The area extends to 229,575 imperial acres, or 358 square miles. Among English counties it is the smallest, with the exception of Middlesex and Rutland; and Rutland is the only English county it surpasses in population.

The surface of the county is low, and, with the exception of the Fen district, pleasantly undulating. For the most part it is bare of trees. A low ridge of hills enters the county from the south near Potton, and runs in a northward direction until it terminates in the Ouse valley near Huntingdon; and a branch of the Cambridgeshire hills enters the south-east part of the county, and from Huntingdon runs north-west to Wansford. The north-eastern part of the county, comprising 50,000 acres, or one-fifth of its whole extent, belongs to the great "Fen" district extending throughout the counties of Cambridge, Lincoln, Northampton, Norfolk, and Suffolk. The principal rivers are the Ouse and Nen. The Ouse from Bedfordshire skirts the borders of the county near St Neots, and after flowing north to Huntingdon takes an easterly direction past St Ives into Cambridgeshire on its way to the Wash. It is navigable for barges as far as Bedford, and in the fen district constitutes a means of transport for the agricultural produce of the county. The Nen, which is also navigable, skirts the northern border, and quitting it at Peterborough enters the Wash below Wisbeach, in Cambridgeshire. Various cuts and drains which join the Nen and Ouse are also made use of for navigation.

Geology, Soil, and Agriculture.—Geologically Huntingdonshire belongs to what is known as the Oolite system. The low round hills in the south-eastern part of the county are composed of ironsand. They contain a band of coprolites, and there is a strip of greensand on the south-eastern border. The central and larger part of the county displays the Oxford clay, which lies between the middle and lower Oolite. It reaches a depth of nearly 100 feet, and passes under the Fens. The Fens are composed of fine mud, deposited formerly by the sea, intermixed with beds of peat, in which are frequently found the remains of animals, frequenters of the old forest, such as the elk, the red-deer, the bear, the beaver, and the wolf. The hills on the border of Northampton are of the stonebrash or forest marble. The Oolite formation is very fossiliferous. Large masses of fossil wood converted into jet or iron pyrites are found in the Oxford clay. Glacier or boulder clay containing chalk and flint deposits is met with in nearly every part of the county. The soil is generally fertile, and cultivation is of an advanced kind. In the fen district the soil is of a blue peaty nature, resting on a subsoil of white marly clay. After being drained and mixed with clay it is very productive, but much damage is often done to the crops by the prevalence of frost and fogs. In the fen districts a four-years' system of cropping—green-crops, barley, seed-clovers, and wheat—is the most common. The "Meres" of Whittlesea, Ramsey, and Ugg, at one time much resorted to by sportsmen for their wildfowl and fish, have now been drained, and, notwithstanding the expensiveness of the process, such is the fertility of their beds that the outlay was speedily more than repaid. The Oxford clay, which extends to an area of 120,000 acres, is of very various soils according as the Oolite rocks crop to the surface. The greater part is under cultivation, and much improvement has lately been effected by drainage; on account of the tenacity of the clay the drains often require to be placed very close. Much of the soil is, however, undrained and uncultivated, and, though partly used for pasturage, must on the whole be regarded as mere waste land. On the drained pasturage a large number of cattle are fed. In this district the system of cropping varies considerably, but a modification of the four-course shift is the most common—fallow sown sometimes with winter tares, turnips, mangold, or mustard; barley; beans where tares were sown on the fallow, and clover where green crops were sown; wheat. A six-years' course of fallow, barley, seed-clovers, wheat, beans, and wheat is, however, not uncommon, especially on the best soils. The third district, comprising the gravel of the Ouse valley, embraces an area of 50,000 acres. On the banks of the Ouse it consists of fine black loam deposited by the overflow of the river, and its meadows form very rich pasture grounds. The upland district is under arable culture, and is generally cultivated on a four-course system of wheat, green crops, barley, and seed-clover. Market-gardening is prosecuted; and willows are largely grown in the fen district. The farms vary in size from 200 to 500 acres, ranging chiefly between 200 and 300. The farm-houses are generally of an inferior kind, and the farm-buildings are often quite inadequate for the shelter and accommodation of the stock. The labourers generally live in villages and hamlets, in cottages of the most miserable description, having mostly mud walls; but many cottages of a better class have been built within the last few years. The county is well supplied with turnpike roads; and the parish and occupation roads, formerly in a bad state of repair, have been lately much improved. The most modern improvements in farm implements are in general use.

According to the agricultural returns for 1879 the total area of arable land was 209,610 acres, of which 96,533 were under corn crop, 21,931 under green crop, 17,121 under rotation grasses, 60,484 permanent pasture, and 13,531 fallow. The area under woods was 20,714 acres. Wheat, which in 1879 cropped 43,129 acres, is much more largely grown than any other grain, and occurs twice in the six-years' shift system in use on the better lands. Barley (27,118 acres) is the more frequent corn crop in the four-years' shift system,—only 10,247 acres being under oats. The quality of barley on many soils is lean and inferior, and unsuitable for malting purposes. Beans and pease occupied 8948 and 6929 respectively. Mangold (3430 acres) and cabbage and similar green crops (2863 acres) are chiefly used for the feeding of sheep. Under turnips there were only 3778 acres, and under potatoes 3083. The number of cattle in 1879 was 27,358, or an average of 13 to every 100 acres under cultivation, as compared with 16·9 for England and 21·0 for the United Kingdom. Of these the number of cows and heifers in milk or in calf was 7536. Though Stilton in Huntingdon gives its name to a celebrated cheese, that variety is now made exclusively in the counties of Lincoln and Leicester; and dairy farming is not now much followed. The milk is now chiefly used for rearing calves. Large numbers of cattle are fattened in the field or the fold-yard, and are sold when rising three years old. They are mostly of the shorthorn breed, large numbers of Irish shorthorns being wintered in the fens. Where there are no upland pastures the farmer usually purchases cattle in the autumn and sells them in the spring. The number of horses in 1879 was 11,057, or an average of 4·2 to every 100 acres under cultivation, as compared with 4·5 for England and 4·1 for the United Kingdom. Of these the number used solely for agricultural purposes was 7583. Most of the farmers breed cart horses, and the large farmers often rear weight-carrying hunters. The number of sheep in 1879 was 157,790, or an average of 75·3 to every 100 acres under cultivation, as compared with the same average for England and 68·0 for the United Kingdom. Great improvement in the breed has lately taken place, Leicesters and Lincolns being most common; they usually attain great weights at an early age. Lambs are occasionally sold at weaning time, but more frequently they are kept through the winter on the grass lands, being fed also on mangolds and other roots, with an addition of cake and corn. The number of pigs in 1879 was 19,990, or an average of 9·5 to every 100 acres under cultivation, as compared with 7·2 for England and 6·7 for the United Kingdom. They include Berkshire, Suffolk, and Neapolitan breeds, and a number of crosses. Many after having gleaned the stubbles are fattened on whey and various preparations of inferior barley; but breeding is also extensively practised.

According to the owners of lands return for 1873 the land was divided among 3903 proprietors, holding land the gross annual value of which was £444,890. Of the owners 45⅗ per cent. possessed less than 1 acre, and the average value all over was £1, 19s. 4¾d. per acre. There were 13 proprietors holding upwards of 3000 acres, viz., Edward Fellowes, 15,629; Duke of Manchester, 13,835; William Wells, 5792; Marquis of Huntly, 5711; Hon. G. W. Fitzwilliam, 5202; Lord Chesham, 3787; Earl of Carysfort, 3654; Ecclesiastical Commissioners, 3559; Colonel Duncombe, 3407; W. Duberley, 3224; Earl of Sandwich, 3219; G. D. Newton, 3209; Richard H. Hussey, 3135.

Manufactures and Trade.—Agriculture is the principal industry, and none of the manufactures are extensive, the chief being paper and parchment. Madder is obtained in considerable quantities, and in nearly every part of the shire lime burning is carried on. Lace-making is practised by the female peasantry; and the other industries, which are not prosecuted beyond what is necessary to meet local wants, are printing, iron-founding, tanning, currying, brick and tile making, malting, and brewing.

Railways.—The middle of the county is traversed from south to north by the Great Northern, which enters it at St Neots and passes by Huntingdon to Peterborough. A branch from the Midland enters the middle of the county from Northampton, and passes by Graffham to Huntingdon, where it is joined by a branch which passes by St Ives to the Great Eastern in Cambridgeshire. From St Ives there is a branch to Wisbeach in Cambridgeshire, and another has been constructed to Stilton. On the Great Northern there is a branch from Holme to Ramsey.

Administration.—Huntingdonshire comprises four "hundreds." For parliamentary purposes it is an undivided constituency returning two members; and it contains one parliamentary borough, that of Huntingdon, formed of Huntingdon (4243) and Godmanchester (2363), and returning one member. Part of the represented city of Peterborough is also in the county. The principal other towns are Ramsey (2378), St Ives (3291), St Neots (3200), and Kimbolton (1509). The county has one court of quarter sessions. It is included in the south-eastern circuit, and circuit courts are held at Huntingdon. It forms part of the shrievalty of Cambridge, and ecclesiastically is in the diocese of Ely.

Population.—The population in 1841 amounted to 58,549, in 1851 to 64,183, in 1861 to 64,250, and in 1871 to 63,708 (31,381 males and 32,327 females). The increase in thirty years from 1841 has been 8·8 per cent., and since 1801 it has been 69·5 per cent.

History and Antiquities.—Previous to the Roman invasion Huntingdonshire, like the other Fen counties, was inhabited by the British tribe the Iceni, originally of Celtic origin, but considerably intermixed from Teutonic sources, although the Belgæ in all probability did not subdue the country as far north as Huntingdon. During the Roman occupation it was included in the Roman province of *Flavia Cæsariensis.* Two Roman stations are supposed to have been situated in the county, *Durolipons* (Godmanchester) and *Durobrivæ* at Water Newton on the Nen. The Roman road *Via Devana* from Cambridge joined Ermine Street at Godmanchester, Ermine Street passing north-west by Water Newton into Northampton. Under the name of Huntandunscyre, Huntingdon formed part of the kingdom of East Anglia, afterwards joined to Mercia. Shortly before the Conquest the earldom of Huntingdon was held by Swend, who, on receiving the earldom of Northampton, granted it to his son Waltheof, who married a niece of William the Conqueror; and, on Waltheof's execution for high treason, it passed to a Norman soldier, Simon de St Liz, who married a daughter of Waltheof. On the death of St Liz, David, afterwards king of Scotland, married his widow, and inherited the earldom in her right, but on account of the subsequent feuds between the English and Scottish monarchs the earldom frequently exchanged hands between the heirs of St Liz and the heirs of David. It is at present borne by a branch of the Hastings family. A great part of the county was held by the monks, who erected two great abbeys at Ramsey and at Sawtry St Judith, and priories at Huntingdon, St Ives, St Neots, and Hinchingbrook. Of these buildings all that now remains is the richly decorated ruined gateway of the abbey of Ramsey, and a dovehouse, a barn, and a few unimportant fragments at St Ives. There were two ancient castles at Huntingdon and Kimbolton; the one at the latter place, now the seat of the Montagues, dukes of Manchester, was the residence of Catherine of Aragon after her divorce from Henry VIII. Another mansion of interest is Hinchingbrook House, the ancient seat of the Cromwell family. Among the old churches may be mentioned Alwalton, Conington, Hartford, Leighton Bromswold, and Ramsey, which contain remains of Roman architecture; Buckden, Elton, Godmanchester, and St Neots, which contain good specimens of the Perpendicular; Chesterton, Holywell, Sawtry, Upton, and Wooton, which are partly Early English. The only events of historical importance connected with the shire are the capture of the castle of Huntingdon by the Royalists under Charles I. in 1645, and the rout at St Neots of one hundred horse under the command of the duke of Buckingham and the earl of Holland by the Parliamentary soldiers, who took the earl of Holland prisoner.

Huntingdon, a municipal and parliamentary borough of England, capital of the above county, is situated on the left bank of the Ouse, and on three railway lines, 58 miles north of London, 15 miles north-west of Cambridge, and 19 miles south of Peterborough. It consists principally of one street about a mile in length, from which small streets branch off at various points. By a fine bridge erected in the 13th century it is connected with the municipal borough of Godmanchester, which, consisting principally of cottages, forms practically one of its suburbs, and is included in the parliamentary borough of Huntingdon. In Huntingdon there are two old churches—All Saints, probably dating originally from the time of the Normans, but re-erected in the time of Henry VIII., and St Mary's, probably occupying the site of the old priory, but rebuilt in the Gothic style after the fall of the old building in 1608, and restored in 1876. The church of Godmanchester, of the date 1625, is also a fine structure in the late Perpendicular, with a tower and spire. At the grammar school of Huntingdon, founded in 1200 by David, king of Scotland, but pulled down in 1877 for the erection of a new building, Oliver Cromwell received his education. Among the other schools are Walden's school for 64 boys, and a national school. There are also in Godmanchester a grammar school and a national school. The principal other buildings of Huntingdon are the county jail, completed in 1827; the militia barracks, erected in 1852; the town and county hospital, erected in 1853; the corn exchange; the town-hall, whose ground floor is used for the courts of justice; and the rooms of the literary and scientific institution. The house in which Oliver Cromwell was born is still standing. Of the three old monastic foundations formerly belonging to the town there are now no remains. The industries of Huntingdon and Godmanchester are very much alike. They possess iron-foundries, breweries, tile-works, and oil and flour mills. The area of the parliamentary borough of Huntingdon is 6086 acres, the municipal boroughs of Godmanchester and Huntingdon occupying 4970 acres and 1116 acres respectively. In 1871 the population of the parliamentary borough was 6606, that of the municipal boroughs of Godmanchester and Huntingdon being respectively 2363 and 4243.

Huntingdon existed in the time of the Saxons under the name of Huntantun, and in the Norman survey it is mentioned as Huntersdune. The castle erected at it by Edward the Elder in 919, and afterwards enlarged by David, king of Scotland, was demolished by the orders of Henry II. In 1645 the town was plundered by the Royalists under Charles I. The origin of the town was doubtless closely connected with that of Godmanchester, which occupied the site of the Roman station *Durolipons*, and at which a castle is said to have been founded by Gormund (hence the name of the town, formerly Gormunchester), a Danish chief in the reign of Alfred the Great. Huntingdon was first incorporated in 1206 and Godmanchester in 1605. From an early period Huntingdon returned two members to parliament; but the Reform Act of 1867 reduced the representation to one member.

HUNTINGDON, Selina, Countess of (1707–1791), leader of a sect of Calvinistic methodists, known as the Countess of Huntingdon's Connexion, was the daughter of Washington Shirley, second Earl Ferrers. She was born at Stanton Harold, a mansion near Ashby-de-la-Zouch in Leicestershire, August 24, 1707, and in her twenty-first year was married to Theophilus, ninth earl of Huntingdon. The religious influence of her husband's sisters, and a dangerous illness soon after her marriage, tended to deepen the serious impressions which the young countess had experienced from childhood; and on the death of her husband in 1746, coming under the influence of the religious revival in which Wesley and Whitfield were at that time conspicuous, she resolved to join these preachers in actively furthering their aims. In 1748 she gave Whitfield a scarf as her chaplain, and in that capacity he frequently preached in her town house to the most fashionable audiences, in which sometimes such men as Chesterfield, Walpole, and Bolingbroke were found. Reducing her personal expenditure, and disregarding the sneers of her aristocratic acquaintances, Lady Huntingdon spent her ample means in building chapels in different parts of England, and appointed ministers to officiate in them, under the impression that as a peeress she had a right to employ as many chaplains as she would. In 1768 she converted the old mansion of Trevecca, near Talgarth, in South Wales, into a theological seminary for training young ministers for the Connexion; and this, which she made her chief residence, she continued to support alone till her death. Up to 1779 Lady Huntingdon and her chaplains continued members of the Church of England, but in that year the prohibition of her chaplains by the consistorial court from preaching in the Pantheon, a large building in London rented for the purpose by the countess, compelled her in order to evade the injunction to take shelter under the Toleration Act. This reluctant step, which placed her legally among dissenters, had the effect of severing from the Connexion several eminent and useful members. Till her death in London, June 17, 1791, Lady Huntingdon continued to exercise an active, and even autocratic, superintendence over her chapels and chaplains, and maintained her leading position as well by her genuine earnest piety and force of character as by her high social station and generous liberality. Her chapels and college were bequeathed to trustees; and in 1792 the latter was removed to Cheshunt, in Hertfordshire, where it has since flourished. Several congregations of the Connexion have become nominally as well as virtually Congregational chapels; while, even by those which retain the original name, the Congregational polity is practically adopted.

The Life of the Countess of Huntingdon was published at London, in 2 vols., in 1844; *The Coronet and the Cross, or Memorials of Selina, Countess of Huntingdon*, by A. H. New, appeared in 1857.

HUPFELD, Hermann (1796–1866), an eminent Orientalist and Biblical commentator and critic, was born March 31, 1796, at Marburg, where he studied philosophy and theology from 1813 to 1817; in 1819 he became a teacher in the gymnasium at Hanau, but in 1822 he resigned that appointment. After studying for some time under Gesenius at Halle, he in 1824 "habilitated" in philosophy at that university, and in the following year he was appointed professor extraordinarius of theology at Marburg. There he received the ordinary professorships of Oriental languages and of theology in 1827 and 1830 respectively; thirteen years later he removed as successor of Gesenius to Halle. In 1865 he was accused by some theologians of the Hengstenberg school, before the minister of public worship, of having taught exegesis in a sense inconsistent with the recognized character of the Old Testament as a divine revelation. From this charge, however, he successfully vindicated himself, the entire theological faculty, including J. Müller and Tholuck, bearing testimony to his essential orthodoxy. He died at Halle April 24, 1866.

His earliest works in the department of Semitic philology (*Exercitationes Æthiopicæ*, 1825, and *De emendanda ratione lexicographiæ Semiticæ*, 1827) were followed by the first part (1841), mainly historical and critical, of an *Ausführliche Hebräische Grammatik*, which he did not live to complete, and by a "program" on the early history of Hebrew grammar among the Jews (*De rei grammaticæ apud Judæos initiis antiquissimisque scriptoribus*, 1846). His principal contribution to Biblical literature, a valuable though prosaic exegetical and critical *Uebersetzung u. Auslegung der Psalmen*, began to appear in 1855, and was completed in 1861 (2d ed. by Riehm, 1867–1871). Other writings are *Ueber Begriff u. Methode der sogenannten biblischen Einleitung* (1844); *De primitiva et vera festorum apud Hebræos ratione* (1851–1864); *Die Quellen der Genesis von neuem untersucht* (1853), in which he dissects that book into an original writing, or "Urschrift," by the older Elohist, and the contributions by the younger Elohist and by the Jehovist respectively, the work of the "redactor" having been comparatively trifling; *Die heutige theosophische u. mythologische Theologie u. Schrifterklärung* (1861); and various contributions to the *Studien u. Kritiken*, to the *Journal* of the Deutsche Morgenländische Gesellschaft, and to the *Neue Evangelische Kirchenzeitung*. See Riehm, *Hermann Hupfeld* (1867).

HURD, Richard (1720–1808), bishop of Winchester, was born at Congreve, in the parish of Penkridge, Staffordshire, where his father was a farmer, on January 13, 1720. He received his early education at the grammar school of Brewood, in his native county, and made such progress in his studies that in October 1733 he was admitted a sizar of Emmanuel College, Oxford; he did not begin residence, however, till a year or two afterwards. In 1739 he took the degree of B.A., and in 1742 he was ordained deacon, and for a short time had charge of the parish of Reymerston, between Thetford and Norwich; but, having in the same year proceeded M.A. and been elected fellow of his college, he returned to Cambridge early in 1743. While residing there he was ordained priest in 1744, and in 1748 he published his *Remarks on a late Book, entitled an Enquiry into the Rejection of the Christian Miracles by the Heathen, by William Weston, B.D.*, 1746. This controversial treatise, which was characterized by considerable learning and ingenuity, was followed in 1749 by an edition of the *Ars Poetica* of Horace (*Q. Horatii Flacci Epistola ad Pisones, with an English Commentary and Notes*), which, as Gibbon has remarked, fully proved the title of its author to "the great but prostituted name of critic," and may still be read with interest, less, however, as an exposition of the original than as containing "a more valuable and better digested collection of criticisms than Horace ever wrote or intended to write." In 1750 Hurd was, through the recommendation of his friend Warburton, appointed one of the preachers at Whitehall; and in 1751 he published *Q. Horatii Flacci Epist. ad Augustum, with an English Commentary and Notes*, justly held by Gibbon to be superior in merit to the edition of the *Ars Poetica*.

In 1756 he accepted the college living of Thurcaston, Leicestershire, in the studious retirement of which he wrote and published a volume of *Dissertations* ("On the Province of the Drama," "On Poetical Imitation," and "On the Marks of Imitation," 1757), and another entitled *Moral and Political Dialogues* ("On Sincerity in the Commerce of the World," "On Retirement," "On the Age of Queen Elizabeth," and "On the Constitution of the English Government," 1759). The latter has proved the most popular of his writings, and was chiefly instrumental in procuring for him at a later period of his life the royal favour. In 1766 he was appointed preacher of Lincoln's Inn, and in 1767 he became archdeacon of Gloucester; his elevation to the see of Lichfield and Coventry followed in 1774, and in 1776 he was selected to be preceptor of the prince of Wales and the duke of York. In 1781 he was translated to Worcester, and in 1783, on the death of Dr Cornwallis, he was pressed to accept the primacy, but declined it as "a charge not suited to his temper and talents, and much too heavy for him to sustain, especially in these times." He died May 28, 1808.

Besides various sermons, charges, and other compositions of a more or less occasional character, Hurd published, in addition to the works already mentioned, a *Dissertation on the Delicacy of Friendship* (1755), a severe attack on Jortin, by whom Warburton had been assailed; *Letters on Chivalry and Romance* (1762); *Dissertation on the Idea of Universal Poetry* (1762); *Dialogues on Foreign Travel* (1764); and *Discourse by way of Preface to the Quarto edition of Bishop Warburton's Works, containing some Account of the Life, Writings, and Character of the Author* (1794). *Remarks on Hume's Natural History of Religion* (1757), a controversial tract which caused considerable irritation to that philosopher, was the joint production of Hurd and Warburton. The collected works of Hurd appeared in an edition of 8 vols. 8vo, in 1811; his *Memoirs* by Kilvert, were published in 1860.

HURDWAR. See Hardwár.

HURON, Lake. See St Lawrence.

HURRUR. See Harar.

HUSBAND AND WIFE, Law relating to. For the modes in which the relation of husband and wife may be constituted and dissolved, see Marriage and Divorce. The present article will deal only with the effect of marriage on the legal position of the spouses. The person chiefly affected is the wife, who probably in all political systems becomes subject, in consequence of marriage, to some kind of disability. The most favourable system scarcely leaves her as free as an unmarried woman; and the most unfavourable subjects her absolutely to the authority of her husband. In modern times the effect of marriage on property is perhaps the most important of its consequences, and on this point the laws of different states show wide diversity of principles.

The history of Roman law exhibits a transition from an extreme theory to its opposite. The position of the wife in the earliest Roman household was regulated by the law of *Manus*. She fell under the "hand" of her husband,—became one of his family, along with his sons and daughters, natural or adopted, and his slaves. The dominion which, so far as the children was concerned, was known as the *patria potestas*, was, with reference to the wife, called the *manus*. The subject members of the family, whether wife or children, had, broadly speaking, no rights of their own; all were merged in the *potestas* of the husband and father. If this institution implied the complete subjection of the wife to the husband, it also implied a much closer bond of union between them than we find in the later Roman law. The wife was at least a member of the family, and on her husband's death she succeeded, like the children, to freedom and a share of the inheritance. *Manus*, however, was not essential to a legal marriage; its restraints were irksome and unpopular, and in course of time it absolutely ceased to exist, leaving no equivalent protection of the stability of family life. The later Roman marriage left the spouses comparatively independent of each other. The bond was easily dissolved, and while it lasted was loose and easy. The distance between the two modes of marriage may be estimated by the fact that, while under the former the wife was one of the husband's immediate heirs, under the latter she was called to the inheritance only after his kith and kin had been exhausted, and only in preference to the treasury. It seems doubtful how far she had, during the continuance of marriage, a legal right to enforce aliment from her husband, although if he neglected her she had the unsatisfactory remedy of an easy divorce. The law in fact preferred to leave the parties to arrange their mutual rights and obligations by private contracts. Hence the importance of the Law of Settlements (*Dotes*). The *Dos* and the *Donatio ante nuptias* were settlements by or on behalf of the husband or wife, during the continuance of the marriage, and the law seems to have looked with some jealousy on gifts made by one to the other in any less formal way, as possibly tainted with undue influence. During the marriage the husband had the administration of the property, and its destination afterwards might depend on the nature of the settlement and the conduct of the parties.

The *manus* of the Roman law appears to be only one instance of an institution common to all primitive societies, and suitable only to society in a primitive state. On the continent of Europe after many centuries, during which local usages were brought under the influence of principles derived from the Roman law, a theory of marriage became established, the leading feature of which is the *community of goods* between husband and wife. Describing the principle as it prevails in France, Story (*Conflict of Laws*, § 130) says—"This community or nuptial partnership (in the absence of any special contract) generally extends to all the movable property of the husband and wife, and to the fruits, income, and revenue thereof. . . . . It extends also to all immovable property of the husband and wife acquired during the marriage, but not to such immovable property as either possessed at the time of the marriage, or which came to them afterwards by title of succession or by gift. The property thus acquired by this nuptial partnership is liable to the debts of the parties existing at the time of the marriage; to the debts contracted by the husband during the community, or by the wife during the community with the consent of the husband; and to debts contracted for the maintenance of the family. . . . . The husband alone is entitled to administer the property of the community, and he may alien, sell, or mortgage it without the concurrence of the wife." But he cannot dispose by will of more than his share of the common property, nor can he part with it gratuitously *inter vivos*. The community is dissolved by death (natural or civil), divorce, separation of body, or separation of property. On separation of body or of property the wife is entitled to the full control of her movable property, but cannot alien her immovable property without her husband's consent, or legal authority. On the death of either party the property is divided in equal moities between the survivor and the heirs of the deceased.

Law of England.—The English common law has as usual followed its own course in dealing with this subject, and in no department are its rules more entirely insular and independent. The text writers all assume two fundamental principles, which between them establish a system of rights totally unlike that we have just described. Husband and wife are said to be one person in the eye of the law—*unica persona, quia caro una et sanguis unus.* Hence a man cannot grant or give anything to his wife, because she is himself, and if there are any compacts between them before marriage they are dissolved by the union of persons. Hence, too, the old rule of law, now greatly modified, that husband and wife could not be allowed to give evidence against each other, in any trial, civil or criminal. The unity, however, is one-sided only; it is the wife who is merged in the husband, not the husband in the wife. And when the theory does not apply, the disabilities of "coverture" suspend the active exercise of the wife's legal faculties. The old technical phraseology describes husband and wife as *baron* and *femme*; the rights of the husband are baronial rights. From one point of view the wife is merged in the husband, from another she is as one of his vassals. A curious example is the immunity of the wife in certain cases from punishment for crime committed in the presence and on the presumed coercion of the husband. "So great a favourite," says Blackstone, "is the female sex of the laws of England."

The application of these principles with reference to the property of the wife, and her capacity to contract, may now be briefly traced.

The *freehold property* of the wife becomes vested in the husband and herself during the coverture, and he has the management and the profits. If the wife has been in actual possession at any time during the marriage of an estate of inheritance, and if there has been a child of the marriage capable of inheriting, then the husband becomes entitled on his wife's death to hold the estate for his own life as tenant by the *curtesy of England* (*curialitas*).[1] Beyond this, however, the husband's rights do not extend, and the wife's heir at last succeeds to the inheritance. The wife cannot part with her real estate without the concurrence of the husband; and even so she must be examined apart from her husband, to ascertain whether she freely and voluntarily consents to the deed.

With regard to personal property, it passes absolutely at common law to the husband. Specific things in the possession of the wife (*choses* in possession) become the property of the husband at once; things not in possession, but due and recoverable from others (*choses* in action), may be recovered by the husband. A *chose* in action not reduced into actual possession, when the marriage is dissolved by death, reverts to the wife if she is the survivor; if the husband survives, he can obtain possession by taking out letters of administration. A *chose* in action is to be distinguished from a specific thing which, although the property of the wife, is for the time being in the hands of another. In the latter case the property is in the wife, and passes at once to the husband; in the former the wife has a mere *jus in personam*, which the husband may enforce if he chooses, but which is still capable of reverting to the wife if the husband dies without enforcing it.

The *chattels real* of the wife (*i.e.*, personal property, dependent on, and partaking of, the nature of reality, such as leaseholds) pass to the husband, subject to the wife's right of survivorship, unless barred by the husband by some act done during his life. A disposition by will does not bar the wife's interest; but any disposition *inter vivos* by the husband will be valid and effective.

The courts of equity, however, greatly modified the rules of the common law by the introduction of the wife's *separate estate, i.e.*, property settled to the wife for her separate use, independently of her husband. The principle seems to have been originally admitted in a case of actual separation, when a fund was given for the maintenance of the wife while living apart from her husband. And the conditions under which separate estate may be enjoyed have taken the court of chancery many generations to develop. No particular form of words is necessary to create a separate estate, and the intervention of trustees, though common, is not necessary. A clear intention to deprive the husband of his common law rights will be sufficient to do so. In such a case a married woman is entitled to deal with her property as if she was unmarried, although the earlier decisions were in favour of requiring her binding engagements to be in writing or under seal. But it is now held that any engagements, clearly made with reference to the separate estate, will bind that estate, exactly as if the woman had been a *femme sole*. Connected with the doctrine of separate use is the equitable contrivance of *restraint on anticipation*, whereby property may be so settled to the separate use of a married woman that she cannot, during coverture, alienate it or anticipate the income. No such restraint is recognized in the case of a man or of a *femme sole*, and it depends entirely on the separate estate; and the separate estate has its existence only during coverture, so that a woman to whom such an estate is given may dispose of it so long as she is unmarried, but becomes bound by the restraint as soon as she is married. In yet another way the court of chancery interfered to protect the interests of married women. When a husband sought the aid of that court to get possession of his wife's *choses* in action, he was required to make a provision for her and her children out of the fund sought to be recovered. This is called the wife's *equity to a settlement*, and is said to be based on the original maxim of chancery jurisprudence, that "he who seeks equity must do equity." Two other property interests of minor importance are recognized. The wife's *pin-money* is a yearly allowance settled on her before marriage for the purchase of clothes and ornaments suitable to her husband's station, but it is not an absolute gift to the separate use of the wife; and a wife surviving her husband cannot claim for more than one year's arrears of pin-money. *Paraphernalia* are jewels and other ornaments given to the wife for the purpose of being worn by her, but not as her separate property. The husband may dispose of them by act *inter vivos* but not by will, unless the will confers other benefits on the wife, in which case she must elect between the will and the paraphernalia.

The corresponding interest of the wife in the property of the husband is much more meagre and illusory. Besides a general right to maintenance at her husband's expense, she has at common law a right to *dower* in her husband's lands, and to a *pars rationabilis* (third) of his personal estate, if he dies intestate. The former, which originally was a solid provision for widows, has by the ingenuity of conveyancers, as well as by positive enactment, been reduced to very slender dimensions. It may be destroyed by a mere declaration to that effect on the part of the husband, as well as by his conveyance of the land or by his will.

The common practice of regulating the rights of husband, wife, and children by marriage settlements obviates the hardships of the common law—at least for the women of

[1] Curtesy or courtesy has been explained by legal writers as "arising *by favour* of the law of England." The word has nothing to do with courtesy in the sense of complaisance.

the wealthier classes. The legislature by the Married Women's Property Acts of 1870 and 1874 has introduced changes, the benefit of which will probably be most keenly felt among the poor. The chief provisions are shortly these:—(1) the earnings of a married woman in an occupation carried on by her apart from her husband are to be held as property settled to her separate use, independent of her husband, and her investments of such earnings are similarly protected; (2) when a woman, married after the passing of the Act, becomes entitled during marriage to personal property as next of kin, or to any sum not exceeding £200 under a deed or will, such property shall belong to her for her separate use; where real property descends to her as heiress of an intestate, the rents and profits thereof shall belong to her for her separate use; (3) in respect of property thus declared to be her "separate estate," she may sue in her own name; on the other hand, her husband is not liable for debts contracted by her before marriage, except to the extent to which he has received property in her right. Married women having separate estates are made liable for the maintenance of their husbands who may become chargeable to any union or parish, and of their children.

A married woman cannot make any contract binding on herself except as to separate estate. She can only bind her husband as his agent, but from the relation of the parties the fact of agency is easily implied. The strongest case is that of a wife whose husband unjustifiably refuses to maintain her; in that case she is his agent, in the sense that he is bound by her contracts for *necessaries* supplied to her. By the Act of 1870 she can insure her own or her husband's life for her separate use.

Law of Scotland.—The law of Scotland on this head differs less from English law than the use of a very different terminology would lead us to suppose. The phrase *communio bonorum* has been employed to express the interest which the spouses have in the *movable* property of both, but its use has been severely censured by a high authority as essentially inaccurate and misleading. Mr Patrick Fraser, in his elaborate and valuable treatise on *Husband and Wife*, contends that there is no real community of goods, and no partnership or societas between the spouses. The wife's movable property, with certain exceptions, and subject to special agreements, becomes as absolutely the property of the husband as it does in English law. The notion of a *communio* is, however, favoured by the peculiar rights of the wife and children on the dissolution of the marriage. Previous to the Act 18 & 19 Vict. c. 23 the law stood as follows. The fund formed by the movable property of both spouses may be dealt with by the husband as he pleases during life; it is increased by his acquisitions and diminished by his debts. The respective shares contributed by husband and wife return on the dissolution of the marriage to them or their representatives if the marriage be dissolved within a year and a day, and without a living child. Otherwise the division is into two or three shares, according as children are existing or not at the dissolution of the marriage. On the death of the husband, his children take one-third (*legitim*), the widow takes one-third (*jus relictæ*), and the remaining one-third (the *dead's part*) goes according to his will or to his next of kin. If there be no children, the *jus relictæ* and the dead's part are each one-half. If the wife die before the husband, her representatives, whether children or not, are creditors for the value of her share. The statute above-mentioned, however, enacts that "where a wife shall predecease her husband, the next of kin, executors, or other representatives of such wife, whether testate or intestate, shall have no right to any share of the goods in communion; nor shall any legacy or bequest, or testamentary disposition thereof by such wife, affect or attach to the said goods or any portion thereof." It also abolishes the rule by which the shares revert if the marriage does not subsist for a year and a day. Two later Acts apply to Scotland the principles of the English Married Women's Property Acts. These are the Act 40 & 41 Vict. c. 29, which protects the earnings, &c., of wives, and limits the husband's liability for antenuptial debts of the wife, and the Act 43 & 44 Vict. c. 26, which enables a woman to contract for a policy of assurance for her separate use.

A wife's *heritable* property does not pass to the husband on marriage, but he acquires a right to the administration and profits. His courtesy, as in English law, is also recognized. On the other hand, a widow has a *terce* or liferent of a third part of the husband's heritable estate, unless she has accepted a conventional provision.

American Law.—In the American States, the revolt against the common law theory of husband and wife has been carried further than in England, and legislation tends in the direction of absolute equality between the sexes. "What are familiarly known as the Married Women's Acts," says a recent writer, "the product of American legislation during the last quarter of a century, aim to secure to the wife the independent control of her own property, and the right to contract, sue, and be sued without her husband, under reasonable conditions" (Schouler's *Law of Domestic Relations*). Each State has, however, taken its own way and selected its own time for introducing modifications of the existing law, so that the legislation on this subject is now exceedingly complicated and difficult. Schouler (*op. cit.*, p. 212) gives an account of the general result in the different States, from which the following is condensed:—In Maine, a liberal right in married women of holding property independently of husband's control, which the wife may, however, relax by written instrument authorizing her husband to manage it; in New Hampshire, the right to hold from strangers, and from her husband (not in fraud of creditors), and to keep earnings when deserted; in Vermont, similar result effected by the Chancery Courts without special legislation; in Massachusetts, a liberal right to acquire separate property; in Rhode Island, property exempt from husband's debts, but his control recognized; in Connecticut, somewhat limited recognition of separate estate; in New York, the most liberal provisions as to property held before or acquired after marriage—a complete emancipation from marital dominion; a similar policy in the laws of New Jersey, Pennsylvania, and Maryland, effected in the last case by the courts rather than by statute; in Ohio, general exemption of wife's estate from her husband's debts; in Indiana, a peculiar policy, on the community system, wife's powers of transfer limited; Illinois, Wisconsin, Minnesota, and Kansas follow closely the legislation of Massachusetts; in Iowa, limited recognition of wife's estate; in California, community of goods recognized after the Spanish system, formerly prevalent there,—so in Nevada; in Oregon, wife's property exempt from husband's debts; in Nebraska, liberal rights recognized in married women; in Missouri, wife's property in land more particularly exempt from husband's debts; in Kentucky, peculiar restraint on husband's marital rights; in Tennessee, wife's property protected, but her right to control not recognized; in Arkansas a liberal policy prevails. The Southern States have been later in taking up this movement, but it is considered likely that they will follow the rest. The peculiar system of Homestead Laws in the Southern and Western States (described in article HOMESTEAD) constitutes an inalienable provision for the wife and family of the householder. (E. R.)

HUSCH, HUSHI, or HUSI, chief town of the Roumanian province of Falciu, Moldavia, is situated on the right bank of the Pruth, about 40 miles south-east of Jassy. It is the seat of the district courts of justice, and of a bishop of the Greek Church. It possesses a cathedral and a normal school, and carries on an active trade in tobacco. The population in 1870 was estimated at 18,000. At Husch was signed in 1711 the treaty of the Pruth, between Russia and Turkey, which freed the army of Peter the Great from a position of great danger.

HUSHIÁRPUR, a British district in the lieutenant-governorship of the Punjab, India, lying between 30° 58′ and 32° 5′ N. lat. and between 75° 31′ and 76° 41′ 15″ E. long. It forms the central district of the Jalandhar division, and is bounded N.E. by the district of Kángra and the native state of Nálagarh, N. and N.W. by the river Bías, S.W. by Jalandhar, and S. by the river Satlaj (Sutlej) and Ambála (Umballa) district.

The district of Hushiárpur falls into two nearly equal portions of hill and plain country. Its eastern face consists of the westward slope of the Kángra Mountains; parallel with that ridge, a line of lower heights traverses the district from south to north, while between the two chains stretches a valley of uneven width, known as the Jaswán Dún. Its upper portion is crossed by the Soán torrent, while the Sutlej sweeps into its lower end by a break in the hills, and flows in a southerly direction till it turns the flank of the central range, and debouches westwards upon the plains. This western plain consists of alluvial formation, with a general westerly slope owing to the deposit of silt from the mountain torrents in the submontane tract. The Bías has a fringe of lowland, open to moderate but not excessive inundations, and considered very fertile. A considerable area is covered by Government woodlands, under the care of the forest department.

The census of 1868 was taken over an area of 2086 square miles, and showed a total population of 938,890 (males, 504,393; females, 434,497). Of these, the Hindus numbered 415,471; Mahometans, 317,967; Síkhs, 79,417; and "others," 126,035. The district contained nine municipalities in 1875-76, namely,—Hushiárpur (see below), Urmar Tanda (13,970), Mukerián (5116), Dasuya (8677), Anandpur (6405), Hariáná (7802), Garhdiwála (3874), Una (4908), and Miáni (Meeanee) (7942). The total imperial revenue in 1872-73 was £148,708; the local revenue for expenditure on works of public utility, £14,856. Fifteen civil and revenue judges exercised jurisdiction in the district. There were 321 schools, with 7066 pupils, receiving £2291 from the public funds.

The cultivated area in 1868 amounted to 751,707 acres, out of an assessed total of 1,335,245. Rice is largely grown, owing to the abundance of marshy flats along the banks of the Bías. The other products are wheat, barley, gram, tobacco, *joár*, maize, *moth*, *mash*, cotton, and sugar-cane. The state of agricultural knowledge is very backward, and implements are of the simplest description. Only 17,836 acres are under irrigation, chiefly from an old canal in the northern corner. The trade of Hushiárpur is confined to its raw material, including grain, sugar, hemp, safflower, fibres, tobacco, indigo, and cotton; of these, sugar forms by far the most important commercial item. The manufactures are of no importance. Several religious fairs are held, at Anandpur, Mukerián, and Achintpurni, all of which attract an enormous concourse of people. The Jalandhar and Kángra road forms the chief route; and good roads connect Hushiárpur and other centres with the neighbouring towns. The district, owing to its proximity to the hills, possesses a comparatively cool and humid climate. Malarious fever, cholera, and bowel complaints are the prevailing illnesses. The annual rainfall in 1871-72 was 32·6 inches. There are five charitable dispensaries.

The country around Hushiárpur formed part of the Katoch kingdom of Jalandhar. The state was eventually broken up, and the present district was divided between the rájás of Ditárpur and Jaswán. They retained undisturbed possession of their territories until 1759, when the rising Síkh chieftains commenced a series of encroachments upon the hill tracts. In 1815 the aggressive mahárájá, Ranjít Sinh, forced the ruler of Jaswán to resign his territories in exchange for an estate on feudal tenure; three years later the rájá of Ditárpur met with similar treatment. By the close of the year 1818 the whole country from the Sutlej to the Bías had come under the Government of Lahore, and after the first Síkh war in 1846 passed into the hands of the English Government. The deposed rájás of Ditárpur and Jaswán received cash pensions from the new rulers, but expressed bitter disappointment at not being restored to their former sovereign position. Accordingly the outbreak of the Mooltan war, and the revolt of Chatthr Sinh in 1848, found the disaffected chieftains ready for rebellion. They organized a revolt, but the two rájás and the other ringleaders were captured, and their estates confiscated.

HUSHIÁRPUR, municipal town and administrative headquarters of the above district, is situated on the bank of a broad sandy torrent. The population in 1868 numbered 13,022, comprising 6350 Hindus, 6002 Mahometans, 119 Síkhs, 62 Christians, and 489 "others." The town was founded, according to tradition, about the early part of the 14th century. In 1809 it was occupied by Ranjít Sinh. The mahárájá and his successors maintained a considerable cantonment one mile south-east of the town, and the British Government kept it up for several years after the annexation. Floods often cause much damage, to guard against which an embankment was raised in 1852. The civil station contains the district court-house and treasury, sessions-house, *tahsíl* and police offices, dispensary, staging bungalow, and *saráí*. Both station and town are plentifully wooded, and enjoy a good sanitary reputation. There is a trade in grain, sugar, and tobacco.

HUSKISSON, WILLIAM (1770-1830), statesman and financier, was descended from an old Staffordshire family of moderate fortune, and was born at Birch Moreton, Worcestershire, March 11, 1770. Having been placed in his fourteenth year under the charge of his uncle Dr Gem, physician to the English embassy at Paris, he passed his early years amidst a political fermentation which led him to take a deep and absorbing interest in politics. But though he approved of the French Revolution, his sympathies were with the more moderate party, and he became a member of the "club of 1789," instituted to support the new form of constitutional monarchy in opposition to the anarchical attempts of the Jacobins. Even at this early period he displayed his mastery of the principles of finance by a *Discours* delivered in August 1790 before this society, in regard to the issue of assignats by the Government. The *Discours* gained him considerable reputation, but as it failed in its purpose he withdrew from the society. In January 1793 he was appointed by Mr Dundas to an office created with a view to direct the execution of the Aliens Act; and in the discharge of his delicate duties he manifested such ability that in 1795 he was appointed under secretary in the colonial department. In the following year he entered parliament as member for Morpeth, but for a considerable period he took scarcely any part in the debates. On the retirement of Pitt in 1801 he resigned office, and after contesting Dover unsuccessfully he withdrew for a time into private life. Having in 1804 been chosen to represent Liskeard, he was on the restoration of the Pitt ministry appointed secretary of the treasury, holding office till the dissolution of the ministry after the death of Pitt in January 1806. After being elected for Harwich in 1807, he accepted the same office under the duke of Portland, but he withdrew from the ministry along with Canning in 1809. In the following year he published a pamphlet on the currency system, which confirmed his reputation as the ablest financier of his time; but his free-trade principles did not accord with those of his party. When in 1814 he re-entered the public service, it was only as chief commissioner of woods and forests, but his influence was from this time very great in the commercial and financial legislation of the country. He took a prominent part in the corn-law debates of 1814 and 1815; and in 1819 he presented a memorandum to Lord Liverpool advocating a large reduction in the unfunded debt, and explaining a method for the resumption of cash payments, which was embodied in the Act passed the same year. In the following year he was named a member of the committee appointed to inquire into the causes of the agricultural distress then prevailing in the country, and the proposed relaxation of the corn laws embodied in the report was understood to have been chiefly due to his strenuous advocacy. In 1823 he was appointed president of the board of trade and treasurer of the navy, and shortly afterwards he received a seat in the cabinet. In the same year he was returned for Liverpool, having from 1812 represented Chichester. Among the more important legislative changes with which he was principally connected were a reform of the Navigation Acts, admitting other nations to a full equality and reciprocity of shipping duties; the repeal of the labour laws; the introduction of a new sinking fund; the reduction of the duties on manufactures and on the importation of foreign goods, and the repeal of the quarantine duties. In accordance with his suggestion Canning in 1827 introduced a measure on the corn laws proposing the adoption of a sliding scale to regulate the amount of duty. The bill passed the House of Commons, but a misapprehension between Huskisson and the duke of Wellington led to the duke proposing an amendment, the success of which caused the abandonment of the measure by the Government. After the death of Canning in the same year Huskisson accepted the secretaryship of the colonies under Lord Goderich, an office which he continued to hold in the new cabinet formed by the duke of Wellington in the following year. From the beginning the cabinet was rent by internal disputes, and, after succeeding with great difficulty in inducing the cabinet to agree to a compromise on the corn laws, Huskisson finally resigned office in May 1829 on account of a difference with his colleagues in regard to the disfranchisement of East Retford. On the 15th September of the following year he was accidentally killed by a locomotive engine while present at the opening of the Liverpool and Manchester Railway.

HUSS, JOHN (1369–1415), the Bohemian reformer and martyr, was born at Hussinecz,[1] a market village at the foot of the Böhmerwald, and not far from the Bavarian frontier, most probably in 1369, and, according to some accounts, on July 6. His parents appear to have been well-to-do Czechs of the peasant class. Of his early life nothing is recorded except that, notwithstanding the early loss of his father, he obtained a good elementary education, first at Hussinecz, and afterwards at the neighbouring town of Prachaticz. At, or only a very little beyond, the usual age he entered the recently (1348) founded university of Prague, where he became bachelor of arts in 1393, bachelor of theology in 1394, and master of arts in 1396. In 1398 he was chosen by the Bohemian "nation" of the university to an examinership for the bachelor's degree; in the same year he began to lecture also, and there is reason to believe that the philosophical writings of Wickliffe, with which he had been for some years acquainted, were his text-books. In October 1401 he was made dean of the philosophical faculty, and for the half-yearly period from October 1402 to April 1403 he held the office of rector of the university. In 1402 also he was made rector or curate (capellarius) of the Bethlehem Chapel, which had in 1391 been erected and endowed by some zealous citizens of Prague for the purpose of providing good popular preaching in the Bohemian tongue. This appointment, which, so far as the aims of the pious founders were concerned, proved a singularly successful one, had a deep influence on the already vigorous religious life of Huss himself; and one of the effects of the earnest and independent study of Scripture into which it soon led him was a profound conviction of the great value not only of the philosophical but also of the theological writings of Wickliffe.

This newly-formed sympathy with the English reformer did not, however, in the first instance at least, involve Huss in any conscious opposition to the established doctrines of Catholicism, or in any direct conflict with the authorities of the church; and for several years he continued to act in full accord with his archbishop (Sbynjek, or Sbynko, of Hasenburg). Thus in 1405 he, along with other two masters, was commissioned to examine into certain reputed miracles at Wilsnack, near Wittenberg, which had caused that church to be made a resort of pilgrims from all parts of Europe. The result of their report was that all pilgrimage thither from the province of Bohemia was prohibited by the archbishop on pain of excommunication, while Huss, with the full sanction of his superior, gave to the world his first published writing, entitled *De Omni Sanguine Christi Glorificato*, in which he declaimed in no measured terms against forged miracles and ecclesiastical greed, urging Christians at the same time to desist from looking for sensible signs of Christ's presence, but rather to seek Him in His enduring word. More than once also Huss, along with his friend Stanislaus of Znaim, was appointed to be synod preacher, and in this capacity he delivered at the provincial councils of Bohemia many faithful admonitions. As early as May 28, 1403, it is true, there had been held a university disputation about the new doctrines of Wickliffe, which had resulted in the condemnation of certain propositions presumed to be his; five years later (May 20, 1408) this decision had been refined into a declaration that these, forty-five in number, were not to be taught in any heretical, erroneous, or offensive sense. But it was only slowly that the growing sympathy of Huss with Wickliffe unfavourably affected his relations with his colleagues in the priesthood. In 1408, however, the clergy of the city and archiepiscopal diocese of Prague laid before the archbishop a formal complaint against Huss, arising out of strong expressions with regard to clerical abuses of which he had made use in his public discourses; and the result was that, having first been deprived of his appointment as synodal preacher, he was, after a vain attempt to defend himself in writing, publicly forbidden the exercise of any priestly function throughout the diocese. Simultaneously with these proceedings in Bohemia, international negotiations had been going on which had for their object the removal of the long-continued papal schism, and it had in the interval become apparent that a satisfactory solution of the difficulties involved could only be secured if, as seemed not impossible, the supporters of the rival popes, Benedict XIII. and Gregory XII., could be induced, in view of the approaching council of Pisa, to pledge themselves to a strict neutrality. With this end King Wenceslaus of Bohemia had requested the co-operation of the archbishop and his clergy, and also the support of the university, in both instances unsuccessfully, although in the case of the latter the Bohemian "nation," with Huss at its head, had only been overborne by the votes of the Bavarians, Saxons, and Poles. There followed an expression of nationalist and particularistic as opposed to ultramontane and also to German feeling, which undoubtedly was of supreme importance for the whole of the subsequent career of Huss. In compliance with this feeling a royal edict (January 18, 1409) was issued, by which, in alleged conformity with Paris usage, and with the original charter of the university, the Bohemian "nation" received three votes, while only one was allotted to the other three "nations" combined; whereupon all the foreigners, to the number of several thousands, almost immediately withdrew from Prague, an occurrence which led to the formation shortly afterwards of the university of Leipsic.

It was a dangerous triumph for Huss; for his popularity at court and in the general community had been secured only at the price of clerical antipathy everywhere and of much German ill-will. Among the first results of the changed order of things were on the one hand the election of Huss (October 1409) to be again rector of the university, but on the other hand the appointment by the archbishop of an inquisitor to inquire into charges of heretical teaching and inflammatory preaching which had been brought against him. He had spoken disrespectfully of the church, it was said, had even hinted that Antichrist might be found to be in Rome, had fomented in his preaching the quarrel between Bohemians and Germans, and had, notwithstanding all that had passed, continued to speak of Wickliffe as both a pious man and an orthodox teacher. The direct result of this investigation is not known, but it is impossible to disconnect from it the promulgation by Pope Alexander V., on December 20, 1409, of a bull which ordered the abjuration of all Wickliffite heresies and the surrender of all his books, while at the same time—a measure specially levelled at the pulpit of Bethlehem Chapel—all preaching was prohibited except in localities which had been by long usage set apart for that use. This decree, as soon as it was published in Prague (March 9, 1410), led to much popular agitation, and provoked an appeal by Huss to the pope's better informed judgment; the archbishop, however, resolutely insisted on carrying out his instructions, and in the following July caused to be publicly burned, in the courtyard of his own

[1] From which the name Huss, or more properly Hus, an abbreviation adopted by himself about 1396, is derived. Prior to that date he was invariably known as Johann Hussynecz, Hussinecz, Hussenicz, or De Hussynecz.

palace, upwards of 200 volumes of the writings of Wickliffe, while he pronounced solemn sentence of excommunication against Huss and certain of his friends, who had in the meantime again protested and appealed to the new pope (John XXIII.). Again the populace rose on behalf of their hero, who, in his turn, strong in the conscientious conviction that "in the things which pertain to salvation God is to be obeyed rather than man," continued uninterruptedly to preach in the Bethlehem Chapel, and in the university began publicly to defend the so-called heretical treatises of Wickliffe, while from king and queen, nobles and burghers, a petition was sent to Rome praying that the condemnation and prohibition in the bull of Alexander V. might be quashed. Negotiations were carried on for some months, but in vain; in March 1411 the ban was anew pronounced upon Huss as a disobedient son of the church, while the magistrates and councillors of Prague who had favoured him were threatened with a similar penalty in case of their giving him a contumacious support. Ultimately the whole city, which continued to harbour him, was laid under interdict; yet he went on preaching, and masses were celebrated as usual, so that at the date of Archbishop Sbynko's death in September 1411, it seemed as if the utmost efforts of ecclesiastical authority had resulted in absolute failure.

The struggle, however, entered on a new phase with the appearance at Prague in May 1412 of the papal emissary charged with the proclamation of the papal bulls by which a religious war was decreed against the excommunicated King Ladislaus of Naples, and indulgence was promised to all who should take part in it, on terms similar to those which had been enjoyed by the earlier crusaders to the Holy Land. By his bold and thorough-going opposition to this mode of procedure against Ladislaus, and still more by his doctrine that indulgence could never be sold without simony, and could not be lawfully granted by the church except on condition of genuine contrition and repentance, Huss at last isolated himself, not only from the archiepiscopal party under Albik of Unitschow, but also from the theological faculty of the university, and especially from such men as Stanislaus of Znaim and Stephen Paletz, who until then had been his chief supporters. A popular demonstration, in which the papal bulls had been paraded through the streets with circumstances of peculiar ignominy and finally burnt, led to intervention by Wenceslaus on behalf of public order; three young men, for having openly asserted the unlawfulness of the papal indulgence after silence had been enjoined, were sentenced to death (June 1412); the excommunication against Huss was renewed, and the interdict again laid on all places which should give him shelter,—a measure which now began to be more strictly regarded by the clergy, so that in the following December he had no alternative but to yield to the express wish of the king by temporarily withdrawing from Prague. A provincial synod, held at the instance of Wenceslaus in February 1413, broke up without having reached any practical result; and the labours of a commission appointed shortly afterwards were equally unsuccessful in the attempt to bring about a reconciliation between Huss and his adversaries. The so-called heretic meanwhile spent his time partly at Kozihradek, some 45 miles south of Prague, and partly at Krakowitz in the immediate neighbourhood of the capital, sometimes varying the monotony of his life with an occasional course of open-air preaching, but finding his chief employment in maintaining with his numerous friends that copious correspondence of which some precious fragments still are extant, and in the composition of the largest and most exhaustive of all his printed works, the *De Ecclesia*, which subsequently furnished most of the material for the capital charges brought against him.

During the year 1413 the arrangements for the meeting of a general council at Constance were agreed upon between Sigismund and Pope John XXIII. The objects originally contemplated had been the restoration of the unity of the church and its reform in head and members; but so great had become the prominence of Bohemian affairs that to these also a first place in the programme of the approaching œcumenical assembly required to be assigned, and for their satisfactory settlement the presence of Huss was obviously necessary. His attendance was accordingly requested, and the invitation was willingly accepted as giving him a long-wished-for opportunity both of publicly vindicating himself from charges which he felt to be grievous and of loyally making confession for Christ. He set out from Bohemia on October 14, 1414, not, however, until he had carefully ordered all his private affairs, with a presentiment, which he did not conceal, that in all probability he was going to his death. The journey, which appears to have been undertaken with the usual passport, and under the protection of several powerful Bohemian friends (John of Chlum, Wenceslaus of Duba, Henry of Chlum) who accompanied him, was a very prosperous one; and at almost all the halting places he was received with a consideration and enthusiastic sympathy which he had hardly expected to meet with anywhere in Germany. On November 3 he arrived at Constance, and took up quarters in the house which is still pointed out (Paulsgasse, 328); shortly afterwards there was put into his hands the famous imperial "safe conduct," the promise of which had been one of his inducements to quit the comparative security he had enjoyed in Bohemia. Of this safe conduct, the formal words of which have often been quoted, it would be absurd to say that it was intended to guarantee its holder against the infliction of due punishment should he be convicted by existing law of any crime; but there can be no doubt that both the letter and the spirit of it were scandalously violated, when on November 28 Huss was arbitrarily seized and thrown into prison before any accusation whatever had been formulated. Sigismund himself never sought to defend this act, which was not done with his consent or authority; the only excuse he ever alleged for having tolerated it was that otherwise in all likelihood the council would have been broken up. On December 4 the pope appointed a commission of three bishops to investigate the case against the heretic, and to procure witnesses; to the demand of Huss that he might be permitted to employ an agent in his defence a favourable answer was at first given, but afterwards even this concession to the forms of justice was denied. While the commission was engaged in the prosecution of its inquiries, the flight of Pope John XXIII. took place on March 20, an event which furnished a pretext for the removal of Huss from the Dominican convent to a more secure and more severe place of confinement under the charge of the bishop of Constance at Gottlieben on the Rhine. On May 4 the temper of the council on the doctrinal questions in dispute was for the first time fully revealed in its unanimous condemnation of Wickliffe, especially of the so-called "forty-five articles" as erroneous, heretical, revolutionary. It was not, however, until June 5 that the case of Huss himself came up for hearing; the meeting, which was an exceptionally full one, took place in the refectory of the Franciscan cloister. Autograph copies of his work *De Ecclesia*, and of the controversial tracts which he had written against Paletz and Stanislaus of Znaim, having been laid before him and duly acknowledged, the extracted propositions on which the prosecution based their charge of heresy were read; but as soon as the accused began to analyse them and to enter upon his defence, he was assailed by violent outcries, amidst which it was impossible for him to be heard, so that he was compelled to bring his speech to an abrupt close, which he did with the calm remark; "In such a council as this I had expected to find more propriety, piety, and order." It was found necessary to adjourn the sitting until June 7, on which occasion the outward decencies were better observed, partly no doubt from the circumstance that the emperor was present in person. The propositions which had been extracted from the *De Ecclesia* were again brought up, and the relations between Wickliffe and Huss were discussed, the object of the prosecution being to fasten upon the latter the charge of having entirely adopted the doctrinal system of the former, including especially a denial of the doctrine of transubstantiation. The accused defended himself by repudiating the charge of having abandoned the Catholic doctrine, while at the same time he gave expression to his hearty admiration and respect for the memory of Wickliffe. Being next asked to make an unqualified submission to the council, he expressed himself as unable to do so, while at the same time stating his willingness in all humility to amend his teaching wherever it had been shown to be false. With this the proceedings of the day were brought to a close. On June 8 the propositions extracted from the *De Ecclesia* were once more taken up with some fulness of detail; some of these he repudiated as incorrectly given, others he defended; but when asked to make a general recantation he steadfastly declined on the ground that to do so would be a dishonest admission of previous guilt. Among the propositions he could heartily abjure was that relating to transubstantiation; among those he felt constrained unflinchingly to maintain was one which had given great offence, to the effect that Christ, not Peter, is the head of the church to whom ultimate appeal must be made. The council, however, showed itself inaccessible to all his arguments and explanations, and its final resolution, as announced by D'Ailly, was threefold:—first, that Huss should humbly declare that he had erred in all the articles cited against him; secondly, that he should promise on oath neither to hold nor teach them in the future; thirdly, that he should publicly recant them. On his declining to make this submission he was removed from the bar, and it was obvious that the end could not be far off. The emperor himself gave it as his opinion that it had been clearly proved by many witnesses that the accused had taught many pernicious heresies, and that even should he recant he ought never to be allowed to preach or teach again or to return to Bohemia, but that should he refuse recantation there was no remedy but the stake. During the next four weeks no effort was spared to shake the determination of Huss; but the spirit of the martyr rose within him as he saw his end approaching, and he steadfastly refused to swerve from the path which conscience had once made clear. "I write this," says he, in a letter to his friends at Prague, "in prison and in chains, expecting tomorrow to receive sentence of death, full of hope in God that I shall not swerve from the truth, nor abjure errors imputed to me by false witnesses." The sentence he expected was pronounced on July 6 in the presence of the emperor and a full sitting of the council; once and again he attempted to remonstrate, but in vain, and finally he betook himself to silent prayer. After he had undergone the ceremony of degradation with all the childish formalities which are usual on such occasions, his soul was formally consigned by all those present to the devil, while he himself with clasped hands and uplifted eyes reverently committed it to Christ. He was then handed over to the secular arm, and immediately led off to the place of execution, the council meanwhile proceeding unconcernedly with the rest of its business for the day. Many touching incidents recorded in the histories make manifest the meekness, fortitude, and even cheerfulness with which he went to his dreadful death. After he had been tied to the stake and the faggots had been piled, he was for the last time urged to recant, but his only reply was:—"God is my witness that I have never taught or preached that which false witnesses have testified against me. He knows that the great object of all my preaching and writing was to convert men from sin. In the truth of that gospel which hitherto I have written, taught, and preached, I now joyfully die." The fire was then kindled, and his voice as it audibly prayed in the words of the "Kyrie Eleison" was soon stifled in the smoke. When the flames had done their office, the ashes that were left and even the soil on which they lay were carefully removed and thrown into the Rhine.

Not many words are needed to convey a tolerably adequate estimate of the character and work of the "pale thin man in mean attire," who in sickness and poverty thus completed the forty-sixth year of a busy life at the stake. Huss was much less remarkable for the amount of his mental endowments and acquirements than for the candour with which he formed his convictions, the tenacity with which he held them, the unselfish enthusiasm with which he spoke them. He cannot be said to have added a single new item to the intellectual wealth of the world, but his contribution to its moral capital was immense. It might not be easy to formulate very precisely the doctrines for which he died, and certainly some of them, as, for example, that regarding the church, were such as many Protestants even would regard as unguarded and difficult to harmonize with the maintenance of external church order; but his is undoubtedly the honour of having been the chief intermediary in handing on from Wickliffe to Luther the torch which kindled the Reformation, and of having been one of the bravest of the martyrs who have died in the cause of honesty and freedom, of progress and of growth towards the light.

The works of Huss are usually classed under four heads:—the dogmatical and polemical, the homiletical, the exegetical, and the epistolary. Of those belonging to the first category, the earliest was that *De Omni Sanguine Christi Glorificato*, already referred to; others, besides the *De Ecclesia*, are a *Quæstio de Indulgentiis*, relating to the bull of Pope John XXIII. against Ladislaus, *Responsio ad Scripta M. S. Paletz*, *Responsio ad Scripta M. S. de Znoyma*, and a *Refutation of the Writing of the Eight Doctors of Prague*. The sermons include several discourses relating to Antichrist. It is worthy of note, in connexion with these, that by means of them and his other public teaching Huss exercised a considerable influence, not only on the religious life of his time, but on the literary development of his native tongue. His exegetical writings include *A History of Jesus Christ according to the Four Gospels*, *A History of the Passion*, *An Exposition of* 1 Cor. i.–vii., *Commentaries* on the epistles of James, Peter, John, and Jude, and an *Enarratio* on Psalms cx.–cxviii. The *Letters* are arranged in two series, one of which, numbering fifteen, relates to the period of his exile under the interdict, while the other, fifty-six in all, belongs to the time when he lived in Constance. The *De Ecclesia* was printed by Ulrich von Hutten as early as 1520, others of the controversial writings by Otto Brunnfels in 1524; and Luther wrote an interesting preface to *Epistolæ Quædam* published in 1537. The earliest collected edition of the Latin works was that of Nuremberg (*Historia et Monumenta Joh. Huss atque Hieron. Pragensis*), published in 1558 in 2 vols. folio; this was reprinted with a considerable quantity of new matter in 1715. The Bohemian works have recently been edited by K. J. Erben (3 vols., Prague, 1866).

On Huss the best and most easily accessible information for the English readers is to be found in the Church Histories, especially in that of Neander (vol. ix., Engl. trans. 1858), and pre-eminently in Lechler's *Wiclef* (1873), translated by Lorimer (1878). Among the earlier authorities is Æneas Sylvius, *De Bohemorum Origine ac Gestis Historia* (1475). The *Acta* of the council of Constance (Labbe *Conc.*, vol xvi., 1731, or Von der Hardt, *Concilium Constantiense*, 1697–1700), as also Lenfant's *Histoire*, must of course be consulted. Palacky's *Geschichte Böhmens* (1836–65) contains much valuable material carefully sifted. The earliest biography is that of Zitte, *Lebensbeschreibung des Magisters Joh. Hus* (1789–95). Monographs have in recent years been very numerous: among others may be mentioned Helfert, *Studien über Hus u. Hieronymus* (1853; this work is ultramontane in its sympathies); Becker, *Hus u. Hieronymus von Prag* (Nördlingen, 1858); Friedrich, *Johann Hus* (1863); Krummel, *Joh. Hus, eine Kirchenhist. Studie* (1863); Id., *Geschichte der böhm. Reformation* (1866); Höfler, *Hus u. der Abzug der Deutschen* (1864); Id., *Die Geschichtschreiber der Husitischen Bewegung* (1856–65); Id., *Fontes Rerum Husiticarum*; Berger, *Joh. Hus u. König Sigismund* (1872); Denis, *Huss et la Guerre des Hussites* (Paris, 1878). (J. S. BL.)

HUSSITES. The arbitrary arrest and imprisonment of Huss at Constance in November 1415 created a very painful impression among all classes in Moravia and Bohemia, and called forth angry remonstrances as soon as it was known. While the nobles resorted to diplomacy, the masses rioted and in many instances attacked the clergy. The excitement was immensely intensified by the tidings of his death, which was freely characterized as a judicial murder; several priests were put to death by the infuriated populace, who cherished the memory of Huss as that of a patriot and a saint; and the archbishop himself, after having been beset in his own palace, with difficulty saved his life by flight. Public feeling found its first organized expression in a diet which was hastily summoned to meet at Prague early in September; there a solemn protest, ultimately signed by 452 magnates and barons, was drawn up, in which the personal character of Huss as man, teacher, preacher, and author was warmly upheld, and the freedom of Bohemia and Moravia from error and heresy was as energetically asserted. Three days later the nobles who had signed this document formed themselves into a league, headed by two Bohemian barons and one from Moravia, by which they bound themselves to protect liberty of preaching on their estates, and to yield obedience to bishop or pope only in so far as might be in accordance with Scripture and the will of God. Matters of dispute were to be subjected to the arbitration of the rector and doctors in theology of the university of Prague. Soon afterwards a counter league was formed for the support of the council and curia; and civil war appeared to be imminent. The tension was further increased by the arrival of the bishop of Leitomischl, long the enemy of Huss, as legate from the council for the extirpation of heresy; and by the pressure of the interdict under which the city of Prague continued to lie. In February 1416 the 452 nobles who had signed the protest in favour of Huss were summoned to appear before the council, while the anti-Hussite league was encouraged to prepare for a crusade; and the burning of Jerome of Prague in the following May still further revealed the prevailing disposition of Catholic Christendom. Owing to the slowness, however, with which matters moved at Constance, it was not until February 1418 that the new pope, Martin V. (Otto di Colonna), was able to issue various bulls and briefs, in which he laid all obstinate Hussites under the ban, and called upon all the ecclesiastical and civil authorities to proceed against them. The council also, shortly before its dissolution, drew up twenty-four articles for withdrawing the Bohemians from the prevailing heresy, bidding King Wenceslaus protect the rights of the Romish Church in his dominion, restore the banished clergy to their benefices, repress the Hussite preaching and hymn singing, dissolve the Hussite associations, and take the ringleaders into custody. To this policy the king after much vacillation began to give effect early in 1419, and forthwith the more prominent Hussites withdrew from court; among these were Nicolaus of Pistna, an able statesman, and the famous John Zizka, a practised soldier, who placed themselves at the head of the malcontents. By the end of the year the war, though it is usually reckoned from 1420, may be said to have begun. It divides itself into two periods—the defensive, which lasted from 1420 to 1425, and the offensive, which began with Procopius's invasion of Germany in 1427, and lasted until the commencement of negotiations with the council of Basel in 1431. The struggle had not proceeded very far, however, before it became manifest that the Hussite party was itself sharply divided in views and aims. All were agreed in warm and tender reverence for the memory of Huss, the evangelical preacher and the faithful servant of Christ; equally unanimous were they in holding the distinctive doctrine of the supreme authority of Holy Scripture, and in urging the reformation of the church. But all were not prepared to go equally far in the amount of reform they proposed. While the more radical section rejected such doctrines as those of purgatory and of the mediation of saints, held that priests in mortal sin could validly administer no sacrament, disapproved of penances, images, relics, mass in a foreign tongue, maintained the right of the pious laity, even of women, to preach, and regarded every building as in itself at least suitable for acts of divine worship, the more moderate or conservative section formulated their much simpler programme in the famous four articles of Prague (July 1420). These were—(1) free preaching of the word of God throughout the kingdom of Bohemia; (2) the administration of the eucharist to all believers not in mortal sin, under both species according to the institution of Christ; (3) deprivation of the clergy of the secular lordship they had assumed and of the secular property they had acquired to their own injury and to the prejudice of the civil power; (4) prohibition and repression of all mortal sins and public scandals. The supporters of these articles, who were led by Baron Czenko of Wartenberg, and had in their number such men as Jakob von Mies, were strong in the town and university of Prague, and occasionally received the name of the Praguers, but ultimately came to be more generally known as Calixtines (from "calix") or Utraquists (from their claim to receive the communion "sub utraque specie"). The more radical party, from having taken up their headquarters at a stronghold which had been fortified by Zizka and called Mount Tabor, some 65 miles southwards of Prague, received the name of Taborites. Whatever differences, however, may have separated the Hussites, all were united in offering resistance to the efforts made by Sigismund to crush them; and at Deutschbrod in 1422, at Aussig in 1426, and finally at Taus (August 14, 1431), they inflicted signal defeats on his troops. Negotiations begun in 1431 with the council of Basel reached a termination only in November 1433, when the so-called "Compactata" or articles of agreement were signed by which the Calixtines were satisfied, communion under both species being granted to all who desired it, although the other concessions in the direction of the four articles of Prague were made in a somewhat illusory manner. The Taborites, or "Orphans" (as the followers of Zizka were sometimes called after his death in 1424), failed, however, to find in the Compactata all that they required, and they speedily took the field again in a campaign which terminated disastrously for them at Hrib near Böhmischbrod on May 30, 1434. In this battle both Procopius and his brother perished; and soon afterwards the Taborites were compelled to surrender all the fortresses to which they had betaken themselves. Thenceforward they rapidly disappeared as a political party, although as a religious body they can be traced to about the middle of the century, when they gradually became merged in the so-called Moravians, or United Brethren of Bohemia. The Calixtines obtained from Sigismund in 1436 the formal recognition of the Compactata, which from that time had the force of law. Satisfied with this somewhat empty achievement (which, however, was jealously guarded against the hostile attack of Pius II. in 1462), they gradually subsided into an inert conformity, so as to be but little distinguished from the Catholics around them At the time of the Reformation some returned to the Roman Church, while the rest attached themselves either to the Lutheran or to the Reformed creed, and Hussitism as a distinct form of Christian profession became extinct.

See Cochlæus, *Hist. Hussitarum* (1549); Palacky, *Urkundliche Beiträge zur Gesch. d. Husitenkrieges* (1872–74). (J. S. BL.)

HUSUM, a town in the Prussian province of Schleswig-Holstein, situated in a fertile district about 2½ miles inland from the German Ocean, on the canalized Husumer Au, which forms its harbour and roadstead. It is a station on the branch railway from Tönning which joins the main line at Jübek; and it has steam communication with the North Frisian Islands (Nordstrand, Pellworm, Föhr, Sylt) and with England. Besides the old ducal palace and park, it possesses two court-houses and a gymnasium, and its public endowments are reckoned at £100,000. There is a considerable local trade; grain and cattle are exported; and the oyster-beds in the neighbourhood yield during the season about 60,000 oysters daily. The population of the town in 1875 was 5765. Husum is first mentioned in 1252, and its first church was built in 1431. Wisby rights (see vol. xi. p. 449) were granted it in 1582, and in 1608 it was raised to the rank of a town by Duke Adolphus, who was also the builder of the castle. Husum is the birthplace of Forchhammer the archæologist, Forchhammer the mineralogist, and Theodor Storm the poet.

HUSZT, a market-town in the county of Máramaros, Hungary, is situated at the confluence of the Nagy-Ág with the Theiss, and about midway on the line of railway from Szatmár-Németi to Máramaros-Sziget, 48° 10′ N. lat., 23° 18′ E. long. At Huszt there are Calvinist, Roman Catholic, and Old United Greek churches, royal law courts, and other Government offices. On an elevated and picturesque position near the town are the ruins of an old fortress. In the neighbourhood of Huszt flax and cereals are largely grown, and many of the inhabitants find employment in fishing. The population in 1870 was 6413, consisting for the most part of Magyars and Ruthenians.

HUTCHESON, Francis (1694–1746), an eminent writer on mental and moral philosophy, was born on the 8th of August 1694. His birthplace was probably the townland of Drumalig, in the parish of Saintfield and county of Down, Ireland.[1] Though the family had sprung from Ayrshire in Scotland, both his father and grandfather were ministers of dissenting congregations in the north of Ireland. Young Hutcheson was educated partly by his grandfather, partly at an academy, where he is stated by his biographer, Dr Leechman, to have been taught "the ordinary scholastic philosophy which was in vogue in those days." In the year 1710, at the age of sixteen, he entered the university of Glasgow, where he spent the next six years of his life, at first in the study of philosophy, classics, and general literature, and afterwards in the study of theology. On quitting the university, he returned to the north of Ireland, received a licence to preach, and was just on the point of settling down as the minister of a small dissenting congregation, when it was suggested to him by some gentlemen living in the neighbourhood of Dublin to start a private academy in that city. At Dublin his literary accomplishments soon made him generally known, and he appears to have rapidly formed the acquaintance of the more notable persons, lay and ecclesiastical, who then resided in the metropolis of Ireland. Among these is specially to be noted Archbishop King, author of the well-known work *De Origine Mali*, who, to his great honour, steadily resisted all attempts to prosecute Hutcheson in the archbishop's court for keeping a school without having previously subscribed to the ecclesiastical canons and obtained the episcopal licence. Hutcheson's relations with the clergy of the Established Church, especially with the archbishops of Armagh and Dublin, Boulter and King, seem to have been of the most cordial description; and "the inclination of his friends to serve him, the schemes proposed to him for obtaining promotion," &c., of which his biographer speaks, probably refer to some offers of preferment, on condition of his accepting episcopal ordination. These offers, however, of whatever nature they might be, were unavailing; "neither the love of riches nor of the elegance and grandeur of human life prevailed so far in his breast as to make him offer the least violence to his inward sentiments."

[1] See *Belfast Magazine* for August 1813.

While residing in Dublin, Hutcheson published anonymously the four essays by which he still remains best known, namely, the *Inquiry concerning Beauty, Order, Harmony, Design*, and the *Inquiry concerning Moral Good and Evil*, in 1725, and the *Essay on the Nature and Conduct of the Passions and Affections*, and *Illustrations upon the Moral Sense*, in 1728. The original title of the former work (which reached a second edition in the next year) was—*An Inquiry into the Original of our Ideas of Beauty and Virtue in two Treatises, in which the Principles of the late Earl of Shaftesbury are explained and defended against the Author of the Fable of the Bees; and the Ideas of Moral Good and Evil are established, according to the Sentiments of the Ancient Moralists, with an attempt to introduce a Mathematical Calculation on subjects of Morality.* The alterations and additions made in the second edition of these *Essays* were published in a separate form in 1726. To the period of his Dublin residence are also to be referred the "Thoughts on Laughter" (a criticism of Hobbes) and the "Observations on the Fable of the Bees," being in all six letters contributed to *Hibernicus' Letters*, a periodical which appeared in Dublin, 1725–27 (2d ed., 1734). At the end of the same period occurred the controversy in the columns of the *London Journal* with Mr Gilbert Burnet (probably the second son of Dr Gilbert Burnet, bishop of Salisbury), on the "True Foundation of Virtue or Moral Goodness." All these letters were collected in one volume, and published by Foulis, Glasgow, 1772.

In 1729 Hutcheson was elected as the successor of his old master, Gerschom Carmichael, to the chair of moral philosophy in the university of Glasgow. It is curious that up to this time both his essays and letters had all been published anonymously, though their authorship appears to have been perfectly well known. In 1730 he entered on the duties of his office, delivering an inaugural lecture (afterwards published), *De Naturali Hominum Socialitate*. The prospect of being delivered from the miscellaneous drudgery of school work, and of securing increased leisure for the pursuit of his favourite studies, occasions an almost boisterous outburst of joy:—"laboriosissimis, mihi, atque molestissimis negotiis implicito, exigua admodum erant ad bonas literas aut mentem colendam otia; non levi igitur lætitia commovebar cum almam matrem Academiam me, suum olim alumnum, in libertatem asseruisse audiveram." And yet the works on which Hutcheson's reputation was to rest had already been published.

The rest of Hutcheson's life, down to his death in 1746, was mainly spent in the assiduous performance of the duties of his professorship, including, of course, the preparation of lectures for his classes. His reputation as a teacher attracted many young men, belonging to dissenting families, from England and Ireland, and he appears to have enjoyed a well-deserved popularity among both his pupils and his colleagues. Though somewhat quick-tempered, he was remarkable for his warm feelings and generous impulses. "He was all benevolence and affection," says Dr Leechman; "none who saw him could doubt of it; his air and countenance bespoke it. It was to such a degree his prevailing temper that it gave a tincture to his writings, which were perhaps as much dictated by his heart as his head; and if there was any need of an apology for the stress that in his scheme seems to be laid upon the friendly and public affections, the prevalance of them in his own temper would at least form an amiable one."

In addition to the works already named, the following were published during Hutcheson's lifetime:—a pamphlet entitled *Considerations on Patronage, addressed to the Gentlemen of Scotland*, 1735; *Philosophiæ Moralis Institutio Compendiaria, Ethices et Jurisprudentiæ Naturalis Elementa continens, Lib. III.*, Glasgow, Foulis, 1742; *Metaphysicæ Synopsis Ontologiam et Pneumatologiam complectens*, Glasgow, Foulis, 1742. The last work was published anonymously.

After his death, his son, Francis Hutcheson, M.D., published in two volumes, quarto, what is much the longest, though by no means the most interesting, of his works, *A System of Moral Philosophy, in Three Books*, London, 1755. To this is prefixed a life of the author, by Dr William Leechman, professor of divinity in the university of Glasgow. The only remaining work that we are able to assign to Hutcheson is a small treatise on *Logic*, which, according to his biographer, was "not designed for the public eye," but which was published by Foulis at Glasgow in 1764. This compendium, together with the *Compendium of Metaphysics*, was republished at Strasburg in 1772.

Of all these works, however, those alone on which Hutcheson's philosophical reputation rests are the four essays, and perhaps the letters, all published during his residence in Dublin. To the more distinctive features of his philosophical system, so far as they may be gathered from these and his other works, we now proceed to draw attention. In the publication of the first two essays, Hutcheson acted quite rightly in connecting his name on the title-page with that of Shaftesbury. There are no two names, perhaps, in the history of English moral philosophy, which stand in a closer connexion. The analogy drawn between beauty and virtue, the functions assigned to the moral sense, the position that the benevolent feelings form an original and irreducible part of our nature, and the unhesitating adoption of the principle that the test of virtuous action is its tendency to promote the general welfare, or good of the whole, are at once obvious and fundamental points of agreement between the two authors.

According to Hutcheson, man has a variety of senses, internal as well as external, reflex as well as direct, the general definition of a sense being "any determination of our minds to receive ideas independently on our will, and to have perceptions of pleasure and pain" (*Essay on the Nature and Conduct of the Passions*, sect. 1). He does not attempt to give an exhaustive enumeration of these "senses," but, in various parts of his works, he specifies, besides the five external senses commonly recognized (which, he rightly hints, might be added to),—(1) consciousness, by which each man has a perception of himself and of all that is going on in his own mind ("Sensus quidam internus, aut conscientia, cujus ope nota sunt ea omnia, quæ in mente geruntur; hac animi vi se novit quisque, suique sensum habet," *Metaph. Syn.*, pars i. cap. 2); (2) the sense of beauty (sometimes called specifically "an internal sense"); (3) a public sense, or sensus communis, "a determination to be pleased with the happiness of others and to be uneasy at their misery;" (4) the moral sense, or "moral sense of beauty in actions and affections, by which we perceive virtue or vice, in ourselves or others;" (5) a sense of honour, or praise and blame, "which makes the approbation or gratitude of others the necessary occasion of pleasure, and their dislike, condemnation, or resentment of injuries done by us the occasion of that uneasy sensation called shame"; (6) a sense of the ridiculous. It is plain, as the author confesses, that there may be "other perceptions, distinct from all these classes," and, in fact, there seems to be no limit to the number of "senses" in which a psychological division of this kind might result.

Of these "senses" that which plays the most important part in Hutcheson's ethical system is the "moral sense." It is this which pronounces immediately on the character of actions and affections, approving of those which are virtuous, and disapproving of those which are vicious. "His principal design," he says in the preface to the two first treatises, "is to show that human nature was not left quite indifferent in the affair of virtue, to form to itself observations concerning the advantage or disadvantage of actions, and accordingly to regulate its conduct. The weakness of our reason, and the avocations arising from the infirmity and necessities of our nature are so great that very few men could ever have formed those long deductions of reason, which show some actions to be in the whole advantageous to the agent, and their contraries pernicious. The Author of nature has much better furnished us for a virtuous conduct than our moralists seem to imagine, by almost as quick and powerful instructions as we have for the preservation of our bodies. He has made virtue a lovely form, to excite our pursuit of it, and has given us strong affections to be the springs of each virtuous action." Passing over the appeal to final causes involved in this and similar passages, as well as the assumption that the "moral sense" has had no growth or history, but was "implanted" in man exactly in the condition in which it is now to be found among the more civilized races, an assumption common to the systems of both Hutcheson and Butler, it may be remarked that the employment of the term "sense" to designate the approving or disapproving faculty has a tendency to obscure the real nature of the process which goes on in an act of moral approbation or disapprobation. For, as is so clearly established by Hume, this act really consists of two parts:—one an act of deliberation, more or less prolonged, resulting in an intellectual judgment; the other a reflex feeling, probably instantaneous, of either satisfaction or repugnance,—of satisfaction at actions of a certain class which we denominate as good or virtuous, of dissatisfaction or repugnance at actions of another class which we denominate as bad or vicious. By the intellectual part of this process we refer the action or habit to a certain class, and invest it with certain characteristics; but no sooner is the intellectual process completed than there is excited in us a feeling similar to that which myriads of actions and habits of the same class, or deemed to be of the same class, have excited in us on former occasions. Now, supposing the latter part of this process to be instantaneous, uniform, and exempt from error, the former certainly is not. All mankind may, apart from their selfish interests, approve of that which is virtuous or makes for the general good, but surely they entertain the most widely divergent opinions, and, if left to their own judgment, would frequently arrive at directly opposite conclusions as to the nature of the particular actions and habits which fall under this class. This distinction is undoubtedly recognized by Hutcheson, as it could hardly fail to be, in his analysis of the mental process preceding moral action, nor does he invariably ignore it, even when treating of the moral approbation or disapprobation which is subsequent on action. Witness the following passages:—"Men have reason given them, to judge of the tendencies of their actions, that they may not stupidly follow the first appearance of public good; but it is still some appearance of good which they pursue" (*Inquiry concerning Moral Good and Evil*, sect. 4). "All exciting reasons presuppose instincts and affections; and the justifying presuppose a moral sense" (*Illustrations upon the Moral Sense*, sect. 1). "When we say one is obliged to an action, we either mean—(1) that the action is necessary to obtain happiness to the agent, or to avoid misery; or (2) that every spectator, or he himself upon reflexion, must approve his action, and disapprove his omitting it, if he considers fully all its circumstances. The former meaning of the word obligation presupposes selfish affections, and the sense of private happiness; the latter meaning includes the moral sense" (*Ibid.*). Notwithstanding these passages, however, it remains true that Hutcheson, both by the phrases which he employs to designate the moral faculty, and by the language in which he ordinarily describes the process of moral approbation, has done much to favour that loose and popular view of morality which, ignoring the difficulties that often attend our moral decisions, and the necessity of deliberation and reflexion, encourages hasty resolves and unpremeditated judgments. The term "moral sense" (which, it may be noticed, had already been employed by Shaftesbury, not only, as Dr Whewell appears to intimate in the margin, but also in the text of his *Enquiry*), if invariably coupled with the term "moral judgment," would be open to little objection; but, taken alone, as designating the complex process of moral approbation, it is liable to lead not only to serious misapprehension but to grave practical errors. For, if each man's decisions are solely the result of an immediate intuition of the moral sense, why be at any pains to test, correct, or review them? Or why educate a faculty whose decisions are infallible? The expression has, in fact, the fault of most metaphorical terms; it leads to an exaggeration of the truth which it is intended to suggest.

But though Hutcheson usually describes the moral faculty as acting instinctively and immediately, he does not, like Butler, confound the moral faculty with the moral standard. The test or criterion of right action is with Hutcheson, as with Shaftesbury, its tendency to promote the general welfare of mankind. "In comparing the moral qualities of actions, in order to regulate our election among various actions proposed, or to find which of them has the greatest moral excellency, we are led by our moral sense of virtue to judge thus—that, in equal degrees of happiness expected to proceed from the action, the virtue is in proportion to the number of persons to whom the happiness shall extend (and here the dignity or moral importance of persons may compensate numbers), and, in equal numbers, the virtue is as the quantity of the happiness or natural good; or that the virtue is in a compound ratio of the quantity of good and number of enjoyers. In the same manner, the moral evil, or vice, is as the degree of misery and number of sufferers; so that that action is best which procures the greatest happiness for the greatest numbers, and that worst which, in like manner, occasions misery" (*Inquiry concerning Moral Good and Evil*, sect. 3). What was subsequently called the utilitarian standard is here unhesitatingly adopted by Hutcheson; and it is curious to notice that he actually employs the very phrase which became so celebrated in the mouth of Bentham, though afterwards reduced by that writer to the more simple expression "greatest happiness."

The adoption of an external standard, requiring much care and reflexion in its application, ought to have led Hutcheson to see that the moral faculty, by which the standard was to be applied, is by no means so simple and instinctive as he imagined it to be, and that, consequently, these two parts of his system are in reality inconsistent.

As connected with Hutcheson's virtual adoption of the utilitarian standard, may be noticed a kind of moral algebra, proposed for the purpose of "computing the morality of actions." This calculus occurs in the *Inquiry concerning Moral Good and Evil*, sect. 3.

The most distinctive of Hutcheson's ethical doctrines, still remaining to be noticed, is what has been called the "benevolent theory" of morals. Hobbes had maintained that all our actions, however disguised under apparent sympathy, have their roots in self-love. Hutcheson not only maintains that benevolence is the sole and direct source of many of our actions, but, by a not unnatural recoil from the repellent doctrine of Hobbes, that it is the only source of those actions of which, on reflexion, we approve. "If we examine all the actions which are accounted amiable anywhere, and inquire into the grounds upon which they are approved, we shall find that, in the opinion of the person who approves them, they always appear as benevolent, or flowing from love of others and a study of their happiness, whether the approver be one of the persons beloved or profited or not; so that all those kind affections which incline us to make others happy, and all actions supposed to flow from such affections, appear morally good, if, while they are benevolent toward some persons, they be not pernicious to others. Nor shall we find anything amiable in any action whatsoever, where there is no benevolence imagined; nor in any disposition, or capacity, which is not supposed applicable to and designed for benevolent purposes" (*Inquiry concerning Moral Good and Evil*, sect. 3). Consistently with this position, actions which flow from self-love only are pronounced to be morally indifferent: "The actions which flow solely from self-love, and yet evidence no want of benevolence, having no hurtful effects upon others, seem perfectly indifferent in a moral sense, and neither raise the love or hatred of the observer" (*Ibid.*). But surely, by the common consent of civilized men, prudence, temperance, cleanliness, industry, self-respect, and in general, the "personal virtues," as they are called, are regarded, and rightly regarded, as fitting objects of moral approbation. This consideration could hardly escape any author, however wedded to his own system, and Hutcheson attempts to extricate himself from the difficulty by laying down the position that a man may justly regard himself as a part of the rational system, and may thus "be, in part, an object of his own benevolence" (*Ibid.*),—a curious abuse of terms, which really concedes the question at issue. Moreover, he acknowledges that, though self-love does not merit approbation, neither, except in its extreme forms, does it merit condemnation. "We do not positively condemn those as evil who will not sacrifice their private interest to the advancement of the positive good of others, unless the private interest be very small, and the public good very great" (*Illustrations upon the Moral Sense*, sect. 6). The satisfaction of the dictates of self-love, too, is one of the very conditions of the preservation of society. "Self-love is really as necessary to the good of the whole as benevolence,—as that attraction which causes the cohesion of the parts is as necessary to the regular state of the whole as gravitation" (*Inquiry concerning Moral Good and Evil*, sect. 17). To press home the inconsistencies involved in these various statements would be a superfluous task.

Hutcheson's benevolent view of human nature is illustrated also by his denying that malevolence is an original principle in the constitution of man. "Perhaps our nature is not capable of desiring the misery of any being calmly, farther than it may be necessary to the safety of the innocent; we may find, perhaps, that there is no quality in any object which would excite in us pure disinterested malice, or calm desire of misery for its own sake" (*On the Nature and Conduct of the Passions*, sect. 3). Against this position of Hutcheson, propounded also by Butler (*Serm.* ix.), it might be objected that, even amongst very young children, we often find a singular and precocious love of cruelty. This is, undoubtedly, one of the most curious facts in moral psychology, but it may perhaps be accounted for by supposing it to originate in a combination of morbid curiosity with an equally morbid love of power.

The vexed question of liberty and necessity appears to be carefully avoided in Hutcheson's professedly ethical works. But, in the *Synopsis Metaphysicæ*, he touches on it in no less than three places, briefly stating both sides of the question, but evidently inclining to that which he designates as the opinion of the Stoics in opposition to what he designates as the opinion of the Peripatetics. This is substantially the same as the doctrine propounded by Hobbes and Locke (to the latter of whom Hutcheson refers in a note), namely, that our will is determined by motives in conjunction with our general character and habit of mind, and that the only true liberty is the liberty of acting as we will, not the liberty of willing as we will. Though, however, his leaning is clear, he carefully avoids dogmatizing, and speaks of the difficulty as "ardua quæstio," "quæstio vexatissima, quæ doctorum et piorum ingenia semper torserat, atque de qua utrinque frustra ad sensum cujusque internum provocatur," earnestly deprecating the angry controversies and bitter dissensions to which the speculations on this subject had given rise.

If our limits allowed us sufficient space, it would be easy to trace the influence of Hutcheson's ethical theories on the systems of Hume and Adam Smith. The prominence given by these writers to the analysis of moral action and moral approbation, with the attempt to discriminate the respective provinces of the reason and the emotions in these processes, is undoubtedly due to the influence of Hutcheson. To a study of the writings of Shaftesbury and Hutcheson we might, probably, in large measure, attribute the unequivocal adoption of the utilitarian standard by Hume, and, if this be the case, the name of Hutcheson connects itself, through Hume, with the names of Priestley, Paley, and Bentham. Butler's *Sermons* appeared in 1726, the year after the publication of Hutcheson's two first essays, and the parallelism between the "conscience" of the one writer and the "moral sense" of the other is, at least, worthy of remark.

In the sphere of mental philosophy and logic, Hutcheson's contributions are by no means so important or original as in that of moral philosophy. In the former subject, the influence of Locke is apparent throughout. All the main outlines of Locke's philosophy seem, at first sight, to be accepted as a matter of course. Thus, in stating his theory of the moral sense, Hutcheson is peculiarly careful to repudiate the doctrine of innate ideas (see, for instance, *Inquiry concerning Moral Good and Evil*, sect. 1 *ad fin.*, and sect. 4; and compare *Synopsis Metaphysicæ*, pars i. cap. 2). At the same time, it may be noticed that he shows more discrimination than does Locke in distinguishing between the two uses of this expression, and between the legitimate and illegitimate form of the doctrine (*Syn. Metaph.*, pars i. cap. 2). All our ideas are, as by Locke, referred to external or internal sense, or, in other words, to sensation and reflexion (see, for instance, *Syn. Metaph.*, pars i. cap. 1; *Logicæ Compend.*, pars. i. cap. 1; *System of Moral Philosophy*, book i. ch. 1). It is, however, a most important modification of Locke's doctrine, and one which connects Hutcheson's mental philosophy with that of Reid, when he states that the ideas of extension, figure, motion, and rest "are more properly ideas accompanying the sensations of sight and touch than the sensations of either of these senses;" that the idea of self accompanies every thought; and that the ideas of number, duration, and existence accompany every other idea whatsoever (see *Essay on the Nature and Conduct of the Passions*, sect. i. art. 1; *Syn. Metaph.*, pars i. cap. 1, pars ii. cap. 1; Hamilton on *Reid*, p. 124, note). Other important points in which Hutcheson follows the lead of Locke are his depreciation of the importance of the so-called laws of thought, his distinction between the primary and secondary qualities of bodies, the position that we cannot know the inmost essences of things ("intimæ rerum naturæ sive essentiæ"), though they excite various ideas in us, and the assumption that external things are known only through the medium of ideas (*Syn. Metaph.*, pars i. cap. 1), though, at the same time, we are assured of the existence of an external world corresponding to these ideas. Hutcheson attempts to account for our assurance of the reality of an external world by referring it to a natural instinct ("Idearum plurimas ad res externas, tanquam earundem imagines aut repræsentationes, referre cogimur ab ipsa natura," *Syn. Metaph.*, pars i. cap. 1). Of the correspondence or similitude between our ideas of the primary qualities of things and the things themselves God alone can be assigned as the cause. This similitude has been effected by Him through a law of nature. "Hæc prima qualitatum primariarum perceptio, sive mentis actio quædam sive passio dicatur; non alia similitudinis aut convenientiæ inter ejusmodi ideas et res ipsas causa assignari posse videtur, quam ipse Deus, qui certa naturæ lege hoc efficit, ut notiones, quæ rebus præsentibus excitantur, sint ipsis similes, aut saltem earum habitudines, si non veras quantitates, depingant" (pars ii. cap. 1). Locke had repeatedly stated that "the primary qualities of bodies are resemblances of them, and their patterns do really exist in the bodies themselves" (see, for instance, *Essay*, bk. ii. ch. 8, sect. 15), and he also speaks of God "annexing" certain ideas to certain motions of bodies (*Ibid.*, sect. 13, and elsewhere); but nowhere, we believe, does he propound a theory so precise and definite as that here propounded by Hutcheson, which reminds us at least as much of the speculations of Malebranche as of those of Locke.

Amongst the more important points in which Hutcheson diverges from Locke is his account of the idea of personal identity, which he appears to have regarded as made known to us directly by consciousness. "Mentem suam eandem manere, sibi conscius est quisque, repetentia illa, sive perceptione interna, certissima, ast ineffabili, qua novit suam mentem a mente quavis alia omnino diversam esse" (*Syn. Metaph.*, pars. i. cap. 3). The distinction between body and mind, "corpus" or "materia" and "res cogitans," is more emphatically accentuated by Hutcheson than by Locke. Generally, he speaks as if we had a direct consciousness of mind as distinct from body (see, for instance, *Syn. Metaph.*, pars ii. cap. 3), though, in the posthumous work on *Moral Philosophy*, he expressly states that we know mind as we know body "by qualities immediately perceived though the substance of both be unknown" (bk. i. ch. 1). The distinction between perception proper and sensation proper, which occurs by implication though it is not explicitly worked out (see Hamilton's *Lectures on Metaphysics*, Lect. 24; Hamilton's edition of *Dugald Stewart's Works*, vol. v. p. 420), the imperfection of the ordinary division of the external senses into five classes, the limitation of consciousness to a special mental faculty (severely criticized in Sir W. Hamilton's *Lectures on Metaphysics*, Lect. xii.), and the disposition to refer on disputed questions of philosophy not so much to formal arguments as to the testimony of consciousness and our natural instincts ("ad gravissima quædam in philosophia dogmata amplectenda, non argumentis aut ratiocinationibus, ex rerum perspecta natura petitis, sed potius sensu quodam interno, usu, atque naturæ impulsu quodam aut instinctu ducimur," pars ii. cap. 3) are also amongst the points in which Hutcheson supplemented or departed from the philosophy of Locke. The last point can hardly fail to suggest to our readers the "common-sense philosophy" of Reid, and here it may be remarked that the interest attaching to Hutcheson's psychological and metaphysical views consists very largely in the intermediate position which they occupy between the system of Locke and that of Reid and the later Scottish school. If we confine ourselves to merely enumerating detached questions, he perhaps stands nearer to Locke, but in the general spirit of his philosophy he seems to approach more closely to his Scottish successors.

The short *Compendium of Logic*, which is more original than such works usually are, is chiefly remarkable for the large proportion of psychological matter which it contains. In these parts of the book Hutcheson mainly follows Locke. The technicalities of the subject are passed lightly over, and the book is eminently readable. It may be specially noticed that he distinguishes between the mental result and its verbal expression [idea—term; judgment—proposition], that he constantly employs the word "idea," and that he defines logical truth as "convenientia signorum cum rebus significatis" (or "propositionis convenientia cum rebus ipsis," *Syn. Metaph.*, pars i. cap. 3), thus implicitly repudiating a merely formal view of logic.

Hutcheson may claim to have been one of the earliest modern writers on æsthetics. His speculations on this subject are contained in the *Inquiry concerning Beauty, Order, Harmony, and Design*, the first of the two treatises published in 1725. He maintains that we are endowed with a special sense by which we perceive beauty, harmony, and proportion. This is a *reflex* sense, because it presupposes the action of the external senses of sight and hearing. It may be called an internal sense, both in order to distinguish its perceptions from the mere perceptions of sight and hearing, and because "in some other affairs, where our external senses are not much concerned, we discern a sort of beauty, very like, in many respects, to that observed in sensible objects, and accompanied with like pleasure" (*Inquiry*, &c., sect. 1). The latter reason leads him to call attention to the beauty perceived in universal truths, in the operations of general causes, and in moral principles and actions. Thus, the analogy between beauty and virtue, which was so favourite a topic with Shaftesbury, becomes also prominent in the writings of Hutcheson. Scattered up and down the treatise, there are many important and interesting observations which our limits prevent us from noticing. But to the student of mental philosophy it may be specially interesting to remark that Hutcheson both applies the principle of association to explain our ideas of beauty and also sets limits to its application, insisting on there being "a natural power of perception or sense of beauty in objects, antecedent to all custom, education, or example" (see *Inquiry*, &c., sects. 6, 7; Hamilton's *Lectures on Metaphysics*, Lect. 44 *ad fin.*).

Hutcheson's writings gave rise, as they could hardly fail to do, to much controversy among those who were interested in ethical speculations. To say nothing of minor opponents, such as "Philaretus" (Mr Gilbert Burnet, already alluded to), Dr John Balguy, author of two tracts on *The Foundation of Moral Goodness*, and Dr John Taylor of Norwich, a Presbyterian minister of considerable reputation in his time, the essays appear to have suggested, by antagonism, at least two works which hold a permanent place in the literature of English ethics. One of these is Butler's *Dissertation on the Nature of Virtue*, which is, throughout, a criticism of the main positions maintained by Hutcheson. The other is an answer of a far more complete and systematic character, Dr Richard Price's *Treatise of Moral Good and Evil*, which first appeared in 1757. In this work, the author maintains, in opposition to Hutcheson, that actions are *in themselves* right or wrong (an ambiguous expression, which he is not sufficiently careful to explain), that right and wrong are simple ideas incapable of analysis, and that these ideas are perceived immediately by the understanding. Price's work is remarkable for the close similarity between many of the ideas and even expressions contained in it and those which subsequently became so celebrated in the speculations of Kant. We thus see that, not only by its direct but also by its indirect influence, through the replies which it called forth, the system of Hutcheson, or at least the system of Hutcheson combined with that of Shaftesbury, may be regarded as having contributed, in very large measure, to the formation and development of some of the most important of the modern schools of ethics.

The original editions of Hutcheson's various works have been already mentioned. Several additions and alterations were made in the second edition (1726) of the *Inquiry into the Original of our Ideas of Beauty and Virtue*. This, as well as most of his other works, passed through various editions. Of the *System of Moral Philosophy*, however, published after Hutcheson's death, there is, we believe, one edition only. Notices of Hutcheson occur in most histories, both of general philosophy and of moral philosophy, as, for instance, in part vii. of Adam Smith's *Theory of Moral Sentiments*; Mackintosh's *Progress of Ethical Philosophy*; Cousin, *Cours d' Histoire de la Philosophie Morale du XVIIIième Siècle*; Whewell's *Lectures on the History of Moral Philosophy in England*; Bain's *Mental and Moral Science*; Dr Noah Porter's Appendix to the English translation of Ueberweg's *History of Philosophy*; Mr Leslie Stephen's *History of English Thought in the Eighteenth Century*, &c. Of Dr Leechman's *Biography* of Hutcheson we have already spoken. Professor Veitch gives an interesting account of his professorial work in Glasgow, *Mind*, vol. ii. pp. 209-211. (T. F.)

HUTCHINSON, JOHN (1616–1664), a Puritan soldier, son of Sir Thomas Hutchinson, was born at Nottingham in September 1616. After completing his education at Cambridge University he entered Lincoln's Inn, but soon became tired both of the study of law and the amusements of London, and was meditating travel on the Continent when he accidentally made the acquaintance of Lucy, daughter of Sir Allan Apsley, whom he married in 1638. After his marriage he returned to Owthorpe, where the study of divinity and politics gradually led to a change of his sentiments in regard to the dispute between the parliament and the king At first he did not find a clear call to join the Parliamentary army, but the efforts of the Royalists to seize him as a disaffected person soon dissipated his neutrality, and, becoming governor of Nottingham, he with great firmness and courage held the town and castle against internal treachery and external attacks till the triumph of the parliamentary cause. Having been chosen to represent Nottingham in the new parliament, he became a member of the high court of justice for the trial of the king, and gave his vote for his execution, but, disapproving of the subsequent political conduct of Cromwell, he took no further part in politics during the lifetime of the Protector. After the Restoration he became member for the county of Nottingham, and he was included in the Act of Amnesty passed in favour of certain of the regicides. Subsequently, however, he was arrested upon suspicion of being concerned in a treasonable conspiracy; and after an imprisonment of ten months in the Tower of London, and of one month in Sandown Castle, Kent, he died 11th September 1664. The life of Colonel Hutchinson is now only of interest from the manner in which it is narrated in the *Memoirs* written by his wife, and first published in 1806, a work not only valuable for the picture which it gives of the time in which he lived, but for the simple beauty of its style, and the naiveté with which the writer records her sentiments and opinions, and details the incidents of her private life.

HUTCHINSON, JOHN (1674-1737), the author of *Moses's Principia* and other works in which the so-called Hutchinsonian system is expounded, was born at Spennithorne, Yorkshire, in 1674, and after receiving an adequate elementary education there, served as steward in several families of position, latterly in that of the duke of Somerset, who ultimately obtained for him the post of riding purveyor to the master of the horse, a sinecure worth about £200 a year. In this employment he became acquainted with Dr Woodward, physician to the duke, and author of a work entitled *The Natural History of the Earth*, to whom he entrusted a large number of fossils of his own collecting, along with a mass of manuscript notes, for arrangement and publication. A misunderstanding as to the manner in which these should be dealt with was the immediate occasion of the publication by Hutchinson in 1724 of *Moses's Principia*, part i., in which Woodward's *Natural History* was bitterly ridiculed, his conduct with regard to the mineralogical specimens not obscurely characterized, and a refutation of the Newtonian doctrine of gravitation seriously attempted. It was followed by part ii. in 1727, and by various other works published at frequent intervals. Hutchinson died in 1737. A complete edition of all the publications of this author, along with his posthumous pieces, edited by Robert Spearman and Julius Bate, appeared in 1748 (12 vols.); an *Abstract* of these followed in 1753; and a *Supplement*, with *Life* by Spearman prefixed, in 1765.

Although the crude ideas of Hutchinson at the time of their first promulgation were successful, by their seeming devoutness, in commending themselves to some of the pious but dim-sighted and over-timid souls of that period, who had taken alarm at the atheistic conclusions they believed to be deducible from the Newtonian doctrines, they are now too uninfluential, as well as too glaringly inconsistent with the universally recognized principles of physics and philology, to call for any detailed analysis. Their nature may be almost sufficiently gathered from the titles of some of the works in which they are set forth, such as *Moses's Principia, Part I.; of the Invisible Parts of Matter, of Motion, of Visible Forms, and of their Dissolution and Reformation*; *Moses's Principia, Part II.; of the Circulation of the Heavens; of the Cause of the Motion and Course of the Earth, Moon, &c.; of the Religion, Philosophy, and Emblems of the Heathens before Moses writ, and of the Jews after; in Confirmation of the Natural History of the Bible*; *Moses's Sine Principio, represented by Names, Words, Types, Emblems; with an introduction to show the Nature of the Fall, of Paradise, and of the Body and Soul*; *The Confusion of Tongues and Trinity of the Gentiles* (*being an account of the origin of Idolatry*); *Power Essential and Mechanical, or what power belongs to God and what to his creatures, in which the design of Sir I. Newton and Dr Samuel Clarke is laid open*; *Glory or Gravity, wherein the Objects and Articles of the Christian Faith are exhibited*; *The Religion of Satan, or Antichrist Delineated.* Bishop Horne of Norwich, it may be mentioned, was during some of his earlier years an avowed Hutchinsonian; and Jones of Nayland continued to be so to the end of his life.

HUTCHINSON, Thomas (1711–1780), governor of the province of Massachusetts, son of a wealthy merchant of Boston, was born there September 9, 1711. The son, being unsuccessful in commerce, studied law, and adopted it as his profession. He was representative of Boston in the general court for ten years, and was three times chosen speaker. From 1749 to 1766 he was a counsellor, in 1752 he was appointed judge of probate, from 1758 to 1771 he was lieutenant-governor, and in 1760 he became chief justice. In 1748 he carried a measure to substitute gold and silver for the paper currency, which had depreciated one-eighth in value. During the Stamp Act riots of 1765 his house was sacked by the mob; and by his subsequent support of the general policy of the British Government he incurred increasing unpopularity. In 1767 he laid claim to a seat in the council on the ground of being lieutenant-governor, but on account of his political views his claims were set aside. On his appointment to the governorship of Massachusetts in 1769, he used every method to support the measures which the mother country sought to enforce against the colonists; and in December 1773, on account of his refusal to permit the reshipment of teas on which a duty had been laid by the Government, several of the inhabitants of Boston emptied the tea into the bay. In January 1774 Hutchinson asked leave to resign his office, and in June he sailed to England, where he spent the remainder of his life. As the result of official inquiry into his conduct while governor of Massachusetts, he was rewarded with a pension. He died at Brompton in June 1780.

Hutchinson was the author of the following works:—*A Brief Statement of the Claim of the Colonies*, 1764; *Collection of Original Papers relative to the History of the Colony of Massachusetts Bay*, 1769; *History of the Colony of Massachusetts Bay from 1628 to 1750*, 2 vols., London, 1765–67; *History of Massachusetts from 1749 to 1774*, published posthumously in 1828.

HUTTEN, Ulrich von (1488–1523), is one of those men who, like Erasmus or Pirckheimer, form the bridge between Humanists and Reformers. He lived with both, sympathized with both, though he died before the Reformation had time fully to develop itself. His life may be divided into four parts:—his youth and cloister-life (1488–1504); his wanderings in pursuit of knowledge (1504–1515); his strife with Ulrich of Würtemburg (1515–1519); and his connexion with the Reformation (1519–1523). Each of these periods had its own special antagonism, which coloured Hutten's career: in the first, his horror of dull monastic routine; in the second, the ill-treatment he met with at Greifswald; in the third, the crime of Duke Ulrich; in the fourth, his disgust with Rome and with Erasmus. He was born April 21, 1488, at the castle of Steckelberg, near Fulda, in Franconia, the eldest son of a poor and not undistinguished knightly family. As he was mean of stature and sickly his father destined him for the cloister, and he was sent to the Benedictine house at Fulda; the thirst for learning there seized on him, and in 1504 he fled from the monastic life, and won his freedom with the sacrifice of his worldly prospects, and at the cost of incurring his father's undying anger. From the Fulda cloister he went first to Cologne, next to Erfurt, and then to Frankfort-on-the-Oder on the opening in 1506 of the new university of that town; there in that year he appears to have graduated in philosophy. When, however, the scholastic party displaced the Humanists, he wandered forth again; in 1508 we find him a shipwrecked beggar on the Pomeranian coast. In 1509 the university of Greifswald welcomed him; "Ulricus Huttenus poeta clericus Herbipolensis gratis intitulatus quia spoliatus omnibus bonis" is the honourable record on the books of this his second Alma Mater. Here too the friends who at first received him so kindly became his foes; the sensitive ill-regulated youth, who took the liberties of genius, wearied his burgher patrons; they could not brook the poet's airs and vanity, and ill-timed assertions of his higher rank. Wherefore he left Greifswald, and as he went was robbed of clothes and books, his only baggage, by the servants of his late friends; in the dead of winter, half starved, frozen, penniless, he reached Rostock. Here again the Humanists, who were throughout full of charity and sympathy towards the luckless young scholar, received him gladly, and under their protection he wrote against his Greifswald patrons, thus beginning the long list of his satires and fierce attacks on personal or public foes. Rostock could not hold him long; he wandered on to Wittenberg and Leipsic, and thence to Vienna, where he hoped to catch the emperor Maximilian's favour by an elaborate national poem on the war with Venice. But neither Maximilian nor the university of Vienna would lift hand for him, and he passed into Italy, that holy land of Humanist enthusiasm, where, at Pavia, he sojourned throughout 1511 and part of 1512. In the latter year his studies were rudely interrupted by war; in the siege of Pavia by papal troops and Swiss, he was plundered by both sides, and escaped sick and penniless to Bologna; on his recovery he even took service as a private soldier in the emperor's army.

This dark period lasted no long time; in 1514 he was again in Germany, where, thanks to his poetic gifts and the friendship of Eitelwolf von Stein, he won the favour of the elector of Mainz, Archbishop Albert of Brandenburg. Here high dreams of a learned career rose on him; Mainz should be made the metropolis of a grand Humanist movement, the centre of good style and literary form. This golden dream was scattered by the murder in 1515 of his cousin John of Hutten by Ulrich, duke of Würtemburg. This outrage changed the whole course of Hutten's life; satire, chief refuge of the weak, became his weapon; with one hand he took his part in the famous *Epistolæ Obscurorum Virorum*, and with the other launched scathing letters, eloquent Ciceronian orations, or biting satires against the duke. Though the emperor was too lazy and indifferent to smite a great prince, he condescended to bestow on Hutten the inexpensive honour of a laureate crown in 1517; as the poet tells us with pleased pride, the wreath was woven by the hands of fair Constantia, Conrad Peutinger's daughter. As recognized poet laureate of Germany, Hutten, who had been to Italy, again attached himself to the electoral court at Mainz; and he was there when in 1518 his true friend Pirckheimer wrote, urging him to abandon the court and dedicate himself to letters. We have the poet's long reply, in an epistle on his "way of life," an amusing mixture of earnestness and vanity, self-satisfaction and satire; he tells his friend that his career is just begun, that he has had twelve years of wandering, and will now enjoy himself a while in patriotic literary work; that he has by no means deserted the humaner studies, but carries with him a little library of standard books. Pirckheimer in his burgher life may have ease and even luxury; he, a knight of the empire, how can he condescend to obscurity? He must abide where he can shine. And so, dazzled by his dream of an intellectual reform, Hutten chose the path which presently led him to his ruin.

In 1519 he issued in one volume his attacks on Duke Ulrich, and then, drawing sword, took part in the private war which overthrew that prince; in this affair he became intimate with Franz von Sickingen, the champion of the knightly order (Ritterstand). Henceforth Hutten takes part in the Lutheran movement, while he becomes mixed up in the attempt of the "Ritterstand" to recover its position, and to assert itself as the militia of the empire against the independence of the German princes. It was soon after this time that he discovered at Fulda a copy of the manifesto of the emperor Henry IV. against Hildebrand, and published it with comments as an attack on the papal claims over Germany. He hoped thereby to interest the new emperor Charles V., and the higher orders in the empire, in behalf of German liberties; but the appeal failed. What Luther had achieved by speaking to cities and common folk in homely phrase, because he touched heart and conscience, that the far finer weapons of Hutten failed to effect, because he tried to touch the more cultivated sympathies and dormant patriotism of princes and bishops, nobles and knights. And so he at once gained an undying name in the republic of letters and ruined his own career. He showed that the artificial verse-making of the Humanists could be connected with the new outburst of genuine German poetry. The Minnesinger was gone; the new national singer, a Luther or a Hans Sachs, was heralded by the stirring lines of Hutten's pen. These form a distinct epoch in the history of German national literature; they have in them a splendid natural swing and ring, strong and patriotic, though unfortunately addressed to knight and landsknecht rather than to the German people.

The poet's high dream of a knightly national regeneration had a rude awakening. The attack on the papacy, and Luther's vast and sudden popularity, frightened Elector Albert, who dismissed Hutten from his court. Hoping for imperial favour, he betook himself to Charles V.; but that cold young prince, who cared little for Humanists, and was not a German, would have none of him. So he returned to his friends, and they rejoiced greatly to see him still alive; for Pope Leo X. had ordered him to be arrested and sent to Rome, and assassins dogged his steps. He now attached himself more closely to Franz von Sickingen and the knightly movement. This also came to a disastrous end in the capture of the Ebernberg, and Sickingen's death; the higher nobles had triumphed; the archbishops avenged themselves on Lutheranism as interpreted by the knightly order. With Sickingen Hutten also finally fell. He fled to Basel, where Erasmus refused to see the sick hero, both for fear of his loathsome diseases, and also because the beggared knight was sure to borrow money from him. A paper war consequently broke out between the two Humanists, which embittered Hutten's last days, and stained the memory of Erasmus. From Basel Ulrich dragged his limbs to Mulhausen; and when the vengeance of Erasmus drove him thence, he went to Zurich. There the large heart of Zwingli welcomed him; he helped him with money, and found him a quiet refuge with the pastor of the little isle of Ufnau on the Zurich Lake. There the frail and worn-out poet, writing swift satire to the end, fell a victim to his infirmities, and died (29th August 1523) at the age of thirty-five. He left behind him some debts due to compassionate friends; he did not even own a single book, and all his goods amounted to the clothes on his back, a bundle of letters, and that valiant pen which had fought so many a sharp battle, and had won for the poor knight-errant a sure place in the annals of literature.

Ulrich von Hutten is one of those men of genius at whom propriety is shocked, and whom the mean-spirited avoid. Yet through his short and buffeted life he was befriended, with wonderful charity and patience, by the chief leaders of the Humanist movement. For, in spite of his irritable vanity, his immoral life and habits, his odious diseases, his painful restlessness, Hutten had much in him that strong men could love. He passionately loved the truth, and was ever open to all good influences. He was a patriot, whose soul yearned for what was high, and soared to ideal schemes and a grand utopian restoration of his country. In spite of all, his was a frank and noble nature; his faults chiefly the faults of genius ill-controlled, and of a life cast in the eventful changes of an age of novelty. A swarm of writings issued from his pen; at first the smooth elegance of his Latin prose and verse seemed strangely to miss his real character; he was the Cicero and Ovid of Germany before he became its Lucian.

His chief works were his *Ars versificandi* (1511); the *Nemo*, (1518); a work on the *Morbus Gallicus* (1519); the volume of Steckelberg complaints against Duke Ulrich (including his four *Ciceronian Orations*, his *Letters*, and the *Phalarismus*) also in 1519; the *Vadismus* (1520); and the controversy with Erasmus at the end of his life. Besides these were many admirable poems in Latin and German. It will never be known with certainty how far Hutten was the parent of the celebrated *Epistolæ Obscurorum Virorum*, that famous satire on monastic ignorance as represented by the theologians of Cologne with which the friends of Reuchlin defended him. At first the cloister-world, not discerning its irony, welcomed the work as a defence of their position; though their eyes were soon opened by the favour with which the learned world received it. The *Epistolæ* were eagerly bought up; the first part (41 letters) appeared at the end of 1515; early in 1516 there was a second edition; later in 1516 a third, with an appendix of seven letters; in 1517 appeared the second part (62 letters), to which a fresh appendix of eight letters was subjoined soon after. Hutten, in a letter addressed to Robert Crocus, denied that he was the author, and is followed by Bayle in his *Dictionary*; but there is no doubt as to his direct connexion with the book. Erasmus was of opinion that there were three authors, of whom Crotus Rubianus was the originator of the idea, and Hutten a chief contributor. D. F. Strauss, who dedicates to the subject a chapter of his admirable work on Hutten, concludes that he had no share in the first part, but that his hand is clearly visible in the second part, which he attributes in the main to him. To him is due the more serious and severe tone of that bitter portion of the satire.

For a complete catalogue of the writings of Hutten, see Böcking's *Index Bibliographicus Huttenianus* (1858). The best biography (though it is also somewhat of a political pamphlet) is that of

Strauss (*Ulrich von Hutten*, 1857; 2d ed., 1871; English translation by Sturge, 1874), with which may be compared the monographs by Potton (accompanying his translation in French of the *Morbus Gallicus*, 1865), Mohnicke, Wagenseil, Von Brunnow, Bürck, and Göhring. See also Panzer (*Ulrich von Hutten in literarischer Hinsicht*, 1798); and K. Hagen ("Ulrich von Hutten in politischer Beziehung" in his *Zur politischen Geschichte Deutschlands*, 1824). (G. W. K.)

HUTTON, Charles (1737–1823), the youngest son of Henry and Eleanor Hutton, was born at Newcastle-on-Tyne, August 14, 1737. His father was an underviewer in the coal-works in the neighbourhood, and died in June 1742; but his mother's second husband, Francis Frain, proved kind to the boy, and, in consequence of a slight accident to the elbow-joint of his right arm, sent him to school while his brothers worked in the pits. The most of his education he received in a school at Jesmond, kept by Mr Ivison, a clergyman of the church of England. There is reason to believe, on the evidence of two pay-bills, that for a short time in 1755 and 1756 Hutton worked in Old Long Benton colliery; at any rate, on Ivison's promotion to a living, Hutton succeeded to the Jesmond school, whence, in consequence of increasing pupils, he removed to Stote's Hall. While he taught during the day at Stote's Hall, he studied mathematics in the evening at a school in Newcastle. In 1760 he married, and began the work of tuition on a larger scale in Newcastle, where he had among his pupils John Scott, afterwards Lord Eldon, chancellor of England. In 1764 he published his first work, *The Schoolmaster's Guide, or a Complete System of Practical Arithmetic*, which in 1770 was followed by his *Treatise on Mensuration both in Theory and Practice*. In 1772 appeared a tract on *The Principles of Bridges*, suggested by the destruction of Newcastle bridge by a high flood on 17th November 1771. On a vacancy occurring in the professorship of mathematics at the Royal Military Academy, Woolwich, in 1773, Hutton became a candidate, and after a severe competitive contest was appointed to the post. He was made a fellow of the Royal Society in 1774, and at their request drew up an account of the calculations to determine the mean density and mass of the earth made by him from the measurements taken in 1774–76 at Schiehallion in Perthshire. This account appeared in the *Philosophical Transactions* for 1778, was afterwards reprinted in the second volume of his *Tracts on Mathematical and Philosophical Subjects*, and procured for Hutton the degree of LL.D. from the university of Edinburgh. He was elected foreign secretary to the Royal Society in 1779, but his resignation in 1783 was brought about by the president Sir Joseph Banks, whose behaviour to the mathematical section of the society was somewhat high-handed (see Kippis's *Observations on the late Contests in the Royal Society*, London, 1784). After his *Tables of the Products and Powers of Numbers*, 1781, and his *Mathematical Tables*, 1785, he issued, for the use of the Royal Military Academy, in 1787 *Elements of Conic Sections*, and in 1798 his *Course of Mathematics*. The last, at the time it appeared, was much superior in mode of treatment to any existing work on the subject, and in succeeding editions the author incorporated many new discoveries and methods. The two volumes of his *Mathematical and Philosophical Dictionary*, a most valuable contribution to scientific biography, were published in 1795, and the four volumes of *Recreations in Mathematics and Natural Philosophy*, mostly a translation from the French, in 1803. One of the most laborious of his works was the abridgment, in conjunction with Drs Shaw and Pearson, of the *Philosophical Transactions*. This undertaking, the mathematical and scientific parts of which fell to Hutton's share, was completed in 1809, and filled eighteen volumes quarto. Hutton's long-continued connexion (it extended over fifty-six years) with the mathematical periodicals of his time, whether as contributor or editor, deserves a word of notice. His name first appears in the *Ladies' Diary* (a poetical and mathematical almanac which was begun in 1704, lasted on till 1871, and which "contributed more to the study and improvement of mathematics than half the books professedly written on the subject") in the year 1764; ten years later he was appointed editor of the almanac, a post which he retained till 1817. Previous to his editorship of the *Diary*, he had begun a small periodical, *Miscellanea Mathematica*, which extended only to thirteen numbers; subsequently to it, he published in five volumes *The Diarian Miscellany*, which consisted of all the useful and entertaining parts of the *Diary* down to 1773, with many additional solutions and improvements. On the resignation, owing to failing health, of his professorship in 1807, he was allowed a pension of £500 a year. He died on 27th January 1823.

All the biographical notices of Hutton are unanimous in describing him as one of the most skilful of teachers, and the most amiable of men. His modesty and simplicity were as remarkable as his intellectual gifts. To his friends and pupils he exhibited a warmth of personal affection that attached both to him in a very rare degree. It was also with him a sacred duty to seek out the poor and unbefriended student of science, and promote and otherwise assist him to the best of his power.

HUTTON, James (1726–1797), one of the great founders of geological science, was born in Edinburgh on 3d June 1726. Educated at the high school and university of his native city, he acquired while still a student a passionate love of scientific inquiry. It had been decided that he should pursue a professional career, and he was accordingly apprenticed to a lawyer. But as instead of copying law papers he was sometimes found amusing his fellow-clerks with chemical experiments, his employer with much sagacity advised that a more congenial profession than the law should be chosen for him. The young apprentice, released from his engagement, chose medicine as the pursuit nearest akin to his favourite study of chemistry. He studied for three years at Edinburgh, and completed his medical education by an attendance of nearly two years at the medical classes in Paris, returning by the Low Countries, and taking his degree of doctor of medicine at Leyden in 1749. At the end of that year he came back to England, only to find, however, that though he had qualified himself to practise as a medical man there seemed hardly any opening for him. In the summer of the ensuing year he definitively abandoned the idea of following out the medical profession, and, having inherited a small property in Berwickshire from his father, resolved to devote himself to agriculture. With the zeal and thoroughness characteristic of his disposition, he then went to Norfolk to learn the practical work of farming. Thereafter he extended his experience by a tour in Holland, Belgium, and the north of France. During these years he began to study the surface of the earth, looking into every pit, ditch, or river-bed that he saw, and gradually shaping in his mind the problem to which he afterwards devoted his energies. In the summer of 1754 he established himself on his own farm in Berwickshire, where he resided for fourteen years, and where he introduced the most improved forms of husbandry. As the farm was brought into excellent order, and as its management, becoming more easy, grew less interesting, he was finally induced to let it, and establish himself for the rest of his life in Edinburgh. This took place about the year 1768.

From this period until his death in 1797 he lived unmarried with his three sisters. Surrounded by congenial literary and scientific friends, he devoted himself to those researches which have had so important an influence upon the progress of science. At that time geology in any proper sense of the term did not exist. Mineralogy, however, had made considerable progress. Hutton's taste for chemistry naturally led him into mineralogy. But he had conceived larger ideas than were entertained by the mineralogists of his day. He desired to trace back the origin of the various minerals and rocks, and thus to arrive at some clear understanding of the history of the earth. For many years he continued to ponder over the subject, making during that time many excursions to different parts of the country to obtain materials for his researches, or to test the hypotheses he had been led to form. At last, in the spring of the year 1785, he communicated his views to the recently established Royal Society of Edinburgh in a paper entitled *Theory of the Earth, or an Investigation of the Laws Observable in the Composition, Dissolution, and Restoration of Land upon the Globe.* In this remarkable work the doctrine is expounded that geology is not cosmogony, but must confine itself to the study of the materials of the earth; that everywhere evidence may be seen that the present rocks of the earth's surface have been formed out of the waste of older rocks; that these materials having been laid down under the sea were there consolidated under great pressure, and were subsequently disrupted and upheaved by the expansive power of subterranean heat; that during these convulsions veins and masses of molten rock were injected into the rents of the dislocated strata; that every portion of the upraised land, as soon as exposed to the atmosphere, is subject to decay; and that this decay must tend to advance until the whole of the land has been worn away and laid down on the sea-floor, whence future upheavals will once more raise the consolidated sediments into new land. In some of these broad and bold generalizations Hutton was anticipated by the Italian geologists; but to him belongs the credit of having first perceived their mutual relations, and combined them in a luminous coherent theory everywhere based upon observation.

It was not merely the ground beneath us to which Hutton directed his attention. He had long studied the changes of the atmosphere. The same volume in which his *Theory of the Earth* appeared contained also a *Theory of Rain*, which was read to the Royal Society of Edinburgh in February 1784. He contended that the amount of moisture which the air can retain in solution increases with augmentation of temperature, and therefore that on the mixture of two masses of air of different temperatures a portion of the moisture must be condensed and appear in visible form. He investigated the data available in his time regarding rainfall and climate in different regions of the globe, and came to the conclusion that the rainfall is everywhere regulated by the humidity of the air on the one hand, and the causes which promote mixtures of different aerial currents in the higher atmosphere on the other.

The vigour and versatility of his genius may be understood from the variety of works which, during his thirty years' residence in Edinburgh, he gave to the world. In the year 1792 he published a quarto volume entitled *Dissertations on different Subjects in Natural Philosophy*, in which he discussed the nature of matter, fluidity, cohesion, light, heat, and electricity. Some of these subjects were further illustrated by him in papers read before the Royal Society of Edinburgh. He did not restrain himself within the domain of physics, but boldly marched into that of metaphysics, publishing three quarto volumes with the title *An Investigation of the Principles of Knowledge, and of the Progress of Reason—from Sense to Science and Philosophy.* In this work he develops the idea that the external world, as conceived by us, is the creation of our own minds influenced by impressions from without, that there is no resemblance between our picture of the outer world and the reality, yet that the impressions produced upon our minds, being constant and consistent, become as much realities to us as if they precisely resembled things actually existing, and therefore that our moral conduct must remain the same as if our ideas perfectly corresponded to the causes producing them. His closing years were devoted to the extension and republication of his *Theory of the Earth*, of which two volumes octavo appeared in 1795. A third volume, necessary to complete the work, was left by him in manuscript, and is referred to by his biographer Playfair, but seems to have disappeared. No sooner had this task been performed than he set to work to collect and systematize his numerous writings on husbandry, which he proposed to publish under the title of *Elements of Agriculture.* He had nearly completed this labour when an incurable disease brought his active career to a close on 26th March 1797.

It is by his *Theory of the Earth* that Hutton will be remembered with reverence while geology continues to be cultivated. The author's style, however, being somewhat heavy and obscure, the book did not attract during his lifetime so much attention as it deserved. Happily for science Hutton numbered among his friends John Playfair, professor of mathematics in the university of Edinburgh, whose enthusiasm for the spread of Hutton's doctrine was combined with a rare gift of graceful and luminous exposition. Five years after Hutton's death he published a volume, *Illustrations of the Huttonian Theory of the Earth*, in which he gave an admirable summary of that theory, with numerous additional illustrations and arguments. This work is justly regarded as one of the classical contributions to geological literature. To its influence much of the sound progress of British geology must be ascribed. In the year 1805 a biographical account of Hutton, written by Playfair, was published in vol. v. of the *Transactions of the Royal Society of Edinburgh.* (A. GE.)

HUY, in Flemish HOEY, a town of Belgium, at the head of an arrondissement in the province of Liége, situated in the most romantic portion of the Meuse valley near the confluence of the Hoyoux, on the railway between Liége and Namur, and about 20 miles west of the former city. It lies on both banks of the river, and the two portions are united by a bridge about 460 feet long. Of best note among the buildings are the town-house, the court-house, the hospital, and the collegiate church of Notre Dame, which is an excellent specimen of Gothic architecture, dating originally from the 14th century, but restored in the course of the 16th and the 19th. The citadel of Huy is now demolished. It was a powerful fortress, constructed between 1817 and 1822 on the site of the older castle dismantled by the Dutch in 1718. Part of the works were excavated in the solid rock, and the whole building looked down on the valley of the Meuse with picturesque defiance. Of the industrial activity of the town the most important results are paper, tin-plate, zinc, iron, earthenware, and brandy; and iron, zinc, and coal are extensively wrought in the vicinity. The population in 1876 was 11,774.

Huy, in modern Latin *Hoium*, *Hogum*, *Huyum*, and *Huum*, existed at least as early as the 7th century, and according to some authorities it was founded in 148 by the emperor Antoninus. Coins of Charles the Simple are extant with the legend *in Vico Hoio.* The older name of the district in which it is situated was the Condroz, or territory of the Condrosii. Under the prince-bishops of Liége Huy was a prosperous place, and it possessed no fewer than fifteen churches, as well as a number of monasteries, for a population of about 5000. It was in one of its suburbs that the abbey of Neufmoustier was founded by Peter the Hermit, who died and was buried within its precincts (1115). Part of the cloisters are still standing; and a monument was erected in 1858 by M. Godin, the owner of the grounds, to mark the site of the hermit's tomb. Huy was captured by the Dutch in 1595, and in 1693 it was taken and burned by the French. The Dutch were in possession from 1702 till 1718, when they restored the town to the emperor. See Gorissen's edition of Melard, *Hist. de la ville et du château de Huy*, Huy, 1839.

HUYGENS, CHRISTIAAN (1629-1695), mathematician, mechanician, astronomer, and physicist, was born at the Hague, April 14, 1629. He was the second son of Constantin Huygens, noticed below. From his father Christiaan received the rudiments of his education, which was continued at Leyden under Vinnius and Schooten, and completed in the juridical school of Breda. His mathematical bent, however, soon diverted him from his legal studies, and the perusal of some of his earliest theorems enabled Descartes to predict his future greatness. In 1649 he accompanied the mission of Henry, count of Nassau, to Denmark, and in 1651 entered the lists of science as an assailant of the unsound system of quadratures adopted by Gregory of St Vincent. This first essay (*Exetasis quadraturæ circuli*, Leyden, 1651) was quickly succeeded by his *Theoremata de quadratura hyperboles, ellipsis, et circuli*; while, in a treatise entitled *De circuli magnitudine inventa*, he made, three years later, the closest approximation hitherto obtained to the ratio of the circumference to the diameter of a circle.

But another class of subjects was about to engage his attention. The improvement of the telescope was then justly regarded as a *sine qua non* for the advancement of astronomical knowledge. Owing, however, to the difficulties interposed by spherical and chromatic aberration, little progress had been made in that direction when, in 1655, Huygens, working with his brother Constantin, hit upon a new method of grinding and polishing lenses. The immediate results of the clearer definition obtained were the detection of a satellite to Saturn (the sixth in order of distance from its primary), and the resolution into their true form of the abnormal appendages to that planet. Each discovery in turn was, according to the prevailing custom, announced to the learned world under the veil of an anagram—removed, in the case of the first, by the publication, early in 1656, of the little tract *De Saturni luna observatio nova*; but retained, as regards the second, until 1659, when in the *Systema Saturnium* the varying appearances of the so-called "triple planet" were clearly explained as the phases of a ring inclined at an angle of 20° to the ecliptic. His application of the pendulum to regulate the movement of clocks was another fruit of his astronomical labours, springing, as it did, from his experience of the need for an exact measure of time in observing the heavens. The invention dates from 1656; the *Horologium*, containing a description of the requisite mechanism, was published in the following year, and on the 16th of June 1657 Huygens presented his first "pendulum-clock" to the states-general.

His reputation now became cosmopolitan. As early as 1655 the university of Angers had distinguished him with an honorary degree of doctor of laws. In 1663, on the occasion of his second visit to England, he was elected a fellow of the Royal Society, and imparted to that body in January 1669 a clear and concise statement of the laws governing the collision of elastic bodies. Although these conclusions were arrived at independently, and, as it would seem, several years previous to their publication, they were in great measure anticipated by the communications on the same subject of Wallis and Wren, made respectively in November and December 1668.

Huygens had before this time fixed his abode in France. In 1665 Colbert made to him on behalf of Louis XIV. an offer too tempting to be refused, and between the following year and 1681 his residence in the philosophic seclusion of the Bibliothèque du Roi was only interrupted by two short visits to his native country. His *magnum opus* dates from this period. The *Horologium Oscillatorium*, published with a dedication to his royal patron in 1673, contained original discoveries sufficient to have furnished materials for half a dozen striking disquisitions. His solution of the celebrated problem of the "centre of oscillation" formed in itself an important event in the history of mechanics. Assuming as an axiom that the centre of gravity of any number of interdependent bodies cannot rise higher than the point from which it fell, he arrived, by anticipating in the particular case the general principle of the conservation of *vis viva*, at correct although not strictly demonstrated conclusions. His treatment of the subject is especially noteworthy as being the first successful attempt to deal with the dynamics of a system. The determination of the true relation between the length of a pendulum and the time of its oscillation; the invention of the theory of evolutes; the discovery, hence ensuing, that the cycloid is its own evolute, and is strictly isochronous; the ingenious although practically inoperative idea of correcting the "circular error" of the pendulum by applying cycloidal cheeks to clocks—were all contained in this remarkable treatise. The theorems on the composition of forces in circular motion with which it concluded formed the true prelude to the *Principia*, and would alone suffice to establish the claim of Huygens to the highest rank among mechanical inventors.

In 1681 he finally severed his French connexions, and returned to Holland. The harsher measures which about that time began to be adopted towards his co-religionists in France are usually assigned as the motive of this step. He now devoted himself during six years to the production of lenses of enormous focal distance, which, mounted on high poles, and connected with the eye-piece by means of a cord, formed what were called "aerial telescopes." Three of his object-glasses, of respectively 123, 180, and 210 feet focal length, are still in the possession of the Royal Society. He also succeeded in constructing an almost perfectly achromatic eye-piece, still known by his name. But his researches in physical optics constitute his chief title-deed to immortality. Although Hooke first proposed the wave theory of light, Huygens gave reality to the conception, establishing it on a foundation so sure that it has never since been shaken. His powerful scientific imagination enabled him to perceive that an undulation may be broken up into an indefinite number of parts, each of which is the origin of a partial wave, and that the aggregate effect of all these partial waves will reconstitute the primary wave at any subsequent stage of its progress. This resolution of the main undulation is the well-known "Principle of Huygens," and by its means he was enabled to prove the fundamental laws of optics, and to assign the correct construction for the direction of the extraordinary ray in uniaxial crystals. These investigations, together with his discovery of the "wonderful phenomenon" of polarization, are recorded in his *Traité de la Lumière*, published at Leyden in 1690, but composed in 1678. In the appended treatise *Sur la Cause de la Pésanteur*, he rejected gravitation as a universal quality of matter, although admitting the Newtonian theory of the planetary revolutions. From his views on centrifugal force he deduced the oblate figure of the earth, estimating its compression, however, at little more than one-half its actual amount.

Huygens was never married. He died at the Hague, June 8, 1695, bequeathing his manuscripts to the university of Leyden, and his considerable property to the sons of his younger brother. In character he was as estimable as he was brilliant in intellect. Although, like most men of strong originative power, he assimilated with difficulty the ideas of others, his tardiness sprang rather from inability to depart from the track of his own methods than from reluctance to acknowledge the merits of his competitors.

In addition to the works already mentioned, his *Cosmotheoros*—a speculation concerning the inhabitants of the planets—was printed posthumously at the Hague in 1698, and appeared almost simultaneously in an English translation. A volume entitled *Opera Posthuma*, Leyden, 1703, contained his "Dioptrica," in which the ratio between the respective focal lengths of object-glass and eye-glass is given as the measure of magnifying power, together with the shorter essays *De vitris figurandis*, *De corona et parheliis*, &c. An early tract *De* *ratiociniis in ludo aleæ*, printed in 1657 with Schooten's *Exercitationes Mathematicæ*, is notable as one of the first formal treatises on the theory of probabilities; nor should his investigations of the properties of the cissoid, logarithmic, and catenary be left unnoticed. His invention of the spiral watch-spring was explained in the *Journal des Savants*, February 25, 1675. An edition of his works was published by 'S Gravesande, of which two quarto volumes appeared under the heading *Opera varia*, Leyden, 1724, and two supplementary ones entitled *Opera reliqua*, Amsterdam, 1728. His scientific correspondence, edited from manuscripts preserved at Leyden by P. J. Uylenbroek, was published with the title *Christiani Hugenii aliorumque seculi XVII. virorum celebrium Exercitationes Mathematicæ et Philosophicæ*, The Hague, 1833. (A. M. C.)

HUYGENS, Sir Constantijn or Constantin (1596–1687), Dutch poet and diplomatist, was born at the Hague on the 4th of September 1596. His father, Christiaan Huygens, was secretary to the state council, and a man of great political importance. At the baptism of the child, the city of Breda was one of his sponsors, and the famous admiral Justinus van Nassau the other. From his earliest childhood he was trained in every polite accomplishment, and before he was seven he could speak French with fluency. He was taught Latin by Johannes Dedelus, and soon became a master of classic versification. As he grew up, he developed not only extraordinary intellectual gifts but great physical beauty and strength, and was one of the most accomplished athletes and gymnasts of his age; his skill in playing the lute and in the arts of painting and engraving attracted general attention before he began to develop his genius as a writer. In 1616 he proceeded, with his elder brother, to the university of Leyden. He stayed there only one year, and in 1618 proceeded to London with the English ambassador Carleton; he remained in London for some months, and then went to Oxford, where he studied for some time in the Bodleian Library, and to Woodstock, Windsor, and Cambridge; he was introduced at the English court, and played the lute before James I. The most interesting feature of this visit was the intimacy which sprang up between the young Dutch poet and the famous Dr Donne, for whose genius Huygens preserved through life an unbounded admiration. He returned to Holland in company with the English contingent of the synod of Dort, and in 1620 he proceeded to Venice in the diplomatic service of his country; on his return he nearly lost his life by a foolhardy exploit, namely, the scaling of the topmost spire of Strasburg cathedral. In 1621 he published one of his most weighty and popular poems, his *Batava Tempe*, and in the same year he proceeded again to London, as secretary to the ambassador, Wijngaerdan, but returned in three months. His third diplomatic visit to England lasted longer, from the 5th of December 1621 to the 1st of March 1623. During his absence, his volume of satires, *Costelick Mal*, dedicated to Jacob Cats, appeared at the Hague. In the autumn of 1622 he was knighted by James I. He published a large volume of miscellaneous poems in 1625 under the title of *Otiorum libri sex*; and in the same year he was appointed private secretary to the stadholder. In 1627 Huygens married Suzanna van Baerle, and the young couple settled in a handsome house in the best part of the Hague; four sons and a daughter were born to them. In 1630 Huygens was called to a seat in the privy council, and he continued to exercise political power with wisdom and vigour for many years, under the title of the lord of Zuylichem. In 1634 he completed his long-talked-of version of the poems of Donne. In 1637 he had the misfortune to lose his admirable wife, and he immediately began to celebrate the virtues and pleasures of their married life in the remarkable didactic poem called *Dagwerck*, which was not published till long afterwards. From 1639 to 1641 he occupied himself by building a magnificent house and garden outside the Hague, and by celebrating their beauties in a poem entitled *Hofwijck*, which saw the light in 1654. In 1647 he wrote his beautiful poem of *Oogentroost* or "Eye Consolation," to gratify his blind friend Lucretia van Trollo. He made his solitary effort in the dramatic line in 1659, when he brought out his comedy of *Trijntje Cornelis*, which deals, in rather broad humour, with the adventures of the wife of a ship's captain at Zaandam. In 1658 he rearranged his poems, and issued them with many additions, under the title of *Corn Flowers*. He proposed to the Government that the present highway from the Hague to the sea at Scheveningen should be constructed, and during his absence on a diplomatic mission to the French court in 1666 the road was made as a compliment to the venerable statesman, who expressed his gratitude in a descriptive poem entitled *Zeestraet*. Huygens edited his poems for the last time in 1672, and died in his ninety-first year, on the 28th of March 1687. His second son, Christiaan, the eminent astronomer, is noticed above.

Constantijn Huygens is the most brilliant figure in Dutch literary history. Other statesmen surpassed him in political influence, and at least two other poets surpassed him in the value and originality of their writings. But his figure was more dignified and splendid, his talents were more varied, and his general accomplishments more remarkable than those of any other person of his age, the greatest age in the history of the Netherlands. Huygens is the *grand seigneur* of the republic, the type of aristocratic oligarchy, the jewel and ornament of Dutch liberty. When we consider his imposing character and the positive value of his writings, we may well be surprised that he has not found a modern editor. It is a disgrace to Dutch scholarship that no complete collection of the writings of Huygens exists. His autobiography, *De vita propria sermones*, did not see the light until 1827, and his remarkable poem, *Cluyswerck*, was not printed until 1842. As a poet Huygens shows a finer sense of form than any other Dutch writer; the language, in his hands, becomes as flexible as Italian. His epistles and lighter pieces, in particular, display his metrical ease and facility to perfection. (E. W. G.)

HUYSMANS. Four painters of this family matriculated in the Antwerp guild in the 17th century. Cornelis the elder, apprenticed in 1633, passed for a mastership in 1636, and remained obscure. Jacob, apprenticed to Frans Wouters in 1650, wandered to England towards the close of the reign of Charles II., and competed with Lely as a fashionable portrait painter. He executed a portrait of the queen, Catherine of Braganza, now in the national portrait gallery, and Horace Walpole assigns to him the likeness of Lady Bellasys, now catalogued at Hampton Court as a work of Lely. His portrait of Izaak Walton in the National Gallery shows a disposition to imitate the styles of Rubens and Van Dyke. According to most accounts he died in London in 1696. Jan Baptist Huysmans, born at Antwerp in 1654, matriculated in 1676–77, and died there in 1715–16. He was younger brother to Cornelis Huysmans the second, who was born at Antwerp in 1648, and educated by Gaspar de Wit and Jacob van Artois. Of Jan Baptist little or nothing has been preserved, except that he registered numerous apprentices at Antwerp, and painted a landscape dated 1697 now in the Brussels museum. But for the signature critics would assign this piece to his brother. Cornelis the second is the only master of the name of Huysmans whose talent was largely acknowledged. He chanced to receive lessons from two artists, one of whom was familiar with the Roman art of the Poussins, whilst the other inherited the scenic style of the school of Rubens. He combined the two in a rich, highly coloured, and usually effective style, which, however, was not free from monotony. Seldom attempting anything but woodside views with fancy backgrounds, half Italian, half Flemish, he painted with great facility, and left numerous examples behind. At the outset of his career he practised at Malines, where he married in 1682, and there too he entered into some business connexion with Van der Meulen, for whom he painted some backgrounds. In 1706 he withdrew to Antwerp, where he resided till 1717, returning then to Malines, where he died on the 1st of June 1727.

Though most of his pictures were composed for cabinets rather than churches, he sometimes emulated Van Artois in the production of large sacred pieces, and for many years his Christ on the Road to Emmaus adorned the choir of Notre Dame of Malines. In the gallery of Nantes, where three of his small landscapes are preserved, there hangs an Investment of Luxembourg, by Van der Meulen, of which he is known to have laid in the background. The two national galleries of London and Edinburgh contain each one example of his skill. Blenheim, too, and other private galleries in England, possess one or more of his pictures. But most of his works are on the Continent,—four a-piece in the Louvre, Augsburg, and Stuttgart; three a-piece in Berlin, Brunswick, Cologne, and Munich; two in Cassel and St Petersburg; one at Antwerp, Brussels, Carlsruhe, Copenhagen, Dresden, and Hanover.

HUYSUM, JAN VAN (1682–1749), was born at Amsterdam in 1682, and died in his native city on the 8th of February 1749. He was the son of Justus van Huysum, whose practice remained entirely local, but who is said to have been expeditious in decorating doorways, screens, and vases. A picture by this artist is still preserved in the gallery of Brunswick, representing Orpheus and the Beasts in a wooded landscape, and here we have some explanation of his son's fondness for landscapes of a conventional and Arcadian kind; for Jan van Huysum, though skilled as a painter of still life, believed himself to possess the genius of a landscape painter. Half his pictures in public galleries are landscapes, views of imaginary lakes and harbours with impossible ruins and classic edifices, and woods of tall and motionless trees,—the whole very glossy and smooth, and entirely lifeless. The earliest dated work of this kind is that of 1717, in the Louvre, a grove with maidens culling flowers near a tomb, ruins of a portico, and a distant palace on the shores of a lake bounded by mountains. In the picture market these landscapes are worth comparatively little, whilst the master's fruit and flower pieces are all the more appreciated, and good examples readily fetch from £800 to £900. It is doubtful whether any artist in this peculiar walk of art ever surpassed Van Huysum in representing fruit and flowers. It has been said that his fruit has no savour and his flowers have no perfume,—in other words, that they are hard and artificial,—but this is scarcely true. In substance fruit and flower are delicate and finished imitations of nature in its more subtle varieties of matter. The fruit has an incomparable blush of down, the flowers have a perfect delicacy of tissue. Van Huysum too shows supreme art in relieving flowers of various colours against each other, and often against a light and transparent background. He is always bright, sometimes even gaudy. Great taste and much grace and elegance are apparent in the arrangement of bouquets and fruit in vases adorned with bas reliefs or in baskets on marble tables. There is exquisite and faultless finish everywhere. But what Van Huysum has not is the breadth, the bold effectiveness, and the depth of thought of De Heem from whom he descends through Abraham Mignon.

Some of the finest of Van Huysum's fruit and flower pieces have been in English private collections:—those of 1723 in the earl of Ellesmere's gallery, others of 1730–32 in the collections of Hope and Ashburton. One of the best examples is now in the National Gallery (1736–37), which came from Mr Wells of Redleaf and Abraham Darby. No public museum has finer and more numerous specimens than the Louvre, which boasts of four landscapes and six panels with still life; then come Berlin and Amsterdam with four fruit and flower pieces; then St Petersburg, Munich, Hanover, Dresden, The Hague, Brunswick, Vienna, Carlsruhe, and Copenhagen.

HWEN T'SANG (HIOUEN THSANG, HIWEN T'SANG) is the most eminent representative of a remarkable and valuable branch of Chinese literature, known during the last half century, chiefly through the labours of Continental scholars. It consists of the narratives of Chinese Buddhists who travelled to India, whilst their religion flourished there, with the view of visiting the sites consecrated by the history of Sakya Muni, of studying at the great convents which then existed in India, and of collecting books, reliques, and other sacred objects. In short, their objects and their narratives bear a strong analogy to the objects and narratives of the many pilgrimages to Palestine in the same and later ages which have come down to us in ecclesiastical collections.

The importance of these writings as throwing light on the geography and history of India and adjoining countries, during a very dark period, is great, and they have been the subject of elaborate commentaries by students in our own day, some of the chief of which will be noted at the end of this article. Several Chinese memoirs of this kind appear to have perished; and especially to be regretted is a great collection of the works of travellers to India, religious and secular, in sixty books, with forty more of maps and illustrations, published at the expense of the emperor Kao-T'song of the T'ang dynasty, 666 A.D., with a preface from the imperial hand. We will mention the clerical travellers of this description who are known to us by name.

1. *Shi-tao-'an* (died 385) wrote a work on his travels to the "western lands" (an expression applying often to India), which is supposed to be lost. 2. *Fa-hian* travelled to India in 399, and returned by sea in 414. His work, called *Fo-Kwé-Ki, or Memoirs on the Buddha Realms*, has been translated by Abel-Rémusat and Landresse, and again into English by the Rev. S. Beale; Mr Laidlay of Calcutta also published a translation from the French, with interesting notes. 3. *Hwai Seng* and *Sung-Yun*, monks, travelled to India to collect books and reliques, 518–521. Their short narrative has been translated by the late Karl Fried. Neumann, and also by Mr Beale (along with Fa-hian). 4. *Hwen T'sang*, the subject of this notice. In relation to his travels there are two Chinese works, both of which have been translated with an immense appliance of labour and learning by M. Stanislas Julien, viz., (*a*) the *Ta-T'ang-Si-Yu-Ki, or Memoirs on Western Countries issued by the T'ang Dynasty*, which was compiled under the traveller's own supervision, by order of the great emperor Tai-T'sung; and (*b*) a *Biography of Hwen T'sang* by two of his contemporaries. 5. *The Itinerary of Fifty-six Religious Travellers*, compiled and published under imperial authority, 730. 6. *The Itinerary of Khi-Nie*, who travelled (964–976) at the head of a large body of monks to collect books, &c. Neither of the last two has been translated.

Hwen T'sang was born in the district of Keu-Shi, near Honan-Fu, about 605, a period at which Buddhism appears to have had a powerful influence upon a large body of educated Chinese. From childhood grave and studious, he was taken in charge by an elder brother who had adopted the monastic life, in a convent at the royal city of Loyang in Honan. Hwen T'sang soon followed his brother's example. For some years he travelled over China, teaching and learning, and eventually settled for a time at the capital Chang-ngan (now Si-ngan-fu in Shensi), where his fame for learning became great. The desire which he entertained to visit India, in order to penetrate all the doctrines of the Buddhist philosophy, and to perfect the collections of Indian books which existed in China, grew irresistible, and in August 629 he started upon his solitary journey, eluding with difficulty the strict prohibition which was in force against crossing the frontier.

The "master of the law," as his biographers call him, plunged alone into the terrible desert of the Gobi, then known as the Sha-ho or "Sand River," between Kwa-chau and Igu (now Hami or Kamil). At long intervals he found help from the small garrisons of the towers that dotted the desert track. Very striking is the description, like that given six centuries later by Marco Polo, of the quasi-supernatural horrors that beset the lonely traveller in the wilderness—the visions of armies and banners; and the manner in which they are dissipated singularly recalls passages in Bunyan's *Pilgrim's Progress.* After great suffering Hwen T'sang reached Igu, the seat of a Turkish principality, and pursued his way along the southern foot of the T'ien-shan, which he crossed by a glacier pass (vividly described) in the longitude of Lake Issikul. In the valley of the Talas river he encounters the great khan of the Turks on a hunting party,—a rencontre which it is interesting to compare with the visit of Zemarchus to the great khan Dizabulus, sixty years before, in the same region. Passing by the present Tashkend, and by Samarkand, then inhabited by fire worshippers, he reached the basin of the Upper Oxus, which had recently been the seat of the powerful dominion of the Haiathelah, Ephthalites, or White Huns, known in earlier days to the Greeks as *Tochari*, and to Hwen T'sang (by the same name) as *Tuholo* or Tukhāra. His account of the many small states into which the Tukhara empire had broken up is of great interest, as many of them are identical in name and topography with the high valley states and districts on the Upper Oxus, which are at this day the object of so much geographical and political interest.

Passing by Bamian, where he speaks of the great idols still so famous, he crosses Hindu-Kush, and descends the valley of the Cabul river to Nagarahara, the site of which, still known as Nagara, adjoining Jalálábád, has recently been explored by Mr W. Simpson. Travelling thence to Pesháwar (*Purushapúra*), the capital of Gandhára, he made a digression, through the now inaccessible valley of Swat and the Dard states, to the Upper Indus, returning to Peshawar, and then crossing the Indus (*Sintu*) into the decayed kingdom of *Taxila* (Ta-cha-si-lo, Takshasilá), then subject to Kashmir. In the latter valley he spent two whole years (631-633), studying in the convents, and visiting the many monuments of his faith. We cannot follow his further travels in detail, and can only mention some of the chief points in his devious route. Such are Mathura (*Mot'ulo*), whence he turned north to Thánesar and the upper Jumna and Ganges, returning south down the valley of the latter to Kanyákubja or Kanauj, then one of the great capitals of India. The pilgrim next entered on a circuit of the most famous sites of Buddhist and of ancient Indian history, such as Ayodhyá, Prayaga (Allahábád), Káusámbhí, Srávastí, Kapilavastu the birthplace of Sákya, Kusinagara his death place, Pátalipútra (Patna, the *Palibothra* of the Greeks), Gayá, Rájagriha, and Nálanda, the most famous and learned monastery and college in India, adorned by the gifts of successive kings, of the splendour of which he gives a vivid description, and of which traces have recently been recovered. There he again spent nearly two years in mastering Sanskrit and the depths of Buddhist philosophy. Again, proceeding down the banks of the Ganges, he diverged eastward to Kámarúpa (Assam), and then passed by the great port of Támralipti (Tamlúk, the misplaced *Tamalitis* of Ptolemy), and through Orissa to Kanchipára (Conjeveram), about 640. Thence he went northward across the Carnatic and Maháráshtra to Barakacheva (Baróch of our day, *Barygaza* of the Greeks). After this he visited Malwa, Kach'h, Suráshtra (peninsular Guzerat, *Syrastrene* of the Greeks), Sindh, Multán, and Ghazni, whence he rejoined his former course in the basin of the Cabul river.

This time, however, he crosses Pamir, of which he gives a remarkable account, and passes by Kashgar, Khotan (*Kustana*), and the vicinity of Lop (*Navapa*) across the desert to Kwa-chau, whence he had made his venturous and lonely plunge into the waste fifteen years before. He carried with him great collections of books, precious images, and reliques, and was received (April 645) with public and imperial enthusiasm. The emperor Tai-T'sung desired him to commit his journey to writing, and also that he should abandon the eremitic rule and serve the state. This last he declined, and devoted himself to the compilation of his narrative and the translation of the books he had brought with him from India. The former was completed 648 A.D. In 664 Hwen T'sang died in a convent at Chang-ngan. Some things in the history of his last days, and in the indications of beatitude recorded, strongly recall the parallel history of the saints of the Roman calendar. But on the other hand we find the Chinese saint, on the approach of death, causing one of his disciples to frame a catalogue of his good works, of the books that he had translated or caused to be transcribed, of the sacred pictures executed at his cost, of the alms that he had given, of the living creatures that he had ransomed from death. "When Kia-shang had ended writing this list, the master ordered him to read it aloud. After hearing it the devotees clasped their hands, and showered their felicitations on him." Thus the "well-done, good and faithful," comes from the servant himself in self-applause.

The book of the biography, by the disciples Hwae-li and Yen t'song, as rendered with judicious omissions by Stan. Julien, is exceedingly interesting; its Chinese style receives high praise from the translator, who says he has often had to regret his inability to reproduce its grace, elegance, and vivacity. We cannot here give any idea of the uses which the accounts of Hwen T'sang have served in illustrating geography and history, but must refer to the appended list of works.

Fo-Koue-Ki, trad. du Chinois, par Abel-Rémusat, revu et complété par Klaproth et Landresse, Paris, 1836; *H. de la Vie de Hiouen-Thsang*, &c., trad. du Chinois par Stanislas Julien, Paris, 1853: *Mémoires sur les Contrées Occidentales* . . . trad. du Chinois en Français (par le même), 2 vols., Paris, 1857-58; *Mémoire Analytique*, &c., attached to the last work, by L. Vivien de St Martin; "Attempt to identify some of the Places mentioned in the Itinerary of Hiuan Thsang," by Major Wm. Anderson, C.B., in *Journ. As. Soc. Bengal*, xvi. pt. 2, p. 1183 (the enunciation of a singularly perverse theory); "Verification of the Itinerary of Hwan Thsang," &c., by Capt. Alex. Cunningham, Bengal Engineers, *ibid.*, xvii. pt. 1, p. 476; *Travels of Fah-hian and Sung-Yun, Buddhist Pilgrims*, &c., by Sam. Beal, 1869; *The Ancient Geography of India*, by Major-Gen. Alex. Cunningham, R.E., 1871; "Notes on Hwen Thsang's Account of the Principalities of Tokharistan," by Col. H. Yule, C.B., in *Journ. Roy. As. Soc.*, new ser., vol. vi. p. 82; "On Hiouen Thsang's Journey from Patna to Ballabhi," by James Fergusson, D.C.L., *ibid.*, p. 213. (H. Y.)

HYACINTH, also called JACINTH, one of the most popular of garden flowers, "supreme amongst the flowers of spring." It is no new favourite, having been in cultivation prior to 1597, at which date Gerard records the existence of six varieties, which are not indicated as particularly rare or novel. Rea in 1676 mentions several single and double varieties as being then in English gardens, and Justice in 1754 describes upwards of fifty single-flowered varieties, and nearly one hundred double-flowered ones, as a selection of the best from the catalogues of two then celebrated Dutch growers. One of the Dutch sorts, called La Reine de Femmes, a single white, is said to have produced from thirty-four to thirty-eight flowers in a spike, and on its first appearance to have sold for 50 guilders a bulb; while one called Overwinnaar or Conqueror, a double blue, sold at first for 100 guilders, Gloria Mundi for 500 guilders, and Koning Saloman for 600 guilders. Several sorts are at that date mentioned as blooming well in water-glasses. Justice relates that he himself raised several very valuable double-flowered kinds from seeds, which many of the sorts he describes are noted for producing freely.

The original of the cultivated hyacinth, *Hyacinthus orientalis*, is by comparison an insignificant plant, bearing on a spike only a few small narrow-lobed washy blue flowers. So great has been the improvement effected by the florists, and chiefly by the Dutch, that the modern hyacinth would scarcely be recognized as the descendant of the type above referred to, the spikes being long and dense, composed of a large number of flowers; the spikes produced by strong bulbs not unfrequently measure 6 or 7 inches in length and from 7 to 9 inches in circumference, with the flowers closely set on from bottom to top. Of late years much improvement has been effected in the size of the individual flowers and the breadth of their recurving lobes, as well as in securing increased brilliancy and depth of colour.

The peculiarities of the soil and climate of Holland are so very favourable to their production that Dutch florists have made a specialty of the growth of those and other bulbous-rooted flowers. An area of 125 acres is devoted to the growth of hyacinths in the vicinity of Haarlem, and is estimated to bring in a revenue of nearly £30,000. Some notion of the vast number imported into England annually may be formed from the fact that, for the supply of flowering plants to Covent Garden, one market grower alone produces from 60,000 to 70,000 in pots under glass, their blooming period being accelerated by artificial heat, and extending from Christmas onwards until they bloom naturally in the open ground.

In the spring flower garden few plants make a more effective display than the hyacinth. Dotted in clumps in the flower borders, and arranged in masses of well-contrasted colours in beds in the flower garden, there are no flowers which impart during their season—March and April—a gayer tone to the parterre. The bulbs are rarely grown a second time, either for indoor or outdoor culture, though with care they might be utilized for the latter purpose; and hence the enormous numbers which are procured each recurring year from Holland.

The first hyacinths were single-flowered, but towards the close of the 17th century double-flowered ones began to appear, and till a recent period these bulbs were the most esteemed. At the present time, however, the single-flowered sorts are in the ascendant, as they produce more regular and symmetrical spikes of blossom, the flowers being closely set and more or less horizontal in direction, while most of the double sorts have the bells distant and dependent, so that the spike is loose and by comparison ineffective. For pot culture, and for growth in water-glasses especially, the single-flowered sorts are greatly to be preferred. Few if any of the original kinds are now in cultivation, a succession of new and improved varieties having been raised, the demand for which is regulated in some respects by fashion. At the present day our nurserymen offer in their annual catalogues of select sorts between two and three hundred distinct varieties.

The earliest of all the hyacinths, and one which is very valuable for forcing into flower in winter, is called the white Roman hyacinth. It is small-flowered, but very sweet, and, if potted in September or October, as soon as the bulbs can be procured after importation, may easily be had in blossom by Christmas, when white flowers are so much sought after. Of course this is done with the aid of a forcing-house, but a very high temperature is not required. The best soil for pot hyacinths is made up of two parts turfy loam, one part decayed leaf-mould, and one part well-decomposed cow dung, with sand enough to make it porous, and with sufficient drainage.

The name of hyacinth is applied to several other plants having bulbous roots. The Cape hyacinth is *Scilla corymbosa*; the grape hyacinth, *Muscari botryoides*; the tassel hyacinth, *Muscari comosum*, and the feathered hyacinth, *Muscari comosum monstrosum*; the starch hyacinth, *Muscari racemosum*; the star hyacinth, *Scilla amœna*; the lily hyacinth, *Scilla Liliohyacinthus*; the hyacinth of Peru, *Scilla peruviana*; the wild hyacinth or blue-bell, *Hyacinthus non scriptus*; the wild hyacinth of America, *Camassia esculenta*; the Missouri hyacinth, *Hesperoscordum lacteum*; and the native hyacinth of Tasmania, *Thelymitra media*.

HYACINTHUS, a mythological figure connected with the Hyacinthia, a festival celebrated by the Spartans in honour of Apollo of Amyclæ, whose primitive image, standing on a throne, is described by Pausanias (iii. 19, 4). The legend attached to the festival is to the effect that Hyacinthus, a beautiful youth beloved by the god, was accidentally killed by him with a discus. From his blood sprang a dark-coloured flower called after him hyacinth, on whose petals is the word *αἰαῖ*, alas. The myth, like that of Linus (v. Brugsch, *Die Adonis-Klage und das Linos-Lied*), is one of the many popular representations of the beautiful spring vegetation slain by the hot sun of summer (which is here and in many other legends denoted by the symbol of a discus). The sister of Hyacinthus is Polybœa, the much nourishing fertility of the rich Amyclæan valley; while his brother is Cynortas, the rising of the dog (the hot) star. But with the death of the spring is united the idea of its certain resuscitation in a new year; like Dionysus, the hero is not merely dead but elevated to heaven. The festival took place on the three hottest days of summer, 7th to 10th of the month Hecatombeus (which was called in Sicily Hyacinthius), and its rites were a mixture of mourning and rejoicing (Athen., iv. 17).

HYADES, five stars forming the head of the larger constellation, the Bull. Their rising along with the sun marks the opening of the rainy season, hence their name Hyades—the Rainy. As mythological figures they were said to be daughters of Atlas, who as a reward for some pious act were translated to heaven. The nature of the deed is variously stated: sometimes it is their long-continued grief for their brother Hyas, who was slain by a snake (or boar or lion); at other times it is their having acted as nurses of Dionysus Hyes. In the latter case they are counted as nymphs of Nysa. When their charge was threatened by Lycurgus they fled with him to Thetis or to Ino in Thebes. They are also described as nymphs of Dodona, who acted as nurses of the infant Zeus. In any case their character as clouds and rain-givers is obvious. Their number is sometimes given as two, also as three, especially in Attica, which leads Brunn to see them in the pediment of the Parthenon in the figures usually spoken of as "The Fates."

HYÆNA (*Hyænidæ*), a family of digitigrade carnivorous mammals, approaching the *Felidæ* or cats in the character of the dentition, while resembling the *Viverridæ* or civets in the possession of a glandular pouch beneath the anus, and therefore usually classed as a transition group between these two families. It comprises a single genus (*Hyæna*), and three species, which resemble each other and differ from all other carnivores in having both pairs of feet with four toes each. They are further characterized by the greater length of their fore legs as compared with those behind, by their well-developed although non-retractile claws, by their prickly cat-like tongue, and by the enormous strength of their jaws and teeth, which enables them to break open the hardest bones, and to retain what they have seized with the most unrelaxing grip.

The Striped Hyæna (*Hyæna striata*) is the most widely distributed and best known form, being found throughout India, Persia, Asia Minor, and the northern half of Africa, while, if the strand wolf (*Hyæna villosa*) of the Cape colonists is only a variety of this species, as many naturalists suppose, its range will be thereby extended to the southern extremity of the African continent. It resembles a wolf in size, and is of a greyish-brown colour, marked with indistinct longitudinal stripes of a darker hue, while the legs are transversely striped as in the zebra. The hairs on its body are long, especially on the ridge of the neck and back, where they form a distinct mane, which is continued along the tail. The hyæna is nocturnal in its habits, preferring by day the gloom of caves and ruins, or of the burrows which it occasionally forms, but coming forth at sunset to make night hideous with its unearthly howling, which, when the animal is excited, changes into what has been compared to demoniac laughter, and hence the name of "laughing hyæna," by which it is also known. The food of those creatures consists chiefly of carrion, and they thus perform a highly useful service in hot countries by devouring the remains of dead animals which might otherwise pollute the air. So ravenous, however, are they that even the bodies of the buried dead are not safe from their attacks, their powerful claws enabling them to gain access to the newly interred bodies in the Eastern cemeteries, which they are said habitually to frequent. They also feed on the flesh of animals, which they hunt in packs. When driven by hunger they have thus been frequently known to enter villages by night and to carry off such domestic animals as they might chance to find. Bruce, the African traveller, states that everywhere in Abyssinia they were a plague. "Gondar," he says, "was full of them from the time it turned dark till the dawn. In short, the hyæna was the plague of our lives, the terror of our night walks, the destruction of our mules and asses, which above all others are his favourite food." Although, in proportion to its size, possessing probably the most powerful teeth and jaws in the whole mammalian series, the pusillanimity of the hyæna is such as to prevent its attacking animals greatly inferior to itself in strength. The

FIG. 1.—Striped Hyæna.

Arab, for this reason, holds it in contempt; and, when he condescends to hunt the hyæna, he does not waste his ammunition upon it, but runs it down with dogs. It has usually been regarded as untameable; this, however, is not the case, for when properly treated in captivity, it has been known to exhibit the greatest docility and attachment to its keepers; and Colonel Sykes states that in certain districts of Central India where those creatures abound they are as susceptible of domestication as ordinary dogs.

The Spotted Hyæna (*Hyæna crocuta*) takes the place of the striped species in the southern half of the African continent, to which it is confined. It resembles the other in size, but differs from it considerably in appearance, the stripes of the one being replaced by dark brown spots on a yellowish ground in the other, while in the "tiger-wolf," as this species is called at the Cape, the mane is much less distinct. According to Schweinfurth, who met with it in the heart of Africa, it is a much more powerful and savage animal than the northern form. Although averse to hunting living prey, it takes to the chase when carrion is not to be had, and the same traveller was on one occasion startled by a spotted hyæna which darted past him, like lightning, in pursuit of an antelope. At the Cape it was formerly very common, and occasionally committed great havoc among the cattle, while it did not hesitate to enter the Kaffre dwellings at night and carry off the child sleeping by its mother's side. By persistent trapping and shooting, its numbers have now been considerably reduced, with the result, however, of making it, like the hippopotamus of the same regions, exceedingly wary, so that it is not readily caught in any trap with which it has had an opportunity of becoming acquainted. Like the northern species, the

FIG. 2.—Spotted Hyæna.

spotted hyæna has been tamed, and has occasionally been trained to take the place of the dog. Its skin exhibits a considerable variety of colour and marking, and Schweinfurth found many skins in use among the Niamniams of Central Africa, in the form of aprons. The brown hyæna (*Hyæna rufa*) is also a native of South Africa.

Although hyænas are now confined to the warmer regions of the Old World, their fossil remains show that they had a much more northerly range during Tertiary times. Abundant remains of a larger species than any now living have been found in the caves of England, France, and Germany. This species, known as the cave hyæna (*Hyæna spelæa*), is supposed to have been most nearly allied to the spotted hyæna of South Africa, but does not appear to have extended farther south than the middle of Europe. Remains which have been doubtfully identified as belonging to the striped species have also been found in the south of France, and others in Sicily and Algeria, undoubtedly belonging to the spotted form of South Africa, which must thus have had a much more northerly extension in Tertiary times. No remains of the hyæna are known to occur in the New World.

HYBLA is the name of several cities in Sicily. A Sicilian goddess was named Hyblæa (Paus. v. 23. 6); hence doubtless the name was so common. The Hybla of which we hear most was founded by the Megarians, about the year 726 B.C., and is probably the same as Megara Hyblæa. For some time it was a flourishing city; a century after its foundation it founded in its turn the colony of Selinus. But about the year 481 B.C. it was completely destroyed by Gelon, tyrant of Syracuse. The mass of the inhabitants were sold as slaves; the richer were transported to Syracuse and there admitted as citizens. Among these was Epicharmus of Cos, who had been brought up in Megara. During the Athenian expedition to Sicily, Lamachus urged that they should occupy the deserted site. It must therefore have had a fine harbour, whence we may consider that it probably lay beside the modern city of Agosta. A small settlement seems afterwards to have grown up on the site. An older city called Hybla, belonging to the native Siculi, lay not far off on the southern slope of Mount Etna, near the river Symæthus. It is mentioned in the history of the Second Punic War; and in the time of Cicero (*Verr.*, iii. 43) it was a flourishing place. It is exceedingly difficult to separate the history of these two cities; and no doubt the ancient writers themselves often do not clearly distinguish between them. The Hyblæan honey, which was produced on the hills beside them, is often celebrated by the Latin poets. There was a third city of the same name on the road from Syracuse to Agrigentum.

HYBRIDISM. The Latin word *hybrida*, or *hibrida*, a hybrid or mongrel, is commonly derived from the Greek ὕβρις, an insult or outrage, with special reference to lust; hence an outrage on nature, a mongrel.

As a general rule animals or plants belonging to distinct species are not able, when crossed with each other, to produce offspring. There are, however, innumerable exceptions to this rule; and hybridism is the word employed to denote these exceptions. It is an abstract term which signifies the more or less fertile crossing of distinct species. In scientific usage, the term "hybrid" is exclusively reserved to denote the result of a fertile cross between two distinct species, while the term "mongrel" is the one which is as exclusively reserved to denote the result of a fertile cross between two varieties of the same species.

Until recently the interest attaching to hybridism was almost entirely of a practical nature, and arose from the fact, which is of considerable importance in horticulture, that hybrids are often found to present characters somewhat different from those of either parent species. But of late years the subject has acquired a high degree of scientific interest in relation to the theory of descent. On this account it has been so carefully and thoroughly treated by Mr Darwin that a brief exposition of its main facts and principles must necessarily be little more than a condensation of his already closely packed material.

Looking first to the general facts and principles of hybridism, apart from their bearing upon the theory of descent, the following may be regarded as the most important:—

1. The laws governing the production of hybrids are identical, or nearly identical, in the animal and vegetable kingdoms.

2. The sterility which so generally attends the crossing of two specific forms is to be distinguished as of two kinds, which, although often confounded by naturalists, are in reality quite distinct. For the sterility may obtain between the two parent species when first crossed, or it may first assert itself in their hybrid progeny. In the latter case the hybrids, although possibly produced without any appearance of infertility on the part of their parent species, nevertheless prove more or less infertile among themselves, and also with members of either parent species.

3. The degree of both kinds of infertility varies in the case of different species, and in that of their hybrid progeny, from absolute sterility up to complete fertility. Thus, to take the case of plants, "when pollen from a plant of one family is placed on the stigma of a plant of a distinct family, it exerts no more influence than so much inorganic dust. From this absolute zero of fertility, the pollen of different species, applied to the stigma of some one species of the same genus, yields a perfect gradation in the number of seeds produced, up to nearly complete, or even quite complete, fertility; so, in hybrids themselves, there are some which never have produced, and probably never would produce, even with the pollen of the pure parents, a single fertile seed; but in some of these cases a first trace of fertility may be detected, by the pollen of one of the pure parent species causing the flower of the hybrid to wither earlier than it otherwise would have done; and the early withering of the flower is well known to be a sign of incipient fertilization. From this extreme degree of sterility we have self-fertilized hybrids producing a greater and greater number of seeds up to perfect fertility."

4. Although there is, as a rule, a certain parallelism, there is no fixed relation between the degree of sterility manifested by the parent species when crossed and that which is manifested by their hybrid progeny. There are many cases in which two pure species can be crossed with unusual facility, while the resulting hybrids are remarkably sterile; and, contrariwise, there are species which can only be crossed with extreme difficulty, though the hybrids, when produced, are very fertile. Even within the limits of the same genus, these two opposite cases may occur.

5. When two species are reciprocally crossed, *i.e.*, male A with female B, and male B with female A, the degree of sterility often differs greatly in the two cases. The sterility of the resulting hybrids may differ likewise.

6. The degree of sterility of first crosses and of hybrids runs, to a certain extent, parallel with the systematic affinity of the forms which are united. "For species belonging to distinct genera can rarely, and those belonging to distinct families can never, be crossed. The parallelism, however, is far from complete; for a multitude of closely allied species will not unite, or unite with extreme difficulty, whilst other species, widely different from each other, can be crossed with perfect facility. Nor does the difficulty depend on ordinary constitutional differences; for annual and perennial plants, deciduous and evergreen trees, plants flowering at different seasons, inhabiting different stations, and naturally living under the most opposite climates, can often be crossed with ease. The difficulty or facility apparently depends exclusively on the sexual constitution of the species which are crossed, or on their sexual elective affinity."

Such being the principal facts of hybridism, we may next consider the relation which they bear to the theory of descent. It is obvious that the most important point of contact between the former and the latter consists in this—that, although hybridism is occasionally possible as an exception to the general infertility of species *inter se*, it is only, as it were, a partial exception; for, even when produced, the hybrid progeny almost invariably manifest some greater or less degree of sterility, and this not only when crossed among themselves, but even when crossed with either of their parent species. The main facts of hybridism thus at first sight seem to support the time-honoured doctrine that there are placed between all species the barriers of mutual sterility, for the purpose of preventing any admixture of specific qualities by heredity, and so for the purpose of maintaining the immutability of specific types. And the apparent support which this doctrine thus receives from the main facts of hybridism is still further strengthened when these facts are contrasted with those which are supplied by the breeding of our domestic "varieties." For, in the latter case, and as an almost invariable rule, neither the organisms when crossed nor their resulting progeny show any indications of sterility, although the two parent varieties may differ from one another even more widely than do many natural species which are wholly infertile when crossed. This very general distinction between natural species and domestic varieties has appeared to many competent persons in the present generation so profound and significant that they deem it to be in itself sufficient to discredit, if not to negative, the whole theory of the transmutation of species.

Now, when this distinction is thus posited as an objection to the theory of descent, we must first of all remember that this theory does not require the possibility of the commingling of specific types; it requires, indeed, that specific types should not be immutably fixed, but it does not require that the causes of their mutation should depend upon their mutual crossing. The whole difficulty, therefore, which the theory of descent has here to meet is to explain why it is that natural species are fenced about, as it were, with the mysterious barriers of sterility, while no such seeming care appears to have been taken in the case of our domestic breeds—even though in the latter case artificial selection by the breeders may have produced more visible difference between the two parent races than that which natural selection is supposed to have produced between two natural species.

In answer to this difficulty, the most important consideration to begin with is one that is very generally lost sight of. The consideration is that mutual sterility between organic forms has been constituted by naturalists the chief criterion of specific distinction, and therefore it is merely to argue in a circle to maintain that specific distinction is of some transcendental nature *because* it is so invariably associated with this mutual sterility. If it were not for the fact of their mutual sterility, this and that species would probably not have been classified as such; and therefore it is now scarcely to be considered a matter of any great significance that all species present more or less of the peculiarity in virtue of which they are recognized as species. Or, otherwise stated, on the supposition that species have had a derivative origin, whenever the modification of a specific type has proceeded sufficiently far to induce sterility with allied types, the modified type is, *for this reason*, classified as a distinct species; otherwise, upon the supposition, the species could scarcely have become separated out as a distinct type. The argument which points to such sterility as evidence against this supposition is, therefore, so far inconclusive.

The case, however, ought not in fairness to be stated quite so strongly as this; for mutual sterility, although the chief, is not the only criterion of specific distinction. In forming their classifications, naturalists endeavour as much as possible to have regard to organisms in the totality of their structures and functions. It may therefore still be maintained that, although the above consideration as to mutual sterility being selected as the chief criterion of specific distinction greatly mitigates the force of the argument that natural species differ from artificial breeds in being more or less sterile with one another, still this consideration does not altogether destroy that argument. For, on the one hand, it is not mutual sterility alone which is taken as a test of specific distinction; and, on the other hand, it generally so happens that the other qualities distinctive of any given species do not differ more widely from those which are distinctive of allied species than is the case with many of our domestic breeds. It therefore still remains a significant circumstance that, *along with* the differences distinctive of natural species, there almost invariably goes the protective attribute of mutual sterility; while the possibly greater differences distinctive of our domestic breeds are unaccompanied by any such protective attribute. But, again, this more refined objection can be met and satisfactorily excluded by the general consideration that "as species rarely or never become modified in one character, without being at the same time modified in many, and as systematic affinity includes all visible resemblances and dissimilarities, any difference in sexual constitution between two species would naturally stand in more or less close relation with their systematic position."

But we are not confined to this general consideration alone. There are several other general considerations which tend still further to mitigate the difficulty, and there are several particular facts which together prove that the alleged distinction between natural species and domestic varieties is one, not of kind, but of degree. We shall, therefore, next proceed to state these general considerations and particular facts.

Upon the theory of descent, mutual sterility between specific types is nothing more than the expression of some certain amount of modification having taken place in the reproductive system of a changing form, which up to that time, and but for the fact of this modification, would have been classified by naturalists as a mere variety. Now the causes which act upon the reproductive system, both of animals and plants, and whether in the direction of sterility or prolificness, are at present hopelessly obscure. We cannot, therefore, expect to distinguish the causes which in the case of any given species have determined sterility. Nor is it necessary, for the meeting of the present difficulty, that this should be done; it is enough for this purpose to show that the causes which thus act upon the reproductive system are much too indistinct to admit of any argument being raised upon them. And this it is most easy to show; for it is not too much to say that the reproductive system is, generally speaking, of all parts of an organism the most delicately susceptible to slight changes in the conditions of life. Mr Darwin has adduced a vast array of facts on this head in his *Variation of Animals and Plants under Domestication*. As a result of this delicacy, there arises an apparent capriciousness in the ways and degrees in which the reproductive system is affected by slight changes in the conditions of life, by too close interbreeding, by grafting, and by many other causes. Thus, for example, the influences of domestication produce more or less sterility in numberless species of wild animals and plants, while in other species—and this, as we shall presently see, is a matter of great importance in the present connexion—such influences are favourable to fertility. Now if we suppose, as in consistency we must suppose, that throughout the course of evolution the reproductive system has always been characterized by a sensitiveness to slight changes similar to that which we now observe, and if we remember that, in any case where these slight changes were sufficient to cause mutual sterility between the modified descendants of a common progenitor, a distinction of species must necessarily have arisen,—we shall cease to regard the present sterility of species *inter se* as anything more than what might be expected *a priori*, supposing the theory of descent with gradual modification to be true.

As evidence of the apparent capriciousness with which sterility may be manifested, owing to the slight and imperceptible causes on which it depends, special allusion must here be made to a highly remarkable and significant fact that has been brought to light by the direct experiments of Mr Darwin. The following is his account of these experiments:—

"Several plants belonging to distinct orders present two forms, which exist in about equal numbers, and which differ in no respect except in their reproductive organs,—one form having a long pistil with short stamens, the other a short pistil with long stamens; both with differently-sized pollen grains. With trimorphic plants there are three forms likewise differing in the length of their pistils and stamens, in the size and colour of the pollen grains, and in some other respects; and, as in each of the three forms there are two sets of stamens, there are altogether six sets of stamens and three kinds of pistils. These organs are so proportioned in length to each other that, in any two of the forms, half the stamens in each stand on a level with the stigma of the third form. Now I have shown, and the result has been confirmed by other observers, that in order to obtain full fertility with other plants, it is necessary that the stigma of the one form should be fertilized by pollen taken from the stamens of corresponding height in the other form. So that with dimorphic species two unions, which may be called legitimate, are fully fertile, and two which may be called illegitimate are more or less infertile. With trimorphic species six unions are legitimate or fully fertile, and twelve are illegitimate or more or less infertile. The infertility which may be observed in various dimorphic and trimorphic plants when they are illegitimately fertilized, that is, by pollen taken from stamens not corresponding in height with the pistil, differs much in degree up to absolute and utter sterility,—just in the same manner as occurs in crossing distinct species."

In this case we appear to have actual evidence of different stages of increasing sterility *in transitu*, and this even within the limits of the same natural species. And if even such evidence as this can be resisted, there still remains one very important fact, which directly affects the whole alleged distinction between the sterility of natural species and the fertility of domestic breeds. This fact is that plants belonging to several species of the genus *Passiflora* have been amply proved, not only to be completely fertile with plants belonging to other species, but even to be as completely infertile with plants belonging to their own. Thus fruit could not be obtained from *P. alata* and *P. racemosa* except by reciprocally fertilizing them with each other's pollen; and similar facts have been observed by several experimentalists with regard to four or five other species of this genus. The fullest details on the subject are those given by Mr Scott in the *Journal of the Linnean Society*, vol. viii. p. 168. Plants belonging to three species of the genus, viz., *P. racemosa, cœrulea,* and *alata*, flowered for many years in Edinburgh, but, though repeatedly fertilized by Mr Scott and others with their own pollen, never produced seed. But when mutually crossed in various ways they all produced seed. After quoting this case Mr Darwin adds :—

"Returning to *P. alata,* I have received (1866) some interesting details from Mr Robinson Munro. Three plants, including one in England, have already been mentioned which were inveterately self-sterile, and Mr Munro informs me of several others which, after repeated trials during many years, have been found in the same predicament. At some other places, however, this species fruits readily when fertilized with its own pollen. At Taymouth Castle there is a plant which was formerly grafted by Mr Donaldson on a distinct species, name unknown, and ever since the operation it has produced fruit in abundance by its own pollen, so that this small and unnatural change in the state of this plant has restored its self-fertility. Some of the seedlings from the Taymouth Castle plant were found to be not only sterile with their own pollen, but with each other's pollen and with the pollen of distinct species. Pollen from the Taymouth plant failed to fertilize certain plants of the same species, but was successful on one plant in the Edinburgh Botanic Gardens. Seedlings were raised from this latter union, and some of their flowers were fertilized by Mr Munro with their own pollen; but they were found to be as self-impotent as the mother plant had always proved, except when fertilized by the grafted Taymouth plant, and except, as we shall see, when fertilized by her own seedlings. Yet Mr Munro fertilized eighteen flowers on the self-impotent mother plant with pollen from these her own self-impotent seedlings, and obtained, remarkable as the fact is, eighteen fine capsules full of excellent seed. I have met with no case in regard to plants which shows so well as this of *P. alata* on what small and mysterious causes complete fertility or complete sterility depends."

These cases in the genus *Passiflora*, although so highly remarkable, are not wholly unique. There is not, indeed, any other case of a natural species, the members of which are only fertile with members of another species; but there are several cases of natural species, the members of which are self-impotent, though freely fertile either with other plants of the same species, or with plants of different though allied species. This may perhaps be regarded as a transitional stage between the ordinary condition of plants and the extraordinary condition that obtains among species of the genus *Passiflora*. It occurs in individual plants of certain species of *Lobelia* and *Verbascum*, and among several genera of orchids. The cases of the latter are particularly remarkable, inasmuch as Fritz Müller found from numerous experiments, not only that individual plants belonging to the several species were not fertilized by their own pollen, while freely so by pollen taken from distinct species, and even from distinct genera, but that the plant's own pollen was positively deleterious to its stigma, and acted as a poison to the destruction of the flower.

So much, then, for the facts which go to prove on what slight constitutional differences sterility may depend, and the consequent probability there is that it should generally be found to accompany a change of organization which is sufficiently great to be regarded by naturalists as a specific distinction. But the pleading must not end here. For there still remains to be adduced the fact, already mentioned as one of the general facts of hybridism, that "the degree of both kinds of fertility varies in the case of different species, and in that of their hybrid progeny, from absolute sterility up to complete fertility." As a matter of fact, the distinction between natural species and domestic varieties, upon which the whole discussion has hitherto proceeded, is in itself untenable; the infertility of natural species when crossed, although without question the general rule, is nevertheless not the invariable rule. We need not point to the highly anomalous case of *Passiflora* recently mentioned in another connexion, and probably to be explained as the result of cultivation; for we appear to have sufficient evidence without it. It is true that a great deal of negative evidence has been published upon this point by very competent experimentalists; but it seems impossible to resist the positive evidence of the Hon. and Rev. W. Herbert, whose distinguished success in hybridizing Mr Darwin attributes to "great horticultural skill, and to his having hot-houses at his command." Of his many results, which from being of a positive kind can scarcely be suspected of inaccuracy, it will be enough to quote the following:—"Every ovule in a pod of *Crinum capense* fertilized by *C. revolutum* produced a plant, which I never saw to occur in a case of its natural fecundation." Thus, as Mr Darwin in alluding to this case remarks, "we have perfect, or even more than commonly perfect, fertility in a first cross between two distinct species."

So far, then, as one side of the question before us is concerned, or that relating to the mutual infertility of natural species, enough has been said to show that it presents no real difficulty to the theory of descent. Indeed, in view of all that has now been said, the difficulty, as Mr Darwin has observed, is not so much to account for the sterility of natural species, as it is to account for the continued, or even increased, fertility of our domestic varieties. Turning, therefore, to this other side of the question, we have to remember that the very same sensitiveness of the reproductive system, which in some cases leads to infertility under a change in the conditions of life, in other cases leads to increased fertility under an apparently similar change in the conditions of life. Thus it is that domestication produces such apparently capricious results with regard to fertility—inducing all degrees of infertility in some wild species, while not at all impairing, or even increasing, fertility in others. Consequently, when the question is as to why our domestic varieties do not become sterile *inter se* when so many natural species have become so, the answer is that the mere fact of their domestication proves that their wild or parent stocks must have been some of those species whose reproductive systems were not highly sensitive to changes in their condition of life, and therefore species which "might be expected to produce varieties little liable to have their reproductive systems injuriously affected by the act of crossing with other varieties which had originated in a like manner." Thus, on the inherently necessary view that our domestic varieties have all proceeded from species which were not easily affected in the direction of sterility, we are not surprised that under variation their reproductive systems should continue to manifest a high degree of tolerance. To this must be added that domestication, if it does not produce sterility, seems well calculated to increase fertility. For if the causes inducing sterility (whatever they may be) are absent, ample and regular nutrition, combined with innumerable lesser benefits attending domestication, may well be supposed to favour fertility. And, as a matter of fact, according to Pallas, there is a great deal of evidence to indicate that prolonged domestication has a tendency to eliminate sterility; so that wild species which when first domesticated intercross with difficulty, become in time able to intercross with facility. Such, for instance, appears to have been the case with the dog; for on the one hand all the domestic varieties of this animal are now freely fertile among themselves, and, on the other hand, there is independent evidence that these varieties have sprung from more than one natural species. Again, mention must not be omitted of the important fact that, although in the case of none of our varieties of domesticated animals is there any evidence of mutual sterility, yet among our varieties of domesticated plants a few cases have been observed of complete mutual sterility, which is in every way analogous to that which occurs between natural species. Thus, Gärtner observed this to be the case with certain varieties of maize and *Verbascum*, Kölreuter with one kind of tobacco, and other experimentalists with sundry varieties of gourd and melon. And here, let it be observed, we have the exact counterpart that evolutionists would desire to the experiments of Herbert above mentioned; for while he was able to break down the general distinction between natural species and domestic varieties on the side of proving perfect fertility between certain natural species, these experimentalists have broken down the distinction on the side of proving perfect sterility between certain of our domestic varieties. Therefore, we may conclude that this side of the question, or that as to the fertility of our domestic varieties, presents as harmless an aspect towards the theory of descent as we have already seen to be presented by the other side of the question, or that as to the sterility of natural species.

Finally, there are two complementary considerations to be adduced, which may now be stated together. One is that the general principles of hybridism, as briefly stated at the beginning of this article, are really far from indicative of having been instituted with any design of simply preventing species from intercrossing. For, upon the view that they were so instituted, scarcely any one of them admits of a rational explanation. Thus, upon this view, no reason can be assigned why the degree of sterility should be so extremely variable in different species, when it must be supposed equally important that all species should be kept distinct; nor can it be said why the degree of sterility should vary even among individuals of the same species. Neither can it be said why some species should cross with facility, and yet produce sterile hybrids, while other species cross with difficulty, and yet produce fertile hybrids. Why should species living in countries remote from one another, and therefore not able in a state of nature to come together, nevertheless prove as sterile *inter se* as species inhabiting the same country? Why, again, should there often be so great a difference in the result of a reciprocal cross between two species? Or why, indeed, should the production of hybrids have been permitted at all? As Mr Darwin observes, "to grant to species the special power of producing hybrids, and then to stop their further propagation by different degrees of sterility, not strictly related to the facility of the first union between their parents, seems a strange arrangement."

The other and complementary consideration which has to be mentioned is that, on the counter supposition of all these general principles of hybridism being "simply incidental," or dependent on unknown differences in the reproductive systems of species,—on this supposition we meet with sundry differences between wild species and domestic varieties which are fully analogous to their difference of fertility, and which yet cannot reasonably be supposed to serve any transcendental purpose. Thus, again to quote Mr Darwin:—

"Some allied species of trees cannot be grafted on each other—all varieties can be so grafted. Some allied animals are affected in a very different manner by the same poison, but with varieties no such case until recently was known, but now it has been proved that immunity from certain poisons stands in some cases in correlation with the colour of the hair. The period of gestation generally differs much with distinct species, but with varieties until lately no such difference had been observed. The time required for the germination of seeds differs in an analogous manner, and I am not aware that any difference in this respect has as yet been detected with varieties. Here we have various physiological differences, and no doubt others could be added, between one species and another of the same genus, which do not occur, or occur with extreme rarity, in the case of varieties; and these differences are apparently wholly or in chief part incidental on other constitutional differences, just in the same manner as the sterility of crossed species is incidental on differences confined to the sexual system. Why, then, should these latter differences, however serviceable they may indirectly be in keeping the inhabitants of the same country distinct, be thought of such paramount importance in comparison with other incidental and functional differences? No sufficient answer to this question can be given."

Upon the whole, therefore, it may be concluded that the difficulty which the facts of hybridism seem at first sight to raise against the theory of descent may be explained in harmony with the main requirements of that theory.

Animal Hybrids.—A few words may here be added with special reference to animal hybrids. As a general statement it may be said that hybrids, not only between specific but generic forms, are more easily produced in the case of animals than in that of plants. The hybrids, however, when produced are, as a general rule, more sterile. Indeed, it is doubtful whether there is any single instance of a perfectly fertile hybrid having emanated from a cross between two animal species. Mr Darwin, however, says—"I have reason to believe that the hybrids from *Cervulus vaginalis* and *Reevesii*, and from *Phasianus colchicus* with *P. torquatus*, are perfectly fertile." Also M. Quatrefages states that the hybrid progeny of two moths (*Bombyx cynthia* and *B. arrindia*) showed themselves to be fertile *inter se* for eight generations. The hare and rabbit are said occasionally to breed together, and their offspring to be highly fertile when crossed with either parent species. Lastly, Mr Darwin observes:—

"The hybrids from the common and Chinese geese (*A. cygnoides*), species which are so different that they have sometimes been ranked in distinct genera, have often bred in this country with either pure parent, and in several instances *inter se*. This was effected by Mr Eyton, who raised two hybrids from the same parents, but from different hatches; and from these two birds he raised no less than eight hybrids (grandchildren of the pure geese) from one nest. In India, however, these cross-bred geese must be far more fertile; for I am assured by two eminently capable judges, namely, Mr Blyth and Captain Hutton, that whole flocks of these crossed geese are kept in various parts of the country; and, as they are kept for profit where neither pure parent-species exists, they must certainly be highly or perfectly fertile."[1]

It is somewhat remarkable that hitherto direct experiments on the hybridization of animals have been so few in number as compared with those on the hybridization of plants. This is the more to be regretted, because, as already observed, animals appear to display a somewhat greater aptitude for hybridizing than plants, and consequently furnish better material for ascertaining the furthest limits of systematic affinity within which a cross may prove fertile. But here direct experiments are wanting, and all we can say with certainty is that in animals, as in plants, no authentic instance is on record of progeny resulting from a union of two individuals separated from one another by more than a generic distinction.

[1] Since the above was published, Mr Darwin has himself procured two of these hybrid geese, and from them (brother and sister) raised five "extremely fine birds from two hatches." These five hybrids "resembled in every detail their hybrid parents" (see *Nature*, Jan. 1, 1880).

Graft-Hybridism.—The only other subject of importance that falls under the present heading, is that which has been appropriately called "graft-hybridism." It is well known that, when two varieties or allied species are grafted together, each retains its distinctive characters. But to this general, if not universal, rule there are on record several alleged exceptions, in which either the scion is said to have partaken of the qualities of the stock, the stock of the scion, or each to have affected the other. Supposing any of these influences to have been exerted, the resulting product would deserve to be called a graft-hybrid. It is clearly a matter of great interest to ascertain whether such formation of hybrids by grafting is really possible; for, if even one instance of such formation could be unequivocally proved, it would show that sexual and asexual reproduction are essentially identical.

The cases of alleged graft-hybridism are exceedingly few, considering the enormous number of grafts that are made every year by horticulturists, and have been so made for centuries. Of these cases the most celebrated are those of Adam's laburnum (*Cytisus Adami*) and the bizzarria orange. Adam's laburnum is now flourishing in numerous places throughout Europe, all the trees having been raised as cuttings from the original graft, which was made by inserting a bud of the purple laburnum into a stock of the yellow. M. Adam, who made the graft, has left on record that from it there sprang the existing hybrid. There can be no question as to the truly hybrid character of the latter—all the peculiarities of both parent species being often blended in the same raceme, flower, or even petal; but until the experiment shall have been successfully repeated, there must always remain a strong suspicion that, notwithstanding the assertion and doubtless the belief of M. Adam, the hybrid arose as a cross in the ordinary way of seminal reproduction. Similarly, the bizzarria orange, which is unquestionably a hybrid between the bitter orange and the citron,—since it presents the remarkable spectacle of these two different fruits blended into one,—is stated by the gardener who first succeeded in producing it to have arisen as a graft-hybrid; but here again a similar doubt, similarly due to the need of corroboration, attaches to the statement. And the same remark applies to the still more wonderful case of the so-called trifacial orange, which blends three distinct kinds of fruit in one, and which is said to have been produced by artificially splitting and uniting the seeds taken from the three distinct species, the fruits of which now occur blended in the triple hybrid.

The other instances of alleged graft-hybridism are too numerous to be here noticed in detail; they refer to jessamine, ash, hazel, vine, hyacinth, potato, beet, and rose. Of these the cases of the vine, beet, and rose are the strongest as evidence of graft-hybridization, from the fact that some of them were produced as the result of careful experiments made by very competent experimentalists. On the whole, the results of some of these experiments, although so few in number, must be regarded as making out a strong case in favour of the possibility of graft-hybridism. For it must always be remembered that in experiments of this kind, negative evidence, however great in amount, may be logically dissipated by a single positive result.

History and Literature.—From time immemorial the leading facts of hybridism have been known in the case of the horse and the ass. The knowledge of corresponding facts as occurring in the vegetable kingdom necessarily dates from a time subsequent to that at which the sexual functions of plants became known, *i.e.*, towards the end of the 17th century. The earliest recorded observation of a hybrid plant is one by Gmelin; the next is that of Thomas Fairchild, who in the second decade of the 18th century produced the cross which is still grown in gardens under the name of "Fairchild's Sweet William." Later on in that century Linnæus made a number of experiments on the cross fertilization of plants, and produced various hybrids; but it was reserved for the laborious investigations of Kölreuter, towards the end of that century (1751-1799), to found and largely to build the existing structure of our scientific knowledge upon this subject. To him also belongs the credit of first discovering the part played by insects in the fertilization of flowers. He published most of his results at the St Petersburg Academy of Sciences. Next in order of time deserve mention the works of Graf Lavola (*Discorso della Irri'abilita d'alcuni Fiori nuovamente scoperta*, 1764), and of Conrad Sprengel (*Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen*, 1793). The latter work is full of interesting observations on the connexion between the structure of flowers and the visitation of insects. Next we come to the celebrated horticulturist, Thomas Andrew Knight, who from 1787 for a number of years devoted an immense amount of labour, with a large measure of results, to the improvement of fruit trees and vegetables by crossing. He published in the *Philosophical Transactions* and in the *Trans. Hort. Soc.* During the first quarter of the present century the only names that in the present connexion call for mention are those of J. E. Smith (*Flora Britannica*, 1800), Villars (*Ro. Coll. Bot.*, 1809), Hoppe (*Neues Bot. Taschenb.*, 1810), Guillemin and Dumas ("Obs. sur l'Hybridité d. Plant.," in *Mém. Paris Soc. Hist. Nat.*, 1833), Henschel, and Godron. During this period, besides Knight, already mentioned, there were two other English experimentalists at work, whose names deserve to be placed in the first rank among those which are associated with this subject. These are Sweet, who published an important work on *Geraniaceæ*, and Herbert, whose work on *Amaryllidæ*, together with sundry publications in the *Journal of the Horticul ural Society*, very materially advanced both the facts and the theory of hybridism. We say "theory," because it was in these publications that Herbert carried on his celebrated controversy with Knight regarding the alleged sterility of hybrids. In 1828 there was published a prize essay by Wiegmann on a thesis which was set several years before by the Berlin Academy of Sciences, and which embodied the question whether hybrid plants are necessarily sterile. We next come, in the second quarter of the present century, to the laborious researches of Gärtner, the number of whose experiments in hybridizing has certainly not been surpassed, and probably has not been equalled, by that of any other experimentalist. His principal work is *Versuche und Beobachtungen über die Bastarderzeugung im Pflanzenreiche.* In connexion with this period we may also mention the names of Braun, Wallroth, Zuccarini, Meyer, Ziz, Koch, Schiede, Lasch, Reichenbach, A. P. de Candolle, Wimmer, Hornschuh, and Nägeli. In 1854 a research of value was published by Klotzsch (*Verhandl. Kgl. Preuss. Akad. Berlin*), and others later by Regel, Godron, and Jordon. In 1860 a prize was offered by the French Academy of Sciences for the best essay on hybridism, with special reference to three points,—the fertility or sterility of hybrids, the cause of their sterility, and the constancy of type manifested by fertile hybrids. In 1865 this prize was awarded jointly to Naudin and Godron, the latter name being identified with researches upon the character of hybrids which deserve to be considered among the most important of the present century. The next work of note appeared in 1865, by Max Wichura, on *Die Bastardbefruchtung in Pflanzenreich*, &c. He combined, in one complex hybrid, six different species of *Salix*; confirmed, in opposition to Godron, the doctrine of Kölreuter, Herbert, Gärtner, and Naudin, that a hybrid is best fertilized by its own pollen; and found, in opposition to Naudin, that the progeny of hybrid willows retains its hybrid character. In 1865-6 Nägeli published his important observations on naturally produced hybrids (*Sitzungsber. Akad. München, Math. Phys.*). The highly important experiments of Darwin on dimorphic and trimorphic plants have been already alluded to. Those who within still more recent years have contributed to the literature of hybridism are Caspary, Mendel, Seden, Dominy, Kellermann, Fr. Schultz, Timbal-Lagrave, Grenier, A. Kerner, Wirtgen, Michalet, Ritschl, Beckhaus, P. Ascherson, R. von Uechtritz, J. Schmalhausen, C. Haussknecht, V. von Borbás, Kuntze, Henniger, and W. O. Focke. The last-named author has just published an elaborate and valuable work on hybridism in plants (*Die Pflanzen-Mischlinge*, Berlin, 1881), giving a tabular series of all the known vegetable hybrids, and treating the entire subject in a very comprehensive manner.

On the subject of animal hybrids there is virtually no literature, save scattered records of fertile crosses among sundry species confined in various menageries; and these are without interest as bearing on any of the principles of hybridism. (G. J. R.)

HYDE, a township of England in the parish of Stockport, Cheshire, is situated near the river Tame and the Peak Forest canal, and on the Midland, and the Manchester, Sheffield, and Lincolnshire Railways, 7½ miles east from Manchester and 6 north-east from Stockport. It is under the government of a local board, and a county court is held there every Wednesday. St George's church, in the Perpendicular style, was erected in 1832, and St Thomas, in the Early English, was erected in 1868. The principal other public buildings are the mechanics' institute, the temperance hall, and the court-house. The town owes its importance to the cotton manufacture, and possesses weaving factories, spinning-mills, print-works, iron-foundries, and machine-works. There are extensive coal-mines in the vicinity. The old family of Hyde, to which the line of earls of Clarendon belonged, held possession of the township as early as the reign of John, but it was a mere village until the establishment of the cotton manufacture at the beginning of the present century. The population of the township in 1861 was 13,722, and in 1871 it was 14,223.

HYDE, EDWARD, Earl of Clarendon. See CLARENDON.

HYDE, THOMAS (1636-1703), a distinguished Orientalist, was born at Billingsley, near Bridgnorth, in Shropshire, June 29, 1636. He inherited his taste for linguistic studies, and received his first lessons in some of the Eastern tongues, from his father, who was rector of the parish. In his sixteenth year Hyde entered King's College, Cambridge, where, under Wheelock, professor of Arabic, he made such rapid progress in the Oriental languages that, after only one year of residence, he was invited to London to assist Brian Walton in his edition of the *Polyglot Bible.* Besides correcting the Arabic, Persic, and Syriac texts for that work, Hyde transcribed into Persic characters the Persian translation of the Pentateuch, which had been printed in Hebrew letters at Constantinople in 1546. To this work, which Archbishop Ussher had thought well-nigh impossible even for a native of Persia, Hyde appended the Latin version which accompanies it in the *Polyglot.* Having successfully accomplished these difficult tasks amidst the flattering acknowledgments of the most learned men of the day, Hyde entered Queen's College, Oxford, in 1658, where he was chosen Hebrew reader; and in 1659, in consideration of his singular erudition in Oriental tongues, he was admitted to the degree of M.A. In the same year he was appointed under-keeper of the Bodleian library, and in 1665 he became librarian-in-chief. Next year he was collated to a prebend at Salisbury, and in 1673 to the archdeaconry of Gloucester, receiving the degree of D.D. shortly afterwards. In 1691 the death of Pocock opened up to Hyde the Laudian professorship of Arabic; and in 1697, on the deprivation of Altham, he succeeded to the regius chair of Hebrew and a canonry of Christ Church. Under Charles II., James II., and William III., Hyde discharged the duties of Eastern interpreter to the court. Worn out by his unremitting labours, he resigned his librarianship in 1701, and died at Oxford, February 18, 1703. Hyde was an excellent classical scholar, and there was hardly an Eastern tongue accessible to foreigners with which his wide erudition had not made him familiar. He had even acquired Chinese, while his writings are the best testimony to his mastery of Turkish, Arabic, Syriac, Persic, Hebrew, and Malay. His books are still valuable; and, although later investigations and additional authorities have partially superseded and corrected his conclusions, he still deserves respect as one of the first scholars to direct attention to the vast treasures of Oriental antiquity.

In his chief work, *Historia Religionis veterum Persarum*, 1700, Hyde made the first attempt to correct from Oriental sources the errors of the Greek and Roman historians who had described the religion of the ancient Persians, but through ignorance of the ancient language of Persia he has been often misled by Mahometan authorities. His other writings and translations comprise *Tabulæ Longitudinum et Latitudinum Stellarum fixarum ex observatione principis Ulugh Beighi*, 1665, to which his notes have given additional value; *Quatuor Evangelia et Acta Apostolorum lingua Malaica, caracteribus Europæis*, 1677; *Epistola de Mensuris et Ponderibus Serum sive Sinensium*, 1688, appended to Bernard's *De Mensuris et Ponderibus antiquis*; *Abraham Peritsol Itinera Mundi*, 1691; and *De Ludis Orientalibus Libri II.*, 1694. With the exception of the *Historia Religionis*, which was republished by Hunt and Costard in 1760, the writings of Hyde, including some unpublished MSS., were collected and printed by Dr Gregory Sharpe in 1767 under the title *Syntagma Dissertationum quas olim . . . Thomas Hyde separatim edidit.* There is a life of the author prefixed. Hyde also published a catalogue of the Bodleian Library in 1674.

HYDER ALI, or HAIDAR 'ALI, (*c.* 1702–1782), the Mahometan soldier-adventurer who, followed by his son Tippoo, became the most formidable Asiatic rival the English have ever had in India, was the great grandson of a fakir or wandering ascetic of Islam, who had found his way from the Punjab to Kulburga in the south, and the second son of the Arab wife of a naik or chief constable at Budikote, near Colar, in Mysore, and was born about the beginning of the 18th century. The elder brother who, like himself, was early turned out into the world to seek his own fortune, became a naik, and ultimately rose to command a brigade in the Mysore army, while Hyder, who never learned to read or write, passed the first forty-seven years of his life aimlessly in sport and sensuality, sometimes, however, acting as the agent of his brother, and meanwhile acquiring a useful familiarity with the tactics of the French when at the height of their reputation under Dupleix. He is said to have induced his brother to employ a Parsee to purchase artillery and small arms from the Bombay Government, and to enrol some thirty sailors of different European nations as gunners, and is thus credited with having been "the first Indian who formed a corps of sepoys armed with firelocks and bayonets, and who had a train of artillery served by Europeans." At the siege of Deonhully (1749) Hyder's services attracted the attention of Nunjeraj, the minister of the maharajah of Mysore, and he at once received an independent command; within the next twelve years his energy and ability had made him completely master of minister and maharajah alike, and in everything but in name he was ruler of the kingdom. In 1763 the conquest of Canara gave him possession of the treasures of Bednore, which he resolved to make the most splendid capital in India, under his own name, thenceforth changed from Hyder Naik into Hyder Ali Khan Bahadoor; and in 1765 he retrieved previous defeat at the hands of the Marhattas by the destruction of the Nairs or military caste of the Malabar coast, and the conquest of Calicut. Hyder Ali now began to occupy the serious attention of the Madras Government, which in 1766 entered into an agreement with the nizam to hold the district known as the Northern Circars from him, and to furnish him with troops to be used against the common foe. But hardly had this alliance been formed when a new and secret arrangement was come to between the two Indian powers, the result of which was that Colonel Smith's small force was met with a united army of 80,000 men and 100 guns. British dash and sepoy fidelity, however, prevailed, first in the battle of Changama (September 3, 1767), and again still more remarkably in that of Trinomalee, which lasted two days; and the nizam's own capital of Hyderabad was threatened by Colonel Peach's expedition sent from Bengal. On the loss of his recently made fleet and forts on the western coast, Hyder Ali now began to make overtures for peace; on the rejection of these, bringing all his resources and strategy into play, he forced Colonel Smith to raise the siege of Bangalore, and brought his army within five miles of Madras. The result was the treaty of April 1769, providing for the mutual restitution of all conquests, and for mutual aid and alliance in defensive war; it was followed by a commercial treaty in 1770 with the authorities of Bombay. Under these arrangements Hyder Ali, when defeated by the Marhattas in 1772, claimed English assistance, but in vain; this breach of faith stung him to fury, and thenceforward he and his son did not cease to thirst for vengeance. His time came when in 1778 the English, on the declaration of war, resolved to drive the French out of India. The capture of Mahe on the coast of Malabar in 1779, followed by the annexation of lands belonging to a dependant of his own, gave him the needed pretext. Again master of all that the Marhattas had taken from him, and with empire extended to the Kistna, he now summoned the French to his assistance, and, descending through the Changama pass amid burning villages, reached Conjeveram, only forty-five miles from Madras, unopposed. Not till the smoke was seen from St Thomas's Mount, where Sir Hector Munro commanded some 5200 troops, was any movement made; then, however, the British general sought to effect a junction with a smaller body under Colonel Baillie recalled from Guntoor. The incapacity of these officers, notwithstanding the splendid courage of their men, resulted in the total loss of Baillie's force of 2800 (September 10, 1780). Hastings, again appealed to, sent from Bengal Sir Eyre Coote, who, though repulsed at Chillumbrum, defeated Hyder thrice successively in the battles of Porto Novo, Polliloor, and Sholingur, while Tippoo was forced to raise the siege of Wandewash, and Vellore was provisioned. On the arrival of Lord Macartney as governor of Madras, the English fleet captured Negapatam, took Trincomalee from the Dutch, and forced Hyder Ali to confess that he could never ruin a power which had such command of the sea. He was directing his attention to the west coast, where he sought the assistance of the French fleet, when his death took place suddenly at Chittore in December 1782.

For the personal character and administration of Hyder Ali see the *History of Hyder Naik*, written by Meer Hussein Ali Khan Kirmani (translated from the Persian by Colonel Miles, and published by the Committee of the Oriental Translation Fund), and the curious work written by M. Le Maître de La Tour, commandant of his artillery (*Histoire d'Hayder-Ali Khan*, Paris, 1783). For the whole life and times see Wilks, *Historical Sketches of the South of India*, 1810-17; Aitchison's *Treaties*, vol. v. (2d ed., 1876); and Pearson, *Memoirs of Schwartz*, 1834.

HYDERABAD, or Haidarábád ("the Territory of the Nizám"), an extensive realm of Southern India. This territory, inclusive of the Hyderabad Assigned Districts, known as Berar, lies between 15° 10′ to 21° 41′ N. lat., and 74° 40′ to 81° 31′ E. long., and is 475 miles in length from south-west to north-east, and about the same distance in breadth. The area of Berar is 17,728 square miles, and of the Nizám's Territories 80,000 square miles,—the total area of the whole state being about 98,000 square miles. It is bounded N. and N.E. by the Central Provinces, and S. and S.E. by territory subject to the presidency of Madras, and W. by territory subject to the presidency of Bombay. The Country of the Nizám presents much variety of surface and feature. In some parts it is mountainous, wooded, and picturesque, in others flat and undulating. The champaign lands are of all descriptions, including many rich and fertile plains, much good land not yet brought under cultivation, and numerous tracts too sterile ever to be cultivated. The geological formations are on a large scale: in the north-west the formations are volcanic, consisting principally of trap, but in some parts of basalt; in the middle, southern, and south-western parts the country is overlaid with gneissic formations. In the valley of the Wardha there are coal-fields; the quality of the coal is inferior, but good enough for railway purposes. Quarries of excellent limestone are worked for a considerable distance along the line of the Nizám's State Railway. The territory is well watered, rivers being numerous, and tanks or artificial pieces of water very abundant. The principal rivers are—the Godávari, with its tributaries the Dudna, the Manjira, and Pranhíta; the Wardha, with its tributaries the Pengangá and Waingangá; and the Kistna, with its tributary the Tungabhadra. Many other streams (considerable rivers during the annual periodical rains) are discharged into these main channels of drainage. The climate may be considered in general good; and as there are no arid, bare deserts, the hot winds are less felt. In the vicinity of Hyderabad city, the annual mean temperature in the shade is 81° F., and the annual rainfall is estimated at 28 to 32 inches.

The soil is in general fertile, though in some parts it consists of *chilka*, a red and gritty mould, little fitted for purposes of agriculture. A low jungle springs up in any ground left uncultivated even for a year or two, and in process of time is enlivened by the growth of numerous trees. The principal crops are rice, wheat, maize, *joár, bájra, rági*, oil-seeds of various kinds, fruits and garden produce in great variety, cotton, indigo, sugar-cane, and tobacco. Silk, the material known as *tusser*, the produce of a wild species of worm, is utilized on a large scale. Lac, suitable for use as a resin or dye, gums, and oils are found in great quantities. Hides, raw and tanned, are articles of some importance in commerce. The chief mart for Deccan-bred horses, adapted for military or general purposes, is at a fair at Malegáon in the Bedar district. There is also a horse bazaar near the capital, which is resorted to by merchants from almost every quarter of Asia.

The principal exports are cotton, oil-seeds, country cloths, hides, metal ware, and agricultural produce; the imports are salt, grain, timber, European piece goods, and hardware. Among the manufactures of the country may be mentioned the ornamental ware of Bedar, the gold embroidered cloths of Aurangábád, Gulbarga, and other towns, and the excellent paper of different kinds which is made by the inhabitants of Kaghazpur, near the fortress of Daulatábád. Several railway lines pass through the state. The line connecting Bombay with Madras traverses the south-western part; the Great Indian Peninsula Railway runs the line as far as Ratchur, where it is joined by the Madras Railway; and from Wadi the Nizám's State Railway branches off to Hyderabad and Secunderabad. The three principal roads in the state all pass through Hyderabad city.

No census of the population has been attempted in Hyderabad territory, with the exception of Berar or the Assigned Districts. But the population in the Nizám's Territory has been estimated at 9,000,000 persons. In the different parts of the territory the Marathí, the Kanarese, and the Telugu languages are spoken. The Marhattás are most numerous in the west. The Musálmans are chiefly to be met with in the capital, and everywhere in the service of Government. In addition there is a large admixture of Parsís, Síkhs, Arabs, Rohillas, aborigines, and others. The revenue of the Nizám's Territories, including Berar, may be stated in round numbers at 40,000,000 rupees (say £4,000,000), including receipts from all sources. About two-thirds of the above large sum is collected by the nizám's own Government from tracts under British rule. The remaining one-third is realized by British officers, principally from Berar. The native Government has a mint situated at Hyderabad, and a currency of its own. It issues a rupee,—namely, the *hali sicca*, or "rupee of the period."

History.—The fortunes of the family of the nizám were founded by Kamr-ud-dín Asaf Jah, a distinguished soldier of the emperor Aurangzeb, who in 1713 was appointed Nizám-ul-Mulk (Regulator of the State) and Subahdár of the Deccan, but eventually threw off the control of the Delhi court. Asaf Jah died in 1748, and the right of accession to his power and authority was contested by his descendants. The claimants most favoured were two; the one, Naár Jang, a son of the deceased ruler, secured the support of the English, the other Muzaffar Jang, a grandson, was supported by the French. After a brief period of contest Muzaffar Jang became the prisoner of his rival, who, however, soon perished by the hands of some of his followers, and Muzaffar Jang was proclaimed subahdár of the Deccan. He, too, soon perished in a fray with some Pathán chiefs, so the seat of power was now unoccupied. Two brothers of Nasír Jang now claimed the dignity, but the contest was averted by the sudden death of Ghazi-ud-dín, the elder brother. The English and French continued a struggle for power and influence in the Deccan, but the latter had to withdraw from the support of Salabat Jang, through the danger threatening their own possessions from the victories gained by Clive. In 1761 this weak prince was dethroned by his younger brother Nizám Alí, who afterwards put him to death. In 1765 he ravaged the Carnatic, but retired on the approach of a British force. Still the British Government was anxious to be on better terms with him, partly from a desire to obtain his concurrence to their retention of a maritime district known as the Northern Circars, which they now occupied. In 1766 a treaty was concluded by which, on condition of a gift of the Circars, the British Government agreed to support the nizám, who on his part engaged to assist the British with his troops. In 1790, on the breaking out of a war with Tippoo, son of Hyder Ali Khán, a treaty of offensive and defensive alliance was concluded between the nizám, the peshwá, and the British Government. Tippoo purchased peace (1792) at the price of half his dominions, and the nizám had no reason to be dissatisfied with his share of the spoil. On the fall of Seringapatam and the death of Tippoo Sultán, the nizám participated largely in the division of territory, under the treaty of 1799, and his share was increased on the peshwá's withdrawal from the treaty. In 1800 the subsidiary force with the nizám was further augmented, and the pecuniary payment for its maintenance was commuted for a cession of territory. This territory is known to the present time under the title of the Ceded Districts. By the treaty of 1853 the nizám still retained the full use of the subsidiary force and contingent, but was released from the unlimited obligation of service in time of war; and the contingent ceased to be part of the nizám's army, and became an auxiliary force kept up by the British Government for the nizám's use. In 1857, when the mutiny had broken out, the state of Hyderabad and the nizám's dominions became critical; and an attack, which was repulsed, was made upon the residency. The Hyderabad contingent displayed its loyalty in the field against the rebels. In 1860 a fresh treaty was made by which the territorial acquisitions of the nizám were increased, a debt of 50 lákhs of rupees was cancelled, and assigned districts in Berar, making up a gross revenue of 3,200,000 rupees (say £320,000), were taken in trust by the British Government. The nizám is the principal Mahometan ruler in India, and is entitled to a salute of twenty-one guns.

HYDERABAD, the chief city and capital of the above state, is situated in 17° 21′ 45″ N. lat. and 78° 30′ 10″ E. long., on the river Musí, and stands at a height of about 1700 feet above sea level. No census of the population has been taken, but it has been estimated at 200,000. The scenery around Hyderabad is wild and picturesque, the country being hilly and dotted with numerous granite peaks and isolated rocks. Approached from the west, the appearance of the city is very striking,—the palace, the mosques, and the magnificent pile of buildings erected for the British residency towering above the outer wall. A large lake, a few miles south of Hyderabad, covering an area of 10,000 acres, supplies the town with water. The palace of the nizám, the mosques, and the British residency are the principal buildings. The palace has no pretensions to splendour, but is of considerable size. Hyderabad is a great Mahometan stronghold, and contains several mosques. The Jamá Masjíd or "cathedral" mosque, so called after the one at Mecca from which it is designed, is large, and is crowned by minarets of an extraordinary height. In the environs of Hyderabad there are many fine gardens with gorgeous pavilions; that of the nizám's minister has long been celebrated for its beauty. One of the most interesting places is the college, or *Chár Minár* (so called from its four minarets), built upon four grand arches at which the four principal streets of the city meet. Above are several stories of rooms, and formerly each story was devoted to a science. On the north side of the Musí is an extensive suburb known as the Begam or "Princess" bazaar. The British residency is in this quarter, and communication between it and the palace of the nizám is maintained by a fine bridge. The residency is a very handsome building, and is remarkable as having been raised entirely by native workmen. It stands in ornamental pleasure grounds enclosed by a wall with two gateways. The staircase is the handsomest in India, each step being a single block of the finest granite. The principal private residence in the city is the palace of the *Bára Dari*, or "Twelve Doors," which is now occupied by the minister of the nizám, Sir Sálar Jang.

History.—Hyderabad was founded in 1589, by Kutáb Sháh Muhammad Kulí, a descendant of Sultán Kulí Kutab Shah, the founder of the dynasty at Golconda in 1512. Muhammad Kulí removed the seat of government on account of its want of water and consequent unhealthiness, and built a new city on the banks of the Musí river, 7 miles from his former capital. He called it *Bhágnagar*, "Fortunate City," from his favourite mistress, Bhágmati; but after her death he named it Hyderabad. The history of Golconda and of Hyderabad after 1589 are almost identical. Soon after establishing himself in his new metropolis, Muhammad Kulí carried on an aggressive war with the neighbouring Hindu rájás. He extended his conquests south of the Kistna river; the strong fortress of Gandikota was captured; and the town of Cuddapah was sacked. His troops penetrated to the frontiers of Bengal, and Muhammad Kulí defeated the rájá of Orissa and subjugated the Northern Circars. In 1603 an ambassador from the king of Persia arrived with a ruby studded crown and other magnificent gifts. When he returned six years afterwards, he was accompanied by an officer of the court of Hyderabad, bearing return presents. In 1611 Muhammad Kulí died, after a most prosperous reign of thirty-four years. The principal memorials of this monarch are the palace and gardens of Iláhí Mahál, the Muhammadí gardens, the palace of Nabat Ghát, and the Jamá Masjíd or "cathedral" mosque. During his reign nearly £3,000,000 was expended on public works, and £24,000 was distributed every year among the poor.

Muhammad Kulí was succeeded by his son, Sultán Abdullah Kutab Sháh. Mír Jumlá, the prime minister, whose son had involved him in a dispute with the court, finding himself unable to obtain favour from his own sovereign, determined to throw himself on the protection of the Mughal emperor. Sháh Jahán, espousing his cause, issued a mandate to Abdullah to redress the complaints of his minister; but Abdullah was so incensed that he sequestrated Mír Jumlá's property, and committed his son to prison. Sháh Jahán now despatched Aurangzeb, his son, to carry his demands into effect by force of arms. Abdullah Kutab Sháh was preparing an entertainment for Aurangzeb's reception, when he suddenly advanced as an enemy, and took the king so completely by surprise that he had only time to flee to the hill-fort of Golconda, whilst Hyderabad fell into the hands of the Mughals, and was plundered and half burned before the troops could be brought into order. Abdullah did all in his power to negotiate reasonable terms, but the Mughals were inexorable, and he was at last forced to accept the severe conditions imposed on him.

Abdullah died in 1672, and was succeeded by his son-in-law Abú Husáin, who in his youth had been notorious for dissipated habits. He fell entirely under the influence of a Marhattá Bráhman, named Madhuna Panth, who became his prime minister. During this reign Aurangzeb again marched upon the city. The king shut himself in the fort of Golconda, and Hyderabad was again left open to plunder. Madhuna Panth was killed in a popular tumult, and the king accepted such terms as he could obtain. A payment of £2,000,000 sterling in money and jewels was demanded. In 1687 Aurangzeb formally declared war against Abú Husáin. The king bravely defended the fort of Golconda, but lost it by treachery, and was sent a captive to Daulatábád, where he resided until his death. Abú Husáin was a very popular monarch, and many anecdotes of his virtue are still current in the Deccan. Aurangzeb immediately took possession of all the territories of Bijápur and Golconda, but his occupation was little more than military.

No event of any importance occurred at Hyderabad until 1707, the year of Aurangzeb's death, when a dispute for the crown took place. His son, Prince Muazím, was victorious, and ascended the throne as Bahádur Sháh. After he made a truce with the Marhattás, affairs in the Deccan remained quiet until the end of his reign, in 1712. His death was followed by struggles amongst his sons. A battle ensued; Azím-ush-Shán was slain, and Jalándhar Sháh remained master of the throne. Among those he could not get into his power was Farrukh Siyyar, the only son of Azím-ush-Shán; but the cause of this prince was espoused by the governor of Behar, Sayyid Husáin Alí. The rivals met near Agra; and on the 1st January 1713 Farrukh Siyyar ascended the throne, and conferred dignities upon all his adherents. Among these was Chin-Kilich Khán, to whom was given the title of Nizám-ul-Mulk Asaf Jáh, and Sayyid Husáin Alí was appointed viceroy of the Deccan. In 1719 Husáin Alí and Sayyid Abdullah Khán, his brother, advanced upon Delhi, and soon their troops took possession of the royal citadel and palace. Farrukh Siyyar was deposed, and two months later put to death. The Sayyids now (1719) selected Muhammad Sháh, who was the last emperor that sat on the Peacock throne of Sháh Jahán. In 1720 Husáin Alí was assassinated, and at the end of the year Abdullah Khán was defeated and taken prisoner by Muhammad Sháh; but the power of this monarch was fast declining. In 1722 Chin-Kilich Khán, also called Asaf Jáh, arrived at Delhi, and assumed the office of vizier. In 1723 he resigned his post, and set off for the Deccan, a proceeding amounting to a declaration of independence. The emperor sent orders to Mobaríz, the local governor of Hyderabad to assume the government of the entire Deccan. Asaf was forced to come to open war, and soon gained a decisive victory over Mobaríz, who lost his life in the battle, fought in October 1724. He then fixed his residence at Hyderabad, and became the founder of an independent kingdom, now ruled over by his descendants, who derive from him the title of the Nizáms of Hyderabad state.

HYDERABAD, or HAIDARÁBÁD, a British district in the commissionership of Sind, India, lying between 24° 13′ and 27° 15′ N. lat., and between 67° 51′ and 69° 22′ E. long., with an area of 9053 square miles. It is bounded N. by Kairpur state, E. by Thar and Párkar political superintendency, S. by the same tract and the river Kori, and W. by the river Indus and Karáchí district. The district is a vast alluvial plain, 216 miles long and 48 broad. Fertile along the course of the Indus, it degenerates towards the east into sandy wastes, sparsely populated, and defying cultivation. The monotony is relieved by the fringe of forest which marks the course of the river, and by the avenues of trees that line the irrigation channels which branch eastward from this stream. The south of the district has a special feature in its large natural water-courses (called *dhoras*) and basin-like shallows (*chhaus*), which retain the rains for a long time. A limestone range called the Gánga and the pleasant frequency of garden lands break the monotonous landscape. The soil, wherever irrigated, is very fertile. Very few species of the large wild animals are found; among birds, the bustard alone is remarkable. Venomous reptiles abound. The Indus supplies a large variety of fish, one of which, the *pala*, is peculiar to the river.

Of the total area of the district about one-half is uncultivable; 2,300,000 acres are cultivable though not cultivated, and 566,800 are under irrigation. Agriculture is entirely dependent upon artificial irrigation, and is looked upon as a lottery, in which the cultivator stakes a certain amount of labour and seed, and takes his chance of getting a return. If the water rises either too high or not high enough, he loses his crop. There are 317 canals, fifty of which are main channels, and tap the Indus direct; the remainder are connecting branches. The principal crops are wheat, barley, oil-seeds, pulses, vegetables, *joár*, *bájra*, *til*, rice, cotton, sugar-cane, *chana*, hemp, tobacco, water-melons, and indigo. The manufactures of the district maintain the excellence for which they have been famous from early times, namely, that for lacquered work, gold and silver embroidery, striped and brilliant cloths known as *süsis* and *rhesis*, and glazed pottery. The manufacture of carpets, silk thread, and gold and silver ornaments is carried on to a large extent; salt also is produced in such quantities as to allow of a considerable exportation. The total number of fairs is 33, and the average attendance about 5000. The roads of the district extend to 1925 miles in length, of which 263 are metalled, bridged, and marked with milestones. The ferries number 68; the one at Gidu-Bandar (3½ miles from Hyderabad) is a steam ferry connecting Hyderabad with Kotri, on Sind Railway. There are 10 travellers' bungalows, 16 *dharmsálás*, 4 dispensaries, a civil and police hospital, a convict hospital, and a charitable dispensary.

Considerable variations of climate are found within the district. In the north, the hot season of April and May is followed by two months of floods, the rest of the year being cold and dry. In the central divisions, the cold season succeeds the hot without any intervening inundations to graduate the transition; and the change occurs sometimes with such suddenness that, to quote a local saying, "sunstroke and frost-bite are possible in one and the same day." In the south the temperature is more equable throughout the year, 60° F. and 100° F. representing the extremes. The rainfall is very moderate; and the district is healthy as compared with other parts of India.

The population is divided as follows:—Mahometans, 560,349; Hindus, 118,652; other creeds and tribes, 44,882;—total, 723,883. Of the Mahometans 373,705, or more than three-fifths, are Sinds. More important, however, as regards social status and personal character, are the Patháns, found chiefly about Hyderabad and Upper Sind; they number only 15,815 persons. As regards occupation, the Hindus of the district may be called the shopkeeping class, the Mahometans the artisan and agricultural.

The chief revenue and magisterial authority is vested in a collector and magistrate. He is assisted by the four deputy collectors of Hála, Tando Muhammad Khan, Naushahro, and Hyderabad *táluks*, of which the district is composed. The police force is under the charge of a European district superintendent, and comprises a total of 876 men, with 4 inspectors and 19 chief constables. The average land revenue for 6 years (1868–74) was £111,655; drug revenue (1873–74), £5304; receipts from the farming of liquor-shops (1873–74), £9640; imperial revenue (1874), £144,944; local revenue (1874), £12,434; forests yield an annual revenue of £11,216. The Government boys' schools numbered 55 in 1874, with 3227 pupils; the girls' schools 12, with 368 pupils. These figures include the returns for the high, normal, engineering, and Anglo-vernacular schools in Hyderabad city.

The local history of Hyderabad district is so mixed up with that of the province that little could be said of it separately which will not more properly find a place under the history of Sind. The battles of Miani (Meeanee) and Dabo, which decided the fate of Sind in favour of the British, were fought within its limits.

Hyderabad, the chief town of the above district, in 25° 23′ 5″ N. lat. and 68° 24′ 51″ E. long., had in 1872 a population of 35,272, of whom 13,065 were Mahometans, 16,889 Hindus, 367 Christians, and 4951 "others." The municipal area is about 15 square miles. Upon the site of the present fort is supposed to have stood the ancient town of Neránkot, which in the 8th century submitted to Muhammad Kásim Sakífí. Its situation near the apex of the delta of the Indus had commended itself to invaders and conquerors of still earlier date. It is identified with Patala, a town which has been connected with a prehistoric Scythian migration into India (*c.* 625 B.C.?). Alexander the Great founded or refounded a city called Patala in or near the same place, 325 B.C., and left in it a military settlement. The best archæological authorities regard the modern Hyderabad as the representative of this Patala of the Greeks. In 1768 the present city was founded by Ghulám Sháh Kalhora; and it remained the chief town of the province until 1843, when, after the battle of Meeanee, it was surrendered to the British, and the capital transferred to Kurrachee (Karáchi). The city is built on the most northerly hills of the Gánga range, a site of great natural strength. In the fort, which covers an area of 36 acres, are the arsenal of the province, transferred hither from Kurrachee in 1861, and the residences of the ex mírs of Sind. Hyderabad is the centre of all the provincial communications—road, telegraphic, postal. From the earliest times its manufactures—ornamented silks, silver and gold work, and lacquered ware—have been the chief of the province, and in recent times have gained prizes at the industrial exhibitions of Europe. The chief public institutions and buildings are the jail, Government schools, post-office, municipal markets, court-houses, civil and police hospital, charitable dispensary, library, travellers' bungalow, and lunatic asylum. The barracks—occupied by artillery and infantry, European and native—are built in twelve blocks, with hospitals, bazaar, &c., to the north-west of the city. The only noteworthy antiquities are the tombs of the Kabhora and Tálpur mírs.

HYDRA (the name is also found as Sidra, Nidra, Idero, &c., and the ancient form was Hydrea), an island of Greece, lying about 4 miles off the south-east coast of Argolis in the Peloponnesus, and forming along with the neighbouring island of Dhoko the Bay of Hydra. The length of the main axis of the island, which runs from south-west to north-east, is about 11 miles, and the area is about 21 square miles; but it is little better than a rocky and treeless ridge with hardly a patch or two of arable soil. There was little exaggeration in the reply made by Antonios Kriezes to the queen of Greece: "The island produces prickly pears in abundance, splendid sea captains, and excellent prime ministers." The highest point, Mount Ere, so called (according to Miaoules) from the Albanian word for wind, has an elevation of 1958 feet. The next in importance is known as the Prophet Elias, from the large convent of that name on its summit. It was there that the patriot Theodorus Colocotronis was imprisoned, and a large pine tree is still called after him. The fact that in former times the island was richly clad with woods is indicated by the name still employed by the Turks, *Tchamliza*, the place of pines; but it is only in some favoured spots that a few trees are now to be found. Tradition also has it that it was once a well-watered island (hence the designation Hydrea), but the inhabitants are now wholly dependent on the rain supply, and they have sometimes had to bring water from the mainland. This lack of fountains is probably to be ascribed in part to the effect of earthquakes, which are not infrequent; that of 1769 continued for six whole days. Hydra, the chief town, is built near the middle of the northern coast, on a very irregular site, consisting of three hills and the intervening ravines. From the sea its white and handsome houses present a picturesque and noble appearance, and its streets though narrow are clean and attractive. Besides the principal harbour, round which the town is built, there are three other ports on the north coast—Mandraki, Molo, Panagia, but none of them is sufficiently sheltered. Almost all the population of the island is collected in the chief town, which is the seat of a bishop, and has a local court, numerous churches, and a high school. Cotton and silk weaving, tanning, and ship-building are carried on, and there is a fairly active trade. The population in 1877 was 6811.

Hydra was of no importance in ancient times. The only fact in its history is that the people of Hermione (a city on the neighbouring mainland now known by the common name of *Kastri*) surrendered it to Samian refugees, and that from these the people of Trœzen received it in trust. It appears to be completely ignored by the Byzantine chroniclers. In 1580 it was chosen as a refuge by a body of Albanians from Kokkinyas in Trœzenia; and other emigrants followed in 1590, 1628, 1635, 1640, &c. At the close of the 17th century the Hydriotes took part in the reviving commerce of the Peloponnesus; and in course of time they extended their range. About 1716 they began to build *sakturia* (of from 10 to 15 tons burden), and to visit the islands of the Ægean; not long after they introduced the *latinadika* (40-50 tons), and sailed as far as Alexandria, Constantinople, Trieste, and Venice; and by and by they ventured to France and even America. From the grain trade of South Russia more especially they derived great wealth. In 1813 there were about 22,000 people in the island, and of these 10,000 were seafarers. At the time of the outbreak of the war of Greek independence the total population was 28,190, of whom 16,460 were natives and the rest foreigners. One of their chief families, the Konduriotti, was worth £2,000,000. Into the struggle the Hydriotes flung themselves with rare enthusiasm and devotion, and the final deliverance of Greece was mainly due to the service rendered by their fleets.

See Pouqueville, *Voy. de la Grèce*, vol. vi.; Antonios Miaoules, *Υπομνημα περι της νησου Υδρας*, Munich, 1834; Id., *Συνοπτικη ιστορια των ναυμαχιων δια των πλοιων των τριων νησων, Υδρας, Πετσων, και Ψαρων*, Nauplia, 1833; Id., *Ιστορια της νησου Υδρας*, Athens, 1874; G. D. Kriezes, *Ιστορια της νησου Υδρας*, Patras, 1860.

HYDRANGEA, a popular flower much in request for the decoration of conservatories during the late summer season, many thousands being annually produced for the London market. The plant to which the name is most commonly applied is the *Hydrangea Hortensia*, a low deciduous shrub, producing rather large oval strongly-veined leaves in opposite pairs along the stem. It is terminated by a massive globular corymbose head of flowers, which remain a long period in an ornamental condition. The normal colour of the flowers, the majority of which have neither stamens nor pistil, is pink; but by the influence of sundry agents in the soil, such as alum or iron, they become changed to blue. The part of the inflorescence which appears to be the flower is an exaggerated expansion of the calyx-leaves, the other parts being generally abortive. The perfect flowers are small, rarely produced in the species above referred to, but well illustrated by others, in which they occupy the inner parts of the corymb, the larger showy neuter flowers being produced at the circumference. A pure white variety, named Thomas Hogg, has been recently introduced, and is a very desirable plant.

There are upwards of thirty species, found chiefly in Japan, in the mountains of India, and in North America, and many of them are familiar in gardens. *H. Hortensia* is the most useful for decoration, as the head of flowers lasts long in a fresh state, and by the aid of forcing can be had for a considerable period for the ornamentation of the greenhouse and conservatory. Their natural flowering season is towards the end of the summer, but they may be had earlier by means of forcing. *H. japonica* is another fine conservatory plant, with foliage and habit much resembling the last-named, but this has flat corymbs of flowers, the central ones small and perfect, and the outer ones only enlarged and neuter. This also produces pink or blue flowers under the influence of different soils.

The Japanese species of hydrangea are sufficiently hardy to grow in any tolerably favourable situation, but except in the most sheltered localities they seldom blossom to any degree of perfection in the open air, the head of blossom depending on the uninjured development of a well-ripened terminal bud, and this growth being frequently affected by late spring frosts. They are much more useful for pot-culture indoors, and should be reared from cuttings of shoots having the terminal bud plump and prominent, put in during summer, these developing a single head of flowers the succeeding summer. Somewhat larger plants may be had by nipping out the terminal bud and inducing three or four shoots to start in its place, and these, being steadily developed and well-ripened, should each yield its inflorescence in the following summer, that is, when two years old. Large plants grown in tubs and vases are fine subjects for large conservatories, and may be used for decorating terrace walks and similar places during summer, being housed in winter, and started under glass in spring.

The Indian and American species, especially the latter, are quite hardy, and some of them are extremely effective. The finest of these by far is the *Hydrangea paniculata grandiflora*, the branched inflorescence of which is under favourable circumstances a yard or more in length, and consists of large spreading masses of crowded white neuter flowers which completely conceal the few inconspicuous fertile ones. The plant attains a height of 8 to 10 feet, and when in flower late in summer and in autumn is a very attractive object in the shrubbery.

HYDRAULICS. See HYDROMECHANICS.

HYDROCEPHALUS (ὕδωρ, water, κεφαλή, the head), a term in medicine applied to two different forms of disease of the brain, both of which are attended with the effusion of fluid into its cavities. They are named respectively *Acute* and *Chronic Hydrocephalus*. They have different pathological associations, and have no necessary connexion with each other.

Acute Hydrocephalus is the term still largely employed to describe the disease now known to physicians as tubercular cerebral meningitis, that is, inflammation of the membranes of the brain produced by the presence of tubercle. This disease is most common in children under ten years of age, but is by no means limited to that period of life, and may affect adults. The scrofulous or tubercular constitution is an important factor in this malady, which is admitted to be one of strongly hereditary tendency; yet unquestionably there are many instances in which no such taint can be traced. In numerous cases it is manifestly connected with bad hygienic conditions, with insufficient or improper feeding, or with over exercise of the mental powers, all of which will doubtless more readily exert their influence where an inherited liability exists, and the same may be said regarding its occasional occurrence as one of the after consequences of certain of the diseases of childhood, especially measles and hooping-cough.

Acute hydrocephalus is usually described as passing through certain stages; but it must be observed, as regards at least its earlier manifestations, that, so far from being well defined, they are often exceedingly vague, and render this disease in an especial manner liable to escape detection for a length of time, or to be confounded with others to which at its commencement it bears an acknowledged resemblance, such, for instance, as typhoid fever or gastro-intestinal derangements. Nevertheless, there are certain typical features characterizing the disease in each of its stages which it is important to describe, as in many instances these present themselves with greater or less distinctness.

The premonitory symptoms of acute hydrocephalus are mostly such as relate to the general nutrition. A falling off in flesh and failure of strength are often observed for a considerable time before the characteristic phenomena of the disease appear. The patient, if a child, becomes listless and easily fatigued, loses appetite, and is restless at night. There is headache after exertion, and the temper often undergoes a marked change, the child becoming unusually peevish and irritable. These symptoms may persist during many weeks; but on the other hand such premonitory indications may be entirely wanting, and the disease be developed to all appearance quite suddenly.

The onset is in most instances marked by the occurrence of vomiting, often severe, but sometimes only slight, and there is in general obstinate constipation. In not a few cases the first symptoms are convulsions, which, however, may in this early stage subside, and remain absent, or reappear at a later period. Headache is one of the most constant of the earlier symptoms, and is generally intense and accompanied with sharper paroxysms, which cause the patient to scream, with a peculiar and characteristic cry. There is great intolerance of light and sound, and general nervous sensitiveness. Fever is present to a greater or less extent, the temperature ranging from 100° to 103° Fahr.; yet the pulse is not quickened in proportion, being on the contrary rather slow, but exhibiting a tendency to irregularity, and liable to become rapid on slight exertion. The breathing, too, is somewhat irregular. Symptoms of this character, constituting the stage of excitement, continue for a period varying from one to two weeks, when they are succeeded by the stage of depression. There is now a marked change in the symptoms, which is apt to lead to the belief that a favourable turn has taken place. The patient becomes quieter and inclines to sleep, but it will be found on careful watching that this quietness is but a condition of apathy or partial stupor into which the child has sunk. The vomiting has now ceased, and there is less fever; the pulse is slower, and shows a still greater tendency to irregularity than before, while the breathing is of markedly unequal character, being rapid and shallow at one time, and long drawn out and sinking away at another. There is manifestly little suffering, although the peculiar cry may still be uttered, and the patient lies prostrate, occasionally rolling the head uneasily upon the pillow, or picking at the bedclothes or at his face with his fingers. He does not ask for food, but readily swallows what is offered. The countenance is pale, but is apt to flush up suddenly for a time. The eyes present important alterations, the pupils being dilated or unequal, and scarcely responding to light. There may be double vision, or partial or complete blindness. Squinting is common in this stage, and there may also be drooping of an eyelid, due to paralysis of the part, and one or more limbs may be likewise paralysed.

To this succeeds the third or final stage, in which certain of the former symptoms recur, while others become intensified. There is generally a return of the fever, the temperature rising sometimes to a very high degree. The pulse becomes feeble, rapid, and exceedingly irregular, as is also the case with the breathing. Coma is profound, but yet the patient may still be got to swallow nourishment, though not so readily as before. Convulsions are apt to occur, while paralysis, more or less extensive, affects portions of the body or groups of muscles. The pupils are now widely dilated, and there is generally complete blindness and often deafness. In this condition the patient's strength undergoes rapid decline, and the body becomes markedly emaciated. Death takes place either suddenly in a fit, or more gradually from exhaustion. Shortly before the fatal event it is not uncommon for the patient, who, it may be for many days previously, lay in a state of profound stupor, to awake up, ask for food, and talk to those around. But the hopes which may thus be raised are quickly dispelled by the setting in of the symptoms of rapid sinking.

The duration of a case of acute hydrocephalus varies somewhat, but in general death takes place within three weeks from the onset of the symptoms. The disease may be said to be almost invariably fatal, yet it must be admitted that cases presenting all the principal symptoms of acute hydrocephalus do occasionally recover, though such instances are undoubtedly very rare. Indeed, the condition of the brain in this disease, as revealed on *post mortem* examination, renders its fatal character in no way surprising. The peculiar formation called tubercle is found deposited in the membranes of the brain, more particularly at its base. The irritation set up as a consequence of this is accompanied with the effusion of fluid into the arachnoid and ventricles, which by its pressure tends to produce softening and destruction of the brain substance, and hence to abolish its functions. In many instances the brain is found to be reduced to a state of complete disorganization.

Besides this condition of the brain, there exists in most cases deposition of tubercle elsewhere, as in the lungs and abdominal glands, and this may have given evidence of its presence even before the head symptoms had appeared. This is especially the case in adults, in whom acute hydrocephalus is more apt to arise as a complication in the course of pulmonary or other disease of tubercular origin than in the manner in which it occurs in children as above described.

With respect to treatment, little can be stated of an encouraging nature. Still it must be observed that much may be done in the way of prevention of this disease, and, in its earlier stages, even in the way of cure. It is most important in families where the history indicates a tuberculous or scrofulous tendency, and particularly where acute hydrocephalus has already occurred, that every effort should be used to fortify the system and avoid the causes already alluded to as favouring the development of the disease during that period in which children are liable to suffer from it. With this view wholesome food, warm clothing, cleanliness, regularity, and the avoidance of overexertion, physical and mental, are of the utmost consequence.

Although there is but little that can be done when the disease has set in, yet the timely use of remedies may mitigate and even occasionally remove the symptoms. The severe headache may often be relieved by the application of one or two leeches to the temples, and by the frequent use of cold water or ice applied to the head. The treatment by blistering the scalp and administering mercury, formerly so much practised, is now acknowledged to be of no real efficacy; and on the whole the maintenance of the patient's strength by light nourishment and the use of sedatives to compose the nervous system are the measures most likely to be attended with success. The bromide, with which may be combined the iodide of potassium, is the medicinal agent of most value for this purpose. Should convulsions occur, they are best treated by chloral or chloroform.

Chronic Hydrocephalus is a different form of disease from that last described, both as regards its pathology and its effects. It consists in an effusion of fluid into the serous cavities (arachnoid and ventricles) of the brain, not preceded by tuberculous deposit or acute inflammation, but apparently depending on chronic inflammatory changes affecting the membranes, and is to be regarded as a kind of dropsy. The disease is frequently congenital, and its presence in the fœtus is apt to be a source of difficulty in parturition. It is, however, more commonly developed in the course of the first six months of life; but it occasionally arises in older children, or even in adults, as in the well-known instance of Dean Swift, who died from this disease.

Chronic hydrocephalus affects mostly children who bear evidence of a scrofulous, ricketty, or otherwise delicate constitution. The chief symptoms observed are the gradual increase in size of the upper part of the head out of all proportion to the face or the rest of the body. Occurring at an age when as yet the separate bones constituting the skull have not become welded, this enlargement may go on to a very considerable extent in all directions, but chiefly in the transverse and antero-posterior diameters, the spaces between the bones becoming more and more expanded, though ultimately, should the child survive, ossification takes place. In a well-marked case the deformity is very striking. The upper part of the forehead projects abnormally, and the orbital plates of the frontal bone being inclined forwards give a downward direction to the eyes, which have also peculiar rolling movements. The face is small, and this, with the enlarged head, gives a remarkably aged expression to the child. There is generally defective development in other respects, the body being ill nourished, the bones thin, the hair scanty and fine, and the teeth carious or absent.

As illustrating the extent to which this disease may proceed, it may be mentioned that the average circumference of the adult head is about 22 inches, while in the child it is of course considerably less. In chronic hydrocephalus the head of an infant three months old has been known to measure 29 inches; and in the well-known case of the man Cardinal, who died in Guy's Hospital, the head measured 33 inches. In the museum of the faculty of medicine in Paris there is a hydrocephalic skull measuring 39 inches. In aggravated cases the head cannot be supported by the neck, and the patient has to keep in the recumbent posture. The expansibility of the skull prevents destructive pressure on the brain, yet this organ is materially affected by the presence of the fluid. The cerebral ventricles are widely distended, and the convolutions flattened, while occasionally the fluid escapes into the cavity of the cranium, which it fills, pressing down the brain to the base of the skull. As a consequence of such changes, the functions of the brain are interfered with, and in general the mental condition of the patient is impaired to a greater or less extent. The child is dull and listless, irritable, and sometimes imbecile. The special senses become affected as the disease advances, especially vision, and sight is often lost, as is also hearing. Towards the close paralysis is apt to occur. Hydrocephalic children rarely live long, generally dying from the malady in a few years, or succumbing to some of the disorders of childhood, which they are little able to resist. Nevertheless there have been many instances of persons with this disease reaching maturity, and even living to old age. It must also be borne in mind that there are grades of this affection, and that children may present many of the symptoms of it in a comparatively slight degree, and yet recover, the head ceasing to expand, and becoming firmly ossified.

Various methods of treatment have been employed in this disease, but the results are seldom satisfactory. Compression of the head by bandages, and the administration of mercury with the view of promoting absorption of the fluid, are now little resorted to. Tapping the fluid from time to time through one of the spaces between the bones, drawing off a little, and thereafter employing gentle pressure, has been tried, but seldom with permanent benefit. On the whole, the plan of treatment which aims at maintaining the patient's nutrition by appropriate food and tonics, is at once the most rational and successful, provided it be resorted to in time to admit of the arrest of the progress of the symptoms. (J. O. A.)

HYDROGEN (from ὕδωρ, water, and γεννάω, to generate) is a chemical element which in the free state occurs in volcanic gases, but exists for the most part in combination with oxygen as water. As its elemental characteristics and the chief compounds of hydrogen have already been described in the article CHEMISTRY, vol. v. pp. 478, 483, 491, 499, 544, &c., it is here only necessary to refer to the liquefaction of gaseous hydrogen.[1]

At the close of 1877 and in the beginning of 1878, not only hydrogen, but all the so-called permanent gases, were reduced to the liquid state, an achievement the more remarkable as it was the result of the simultaneous but entirely independent labours of two distinguished physicists, M. Cailletet of Châtillon-sur-Seine and M. Pictet of Geneva. The experiments of the former, who clearly demonstrated the possibility of liquefying acetylene, carbonic oxide, hydrogen, methane, nitric oxide, nitrogen, and oxygen, are described in detail in the *Annales de Chimie et de Physique*, ser. 5, vol. xv. p. 132; those of M. Pictet, who operated only upon oxygen and hydrogen, are detailed in the same journal, ser. 5, vol. xiii. p. 145. The instrumental means employed by them were very different, as will be evident from the following description.

M. Cailletet's apparatus is represented in the annexed sketch (fig. 1). The gas under experiment is contained in a stout glass tube of narrow bore of the form shown in fig. 2.

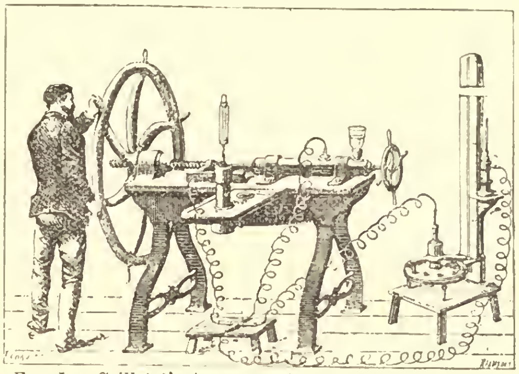


FIG. 1.—Cailletet's Apparatus for Liquefaction of Gases.

To fill this tube with gas, both ends being open, a globule of mercury is first introduced at the lower curved extremity; the tube is then placed in a nearly horizontal position, the curved extremity is connected with the holder containing the gas, or with the apparatus in which the gas is being evolved, by means of caoutchouc tubing, and a current of the pure dry gas is passed through the tube until the air is entirely expelled; this being effected, the point opposite to the curved extremity is sealed in the blowpipe flame; the tube is then brought into a vertical position, so that the globule of mercury closes the lower extremity, the caoutchouc tube is withdrawn, and the tube AA thus filled is screwed into its place in the cylinder B. The lower part of the cylinder contains mercury, the upper part water. The pressure is exerted by forcing a plunger into a massive steel cylinder filled with water by means of the screw and wheel seen on the left in fig. 1, the water being forced from this cylinder through the fine coiled tube into the upper part of the cylinder in which the glass tube is fixed; by rapidly turning the wheel seen on the right of the figure, a valve may be opened, allowing of the escape of the water, and thus the pressure on the gas may be suddenly withdrawn. The pressure to which the gas is submitted is measured by means of either of the manometers seen on the right. The gas may be cooled by surrounding the tube A with liquid sulphur dioxide, carbon dioxide, or nitrous oxide, and the deposition of ice on the outside of the cylinder containing the refrigerating liquid is prevented by covering it with a glass cylinder or bell jar, under which is placed some desiccating material. By strongly compressing a gas in this apparatus, and then suddenly relieving it from pressure, an enormous reduction in its temperature is effected, owing to the sudden expansion of the gas, and it is under these circumstances that liquefaction takes place in cases where pressure alone is ineffective. On submitting hydrogen to a pressure of nearly 300 atmospheres, and then suddenly withdrawing the pressure, M. Cailletet observed the formation of a fine mist in the interior of the tube; the experiments of Andrews and his own previous observations had shown that this result afforded incontestable proof of the presence of liquid, if not of solid, particles.

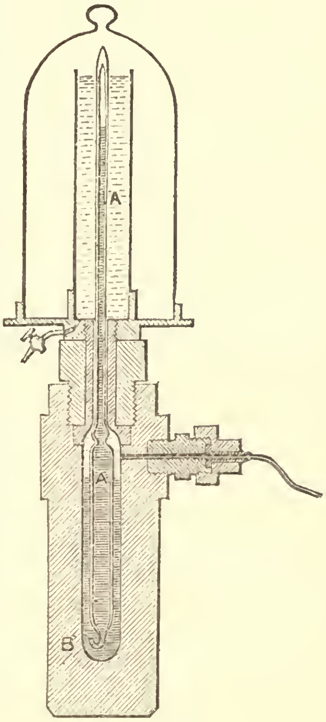


Fig. 2.

[1] The statement in the article CHEMISTRY, vol. v. p. 479, that hydrogen has never been liquefied, was true at the date of publication.

The general disposition of M. Pictet's apparatus is seen in fig. 3. It is of a much more complex character, but permits of the experiment being made on a comparatively very large scale. The condensation of the gas is effected in a copper tube of narrow bore,

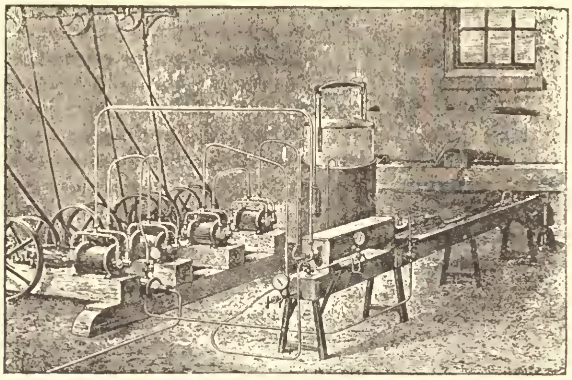


FIG. 3.—Pictet's Apparatus for Liquefaction of Gases.

connected at the one end with a manometer capable of indicating pressures up to 800 atmospheres, and with a fine steel stop-cock, and at the other with a very strong wrought-iron vessel in which the hydrogen is generated by heating a perfectly dry mixture of potassium formate with potassium hydroxide; these two substances enter into reaction in accordance with the equation $HCOOK + HOK = K_2CO_3 + H_2$, the hydrogen being evolved in a perfectly regular manner when the temperature is maintained at 225°. The dimensions of the condensation tube are—internal diameter ·001 metre, external diameter ·015 metre, length 4·16 metres; and the retort has a capacity of 1659 cubic centimetres. The charge introduced consisted of 500 grammes potassium hydroxide and 1251 grammes potassium formate. The condensation tube is surrounded with a wider tube containing condensed carbon dioxide or nitrous oxide; these tubes are enclosed in the lower box seen in the sketch. The upper box contains a tubular arrangement in which carbon dioxide or nitrous oxide from the gasholder is reduced to the liquid state. The pumps are such as are used in ice-making machines, one of each pair being an exhausting, the other a condensing pump; one pair of these pumps is employed in condensing and volatilizing the sulphur dioxide, and the other in condensing and volatilizing the carbon dioxide or nitrous oxide. Figs. 4 and 5 show the apparatus in vertical section and in plan.

In working the apparatus, in the first place liquid sulphur dioxide from the reservoir seen between the first pair of pumps is charged into the outer tube of the condenser in the upper box, and is caused rapidly to evaporate by the action of the exhausting pump in connexion with the tube, while the other pump serves to recondense it in the reservoir, which is a kind of tubular boiler provided with a cold water circulation. The temperature of the liquid sulphur dioxide is thus reduced to − 65° C.; on allowing the carbon dioxide or

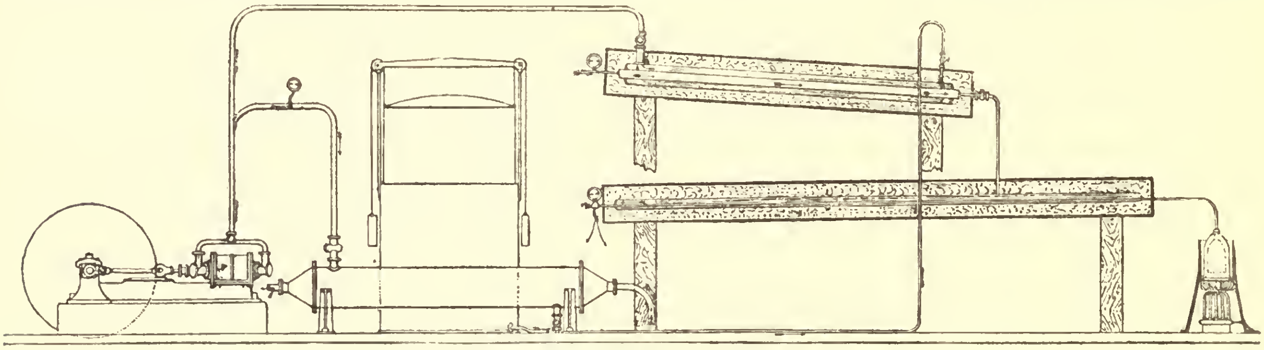


FIG 4.—Vertical Section of Pictet's Apparatus.

nitrous oxide to enter the inner tube of the condenser thus cooled, it begins to liquefy under a pressure of about 4 atmospheres, and the condensation of the whole of the gas is effected at a pressure of from 4 to 7 atmospheres, the temperature of the liquid sulphur dioxide fluctuating between − 65° and − 50°. The liquid carbon dioxide (or nitrous oxide) thus obtained is then allowed to pass into the tube surrounding the condensation tube, and by the action of the second exhausting pump it is caused to evaporate so quickly that it solidifies. The temperature may thus be reduced to − 120° or even − 140°.

In describing his first experiment with hydrogen with this apparatus, M. Pictet states that the pressure, having risen gradually during about 40 minutes, became stationary at about 650 atmospheres; on then opening the stop-cock, the orifice being illuminated by a powerful electric light, an opaque jet of a highly characteristic steel-blue tint was seen to issue forth. At the same moment, a sharp hissing noise like that produced on plunging a red-hot bar of iron into water was heard, and simultaneously a highly

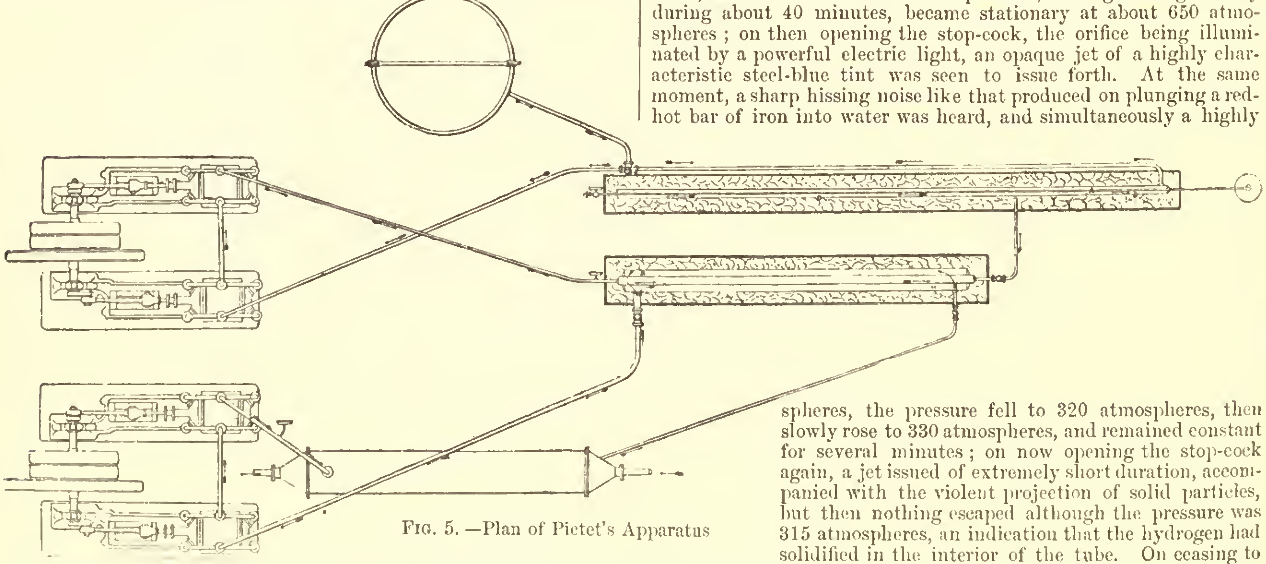


FIG. 5.—Plan of Pictet's Apparatus

characteristic rustling noise on the ground, recalling the sound of small seed falling. Moreover, the jet was not continuous as in the case of oxygen, but intermittent, each projection of matter being attended with the peculiar rustling noise alluded to; in fact, owing to the great reduction in temperature, due to the sudden volatilization of the liquid, portions became solidified in the tube. On closing the stop-cock after several seconds, the pressure being still 370 atmospheres, the pressure fell to 320 atmospheres, then slowly rose to 330 atmospheres, and remained constant for several minutes; on now opening the stop-cock again, a jet issued of extremely short duration, accompanied with the violent projection of solid particles, but then nothing escaped although the pressure was 315 atmospheres, an indication that the hydrogen had solidified in the interior of the tube. On ceasing to aspirate from the tube surrounding the condensation tube, and thus allowing the temperature of the latter to rise somewhat, discharges took place with increasing frequency, until after about a quarter of an hour the pressure fell to zero.

Pictet thus succeeded in liquefying and solidifying hydrogen on January 10th, 1878, Cailletet having demonstrated its liquefaction on December 30th previously.

HYDROMECHANICS

Historical Introduction.[1]

The word *Hydromechanics* is derived from the Greek ὑδρο-μηχανικά, meaning the mechanics of water and fluids in general. The science is divided into three branches:—*Hydrostatics*, which deals with the equilibrium of fluids; *Hydrodynamics*, which deals with the mathematical theory of the motion of fluids, neglecting the viscosity; and *Hydraulics*, in which the motion of water in pipes and canals is considered, and hydrodynamical questions of practical application are investigated.

The science of hydromechanics was cultivated with less success among the ancients than any other branch of mechanical philosophy. When the human mind had made considerable progress in the other departments of physical science, the doctrine of fluids had not begun to occupy the attention of philosophers; and, if we except a few propositions on the pressure and equilibrium of water, hydromechanics must be regarded as a modern science, which owes its existence and improvement to these great men who adorned the 17th and 18th centuries.

rchi-edes. Those general principles of hydrostatics which are to this day employed as the foundation of that part of the science were first given by Archimedes in his work Περὶ τῶν ὀχουμένων, or *De iis quæ vehuntur in humido*, about 250 B.C., and were afterwards applied to experiments by Marinus Ghetaldus in his *Promotus Archimedes* (1603). Archimedes maintained that each particle of a fluid mass, when in equilibrium, is equally pressed in every direction; and he inquired into the conditions according to which a solid body floating in a fluid should assume and preserve a position of equilibrium. We are also indebted to him for that ingenious hydrostatic process by which the purity of the precious metals can be ascertained, and for the screw engine which goes by his name.

ex-drian iool. In the Greek school at Alexandria, which flourished under the auspices of the Ptolemies, the first attempts were made at the construction of hydraulic machinery. About 120 B.C. the fountain of compression, the siphon, and the forcing pump were invented by Ctesibius and Hero; and, though these machines operated by the pressure of the air, yet their inventors had no distinct notions of the preliminary branches of pneumatical science. The siphon is a simple instrument; but the forcing pump is a complicated and abstruse invention, which could scarcely have been expected in the infancy of hydraulics. It was probably suggested to Ctesibius by the *Egyptian Wheel* or *Noria*, which was common at that time, and which was a kind of chain pump, consisting of a number of earthen pots carried round by a wheel. In some of these machines the pots have a valve in the bottom which enables them to descend without much resistance, and diminishes greatly the load upon the wheel; and, if we suppose that this valve was introduced so early as the time of Ctesibius, it is not difficult to perceive how such a machine might have led that philosopher to the invention of the forcing pump.

Notwithstanding these inventions of the Alexandrian school, its attention does not seem to have been directed to the motion of fluids. The first attempt to investigate this subject was made by Sextus Julius Frontinus, inspector of the public fountains at Rome in the reigns of Nerva and Trajan; and we may justly suppose that his work, entitled *De Aquæductibus Urbis Romæ Commentarius*, contains all the hydraulic knowledge of the ancients. After describing the nine [2] great Roman aqueducts, to which he himself added five more, and mentioning the dates of their erection, he considers the methods which were at that time employed for ascertaining the quantity of water discharged from ajutages, and the mode of distributing the waters of an aqueduct or a fountain. He justly remarks that the flow of water from an orifice depended not only on the magnitude of the orifice itself, but also on the height of the water in the reservoir; and that a pipe employed to carry off a portion of water from an aqueduct should, as circumstances required, have a position more or less inclined to the original direction of the current. But as he was unacquainted with the true law of the velocities of running water as depending upon the depth of the orifice, we can scarcely be surprised at the want of precision which appears in his results.

It has generally been supposed that the Romans were ignorant of the art of conducting and raising water by means of pipes; but it can scarcely be doubted, from the statement of Pliny and other authors, not only that they were acquainted with the hydrostatical principle, but that they actually used leaden pipes for the purpose. Pliny asserts that water will always rise to the height of its source, and he also adds that, in order to raise water up to an eminence, leaden pipes must be employed.[3]

Castelli and Torricelli, two of the disciples of Galileo, applied the discoveries of their master to the science of hydrodynamics. In 1628 Castelli published a small work, *Della Misura dell' acque correnti*, in which he gave a very satisfactory explanation of several phenomena in the motion of fluids in rivers and canals. But he committed a great paralogism in supposing the velocity of the water proportional to the depth of the orifice below the surface of the vessel. Torricelli, observing that in a jet where the water rushed through a small ajutage it rose to nearly the same height with the reservoir from which it was supplied, imagined that it ought to move with the same velocity as if it had fallen through that height by the force of gravity. And hence he deduced this beautiful and important proposition, that the velocities of fluids are as the square root of the head, allowing for the resistance of the air and the friction of the orifice. This theorem was published in 1643, at the end of his treatise *De Motu gravium Projectorum*. It was afterwards confirmed by the experiments of Raphael Magiotti on the quantities of water discharged from different ajutages under different pressures; and, though it is true only in small orifices, it gave a new turn to the science of hydraulics. Castelli. Torricelli.

After the death of the celebrated Pascal, who discovered the pressure of the atmosphere, a treatise on the equilibrium of fluids (*Sur l'Équilibre des Liqueurs*) was found among Pascal.

[1] This historical sketch of the subject is a revised abridgment of that written by David Buchanan, and prefixed to the article Hydrodynamics in the 8th edition of this work.

[2] These nine aqueducts delivered every day 14,000 quinaria, or about 50,000,000 cubic feet of water, or about 50 cubic feet for the daily consumption of each inhabitant, supposing the population of Rome to have been a million. From measurements of Frontinus at the close of the 1st century, the total length of channels of aqueducts was 285 Roman miles (Roman mile = 1618 English yards). The supply measured by Frontinus amounted to 13,470 quinaries,—outside Rome 3164, inside 10,306. Measured at the head the supply was 24,413 quinaries, the difference being due to waste, and to some of the channels having fallen into decay. Parker says:—"It has been computed by a French engineer that the supply to Rome was 332,306,624 gallons daily. If we assume the population at a million, the rate was 332 gallons daily per person. In our day we consider 40 gallons sufficient, and many think this excessive." Modern supply varies from 24 to 50 gallons per head per day.

[3] Plin. xxxvi. See also Palladius, *De Re Rustica*, ix., xi.; Horace, *Epist.*, i. 10, 20; Ovid, *Met.*, iv. 122.

his manuscripts, and was given to the public in 1663. In the hands of Pascal hydrostatics assumed the dignity of a science. The laws of the equilibrium of fluids were demonstrated in the most perspicuous and simple manner, and amply confirmed by experiments. The discovery of Torricelli, it may be supposed, would have incited Pascal to the study of hydraulics. But as he has not treated this subject in the work mentioned, it was probably composed before that discovery had been made public.

Mariotte. The theorem of Torricelli was employed by many succeeding writers, but particularly by the celebrated Mariotte, whose labours in this department of physics deserve to be recorded. His *Traité du Mouvement des Eaux*, which was published after his death in the year 1686, is founded on a great variety of well-conducted experiments on the motion of fluids, performed at Versailles and Chantilly. In the discussion of some points he has committed considerable mistakes. Others he has treated very superficially, and in none of his experiments does he seem to have attended to the diminution of efflux arising from the contraction of the fluid vein, when the orifice is merely a perforation in a thin plate; but he appears to have been the first who attempted to ascribe the discrepancy between theory and experiment to the retardation of the water's velocity arising from friction. His contemporary Guglielmini, who was inspector of the rivers and canals in the Milanese, had ascribed this diminution of velocity in rivers to transverse motions arising from inequalities in their bottom. But as Mariotte observed similar obstructions even in glass pipes, where no transverse currents could exist, the cause assigned by Guglielmini seemed destitute of foundation. The French philosopher, therefore, regarded these obstructions as the effects of friction. He supposes that the filaments of water which graze along the sides of the pipe lose a portion of their velocity; that the contiguous filaments, having on this account a greater velocity, rub upon the former, and suffer a diminution of their celerity; and that the other filaments are affected with similar retardations proportional to their distance from the axis of the pipe. In this way the medium velocity of the current may be diminished, and consequently the quantity of water discharged in a given time must, from the effects of friction, be considerably less than that which is computed from theory. Guglielmini was the first who attended to the motion of water in rivers and open canals (*La Misura dell' acque correnti*). Embracing the theorem of Torricelli, which had been confirmed by repeated experiments, Guglielmini concluded that each particle in the perpendicular section of a current has a tendency to move with the same velocity as if it issued from an orifice at the same depth from the surface. The consequences deducible from this theory of running waters are in every respect repugnant to experience, and it is really surprising that it should have been so hastily adopted by succeeding writers. Guglielmini himself was sufficiently sensible that his parabolic theory was contrary to fact, and endeavoured to reconcile them by supposing the motion of rivers to be obstructed by transverse currents arising from irregularities in their bed. The solution of this difficulty, as given by Mariotte, was more satisfactory, and was afterwards adopted by Guglielmini, who maintained also that the viscosity of water had a considerable share in retarding its motion.

Newton. The effects of friction and viscosity in diminishing the velocity of running water were noticed in the *Principia* of Sir Isaac Newton, who threw much light upon several branches of hydromechanics. At a time when the Cartesian system of vortices universally prevailed, this great man found it necessary to investigate that absurd hypothesis, and in the course of his investigations he showed that the velocity of any stratum of the vortex is an arithmetical mean between the velocities of the strata which enclose it; and from this it evidently follows that the velocity of a filament of water moving in a pipe is an arithmetical mean between the velocities of the filaments which surround it. Taking advantage of these results, it was afterwards shown by Pitot that the retardations arising from friction are inversely as the diameters of the pipes in which the fluid moves. The attention of Newton was also directed to the discharge of water from orifices in the bottom of vessels. He supposed a cylindrical vessel full of water to be perforated in its bottom with a small hole by which the water escaped, and the vessel to be supplied with water in such a manner that it always remained full at the same height. He then supposed this cylindrical column of water to be divided into two parts,—the first, which he calls the "cataract," being an hyperboloid generated by the revolution of an hyperbola of the fifth degree around the axis of the cylinder which should pass through the orifice, and the second the remainder of the water in the cylindrical vessel. He considered the horizontal strata of this hyperboloid as always in motion, while the remainder of the water was in a state of rest, and imagined that there was a kind of cataract in the middle of the fluid. When the results of this theory were compared with the quantity of water actually discharged, Newton concluded that the velocity with which the water issued from the orifice was equal to that which a falling body would receive by descending through half the height of water in the reservoir. This conclusion, however, is absolutely irreconcilable with the known fact that jets of water rise nearly to the same height as their reservoirs, and Newton seems to have been aware of this objection. In the second edition of his *Principia* accordingly, which appeared in 1714, he reconsidered his theory. He had discovered a contraction in the vein of fluid (*vena contracta*) which issued from the orifice, and found that, at the distance of about a diameter of the aperture, the section of the vein was contracted in the subduplicate ratio of two to one. He regarded, therefore, the section of the contracted vein as the true orifice from which the discharge of water ought to be deduced, and the velocity of the effluent water as due to the whole height of water in the reservoir; and by this means his theory became more conformable to the results of experience. This theory, however, is still liable to serious objections. The formation of a cataract is by no means agreeable to the laws of hydrostatics; for when a vessel is emptied by the efflux of water through an orifice in its bottom, all the particles of the fluid direct themselves toward this orifice, and therefore no part of it can be considered as in a state of repose.

The subject of the oscillation of waves, one of the most difficult in the science of hydrodynamics, was first investigated by Newton. In the forty-fourth proposition of the second book of his *Principia*, he has furnished us with a method of ascertaining the velocity of the waves of the sea, by observing the time in which they rise and fall. If the two vertical branches of a siphon, which communicate by means of a horizontal branch, are filled with a fluid of known density, the two fluid columns, when in a state of rest, will be in equilibrium and their surfaces horizontal. But if the one column is raised above the level of the other, and left to itself, it will descend below that level, and raise the other column above it, and, after a few oscillations, they will return to a state of repose. Newton occupied himself in determining the duration of these oscillations, or the length of a pendulum isochronous to their duration; and he found, by a simple process of reasoning, that, allowing for the effects of friction, the length of a synchronous pendulum is equal to one-half of the length of the siphon, that is, of the two vertical branches and the horizontal one, and hence he deduced the isochronism of these oscillations. From this Newton concluded that the velocity of waves formed on the surface of water, either by the wind or by a body thrown into it, was in the subduplicate ratio of their size. When their velocity, therefore, is measured, which can be easily done, the size of the waves will be determined by means of a pendulum which oscillates in the time that a wave takes to rise and fall.

ernoulli. Such was the state of hydrodynamics in 1738, when Daniel Bernoulli published his *Hydrodynamica, sive de Viribus et Motibus Fluidorum Commentarii.* The germ of Daniel Bernoulli's theory was first published in his memoir entitled *Theoria Nova de Motu Aquarum per Canales quocunque fluentes,* which he had communicated to the Academy of St Petersburg as early as 1726. His theory of the motion of fluids was founded on two suppositions, which appeared to him conformable to experience. He supposed that the surface of a fluid, contained in a vessel which is emptying itself by an orifice, remains always horizontal; and, if the fluid mass is conceived to be divided into an infinite number of horizontal strata of the same bulk, that these strata remain contiguous to each other, and that all their points descend vertically, with velocities inversely proportional to their breadth, or to the horizontal sections of the reservoir. In order to determine the motion of each stratum, he employed the principle of the *conservatio virium vivarum,* and obtained very elegant solutions. In the opinion of the Abbé Bossut, his work was one of the finest productions of mathematical genius. The uncertainty of the principle employed by Daniel Bernoulli, which has never been demonstrated in a general manner, deprived his results of that confidence which they would otherwise have deserved, and rendered it desirable to have a theory more certain, and depending solely on the fundamental laws of mechanics. Maclaurin and John Bernoulli, who were of this opinion, resolved the problem by more direct methods, the one in his *Fluxions,* published in 1742, and the other in his *Hydraulica nunc primum detecta, et demonstrata directe ex fundamentis pure mechanicis,* which forms the fourth volume of his works. The method employed by Maclaurin has been thought not sufficiently rigorous; and that of John Bernoulli is, in the opinion of Lagrange, defective in perspicuity and precision.

Alembert. The theory of Daniel Bernoulli was opposed also by the celebrated D'Alembert. When generalizing James Bernoulli's theory of pendulums he discovered a principle of dynamics so simple and general that it reduced the laws of the motions of bodies to that of their equilibrium. He applied this principle to the motion of fluids, and gave a specimen of its application at the end of his *Dynamics* in 1743. It was more fully developed in his *Traité des Fluides,* which was published in 1744, where he has resolved, in the most simple and elegant manner, all the problems which relate to the equilibrium and motion of fluids. He makes use of the very same suppositions as Daniel Bernoulli, though his calculus is established in a very different manner. He considers, at every instant, the actual motion of a stratum as composed of a motion which it had in the preceding instant and of a motion which it has lost. The laws of equilibrium between the motions lost furnish him with equations which represent the motion of the fluid. Although the science of hydrodynamics had then made considerable progress, yet it was chiefly founded on hypothesis. It remained a desideratum to express by equations the motion of a particle of the fluid in any assigned direction. These equations were found by D'Alembert from two principles,—that a rectangular canal, taken in a mass of fluid in equilibrium, is itself in equilibrium; and that a portion of the fluid, in passing from one place to another, preserves the same volume when the fluid is incompressible, or dilates itself according to a given law when the fluid is elastic. His very ingenious method was published in 1752, in his *Essai sur la Resistance des Fluides.* It was brought to perfection in his *Opuscules Mathématiques,* and was adopted by Euler.

Before the time of D'Alembert, it was the great object of philosophers to submit the motion of fluids to general formulæ, independent of all hypothesis. Their attempts, however, were altogether fruitless; for the method of fluxions, which produced such important changes in the physical sciences, was but a feeble auxiliary in the science of hydraulics. For the resolution of the questions concerning the motion of fluids, we are indebted to the method of partial differences, a new calculus, with which Euler enriched the sciences. This great discovery was first applied to the motion of water by D'Alembert, and enabled both him and Euler to represent the theory of fluids in formulæ restricted by no particular hypothesis.

The most successful labourer in the science of hydrodynamics was the Chevalier Dubuat, engineer in ordinary to the king of France. Following in the steps of the Abbé Bossut (*Nouvelles expériences sur la resistance des fluides,* 1777), he prosecuted the inquiries of that philosopher with uncommon ingenuity; and in the year 1786 he published, in two volumes, his *Principes d'Hydraulique,* which contains a satisfactory theory of the motion of fluids, founded solely upon experiments. Dubuat considered that if water were a perfect fluid, and the channels in which it flowed infinitely smooth, its motion would be continually accelerated, like that of bodies descending in an inclined plane. But as the motion of rivers is not continually accelerated, and soon arrives at a state of uniformity, it is evident that the viscosity of the water, and the friction of the channel in which it descends, must equal the accelerating force. Dubuat therefore assumes it as a proposition of fundamental importance that, when water flows in any channel or bed, the accelerating force which obliges it to move is equal to the sum of all the resistances which it meets with, whether they arise from its own viscosity or from the friction of its bed. This principle was employed by Dubuat in the first edition of his work, which appeared in 1779, but the theory contained in that edition was founded on the experiments of others. He soon saw, however, that a theory so new, and leading to results so different from the ordinary theory, should be founded on new experiments more direct than the former, and he was employed in the performance of these from 1780 to 1783. The experiments of Bossut having been made only on pipes of a moderate declivity, Dubuat found it necessary to supply this defect. He used declivities of every kind, and made his experiments upon channels from a line and a half in diameter to seven or eight square toises. Dubuat

The theory of running water was greatly advanced by the researches of Prony. From a collection of the best experiments by Couplet, Bossut, and Dubuat he selected eighty-two (fifty-one on the velocity of water in conduit pipes, and thirty-one on its velocity in open canals); and, discussing these on physical and mechanical principles, he succeeded in drawing up general formulæ, which afford a simple expression for the velocity of running water. Prony.

Eytelwein of Berlin published, in 1801, a valuable compendium of Hydraulics, entitled *Handbuch der Mechanik und der Hydraulik,* which contains an account of many new and valuable experiments made by himself. He investigates the subject of the discharge of water by compound pipes, the motions of jets, and their impulses against plane and oblique surfaces; and he shows theoretically that a water wheel will have its effect a maximum when its circumference moves with half the velocity of the stream. Eytelwein.

Mallet and Vici. A series of interesting hydraulic experiments was made at Rome in 1809 by Mallet and Vici. They found that a pipe whose gauge was five ounces French measure (or 0·03059 French kilolitres) furnished one-seventh more water than five pipes of one ounce, an effect arising from the velocity being diminished by friction in the ratio of the perimeters of the orifices as compared with their areas.

Hachette. Hachette, in the year 1816, presented to the National Institute a memoir containing the results of experiments which he had made on the spouting of fluids, and the discharge of vessels. The objects he had in view were to measure the contracted part of a fluid vein, to examine the phenomena attendant on additional tubes, and to investigate and describe the figure of the fluid vein, and the results which take place when different forms of orifices are employed. Hachette showed in the second part of his memoir that greater or lesser volumes of water will be discharged in the same time through tubes of different figures, the apertures in all having the same dimensions. He also gave several remarkable results respecting other fluids issuing out of orifices into air or a vacuum.

Investigations as to waves. Several very interesting experiments on the propagation of waves have been made by the brothers Weber[1] and by Bidone. Mr John Scott Russell performed a number of experiments on waves, which are described in the *Edinburgh Transactions*, vol. xiv., and in the *British Association Report* for 1837. The mathematical theory has been worked out by Green, Stokes, Rankine, and other mathematicians, but still offers an interesting field for the investigator. Stokes's Report of the British Association for 1846 on Recent Researches in Hydrodynamics gives an account of the subject as it existed at that date.

Bidone. In 1826 Bidone,[2] besides his experiments on waves, made a series on the velocity of running water at the hydraulic establishment of the university of Turin, and he published an account of them in 1829. After giving a description of his apparatus and method of experimenting, he gives the figures obtained from fluid veins, sections of which were taken at different distances from the orifice.

Poncelet. In the year 1827 Poncelet published a *Mémoire sur les Roues Hydrauliques à Aubes Courbes*, containing his experiments on the undershot wheel with curved palettes, which he had invented in the year 1824. The best undershot previous to the introduction of the Poncelet wheel never developed more than 0·25 of the work of the water, whereas this utilized 0·60 of that work, which is nearly equivalent to the maximum effect of the breast wheel. The principle on which the Poncelet wheel acts, and that which makes it utilize so much of the work of the water, is that the water is received by the curved floats without any shock, and is discharged finally with a small velocity. This undershot wheel is much used in France.

Fourneyron. Previous to the year 1827, the wheels required in the mills and manufactories of Germany and France were generally those which worked with the axis horizontal, or the tub and spoon wheels with the axis vertical; but in that year a young mechanician named Fourneyron introduced a wheel working with the axis vertical, yet wholly different from the latter kind. Fourneyron showed that in existing wheels with a vertical axis the water left the wheel with considerable velocity in the direction of the motion of the wheel, and thus carried away and wasted much of the energy of the fall. By the introduction of a series of fixed guide blades, which gave the water initially a backward velocity of rotation, the water left the wheel with a much smaller velocity of discharge. He thus invented the first complete turbine, a kind of water motor which has largely superseded the more cumbrous water wheels previously in use. Shortly after the invention was made public, Fourneyron was awarded the prize of 6000 francs which was offered by the Society for the Encouragement of National Industry.

Recent investigations. The most extensive experiments on the discharge of water from orifices are those made under the direction of the French Government by Poncelet and Lesbros (*Experiences Hydrauliques*, Paris, 1851). Boileau (*Traité de la mesure des eaux courantes*) has discussed these results and added experiments of his own. Bornemann has re-examined all these results with great care, and has been able to express in formulæ the variation of the coefficients of discharge in different conditions (*Civilingenieur*, 1880). Very valuable experiments leading to a modification of the usual formula for the discharge over weirs were made by Mr J. B. Francis (*Lowell Hydraulic Experiments*, Boston, Mass., 1855). Wiesbach also has made many experimental investigations of the discharge of fluids.

The friction of water investigated originally by Coulomb at slow speeds has been measured for higher speeds by Mr W. Froude, whose researches have very great value in the theory of ship resistance (*Report of Brit. Assoc.*, 1869).

The flow of air and steam from orifices has been measured by many experimenters from Young to Saint Venant. Mr Napier in some interesting experiments first pointed out that when the ratio of the pressures on the two sides of an orifice exceeded a certain limit the measured discharge was very different from that calculated by the accepted formulæ. Since then numerous experiments have been made, and the theory of the flow of elastic fluids has been discussed in numerous memoirs. The valuable investigations of Fliegner (*Civilingenieur*, 1878) deserve special mention.

A most valuable investigation of the flow of water in pipes and channels has been carried out with exceptional accuracy and on a very large scale by the late M. Darcy, and continued by his successor the late M. Bazin, at the expense of the French Government (*Recherches Hydrauliques*, Paris, 1866). The measurement of the flow in rivers has been extensively carried out, especially by German engineers. Harlacher's *Beiträge zur Hydrographie des Königreiches Böhmen* contains exceedingly valuable measurements of this kind, and a comparison of the experimental results with all the formulæ of flow which have been proposed. Messrs Humphreys and Abbott's gaugings of the Mississippi for the United States Government, Mr Gordon's gaugings of the Irrawaddi, and Captain Cunningham's experiments on the Ganges Canal may be referred to as having materially advanced hydraulic science.

The first adequate theory of turbines is that of Poncelet in the *Comptes Rendus de l'Academie de Paris*, 1838. Redtenbacher's *Theorie und Bau der Turbinen und Ventilatoren* (Mannheim, 1844) is the first complete treatise on the subject. Girard's turbine, which was of an entirely new type, was discussed in *Le Génie industrielle*, 1856–1857, and lately by Fink (*Civilingenieur*, 1880). Important experiments on turbines were made by Francis (*Lowell Hydraulic Experiments*, Boston, Mass., 1855).

General Principles.

Hydromechanics is the science of the equilibrium and motion of fluids, both elastic and non elastic. A fluid is defined to be a substance which yields continually to the slightest tangential stress; and, consequently, when the fluid has come to rest, the stress across any surface in the fluid must be normal to the surface.

The stress considered in hydromechanics is always a pressure, as fluids are in general capable of sustaining only a slight tension without disruption (see Capillary Action). The intensity of the pressure is measured, as in the subject of elasticity, by the number of units of force per unit of area.

[1] *Wellenlehre auf Experimente gegrundet*, Leipsic, 1825.
[2] *Turin Memoirs*, vol. xxv.

If an area a be pushed by P units of force, then the mean pressure p over the area a is $\frac{P}{a}$; or, if p be variable, then at any point $p = \text{lt}\frac{P}{a}$, a being any small area enclosing the point at which p is required, and P the number of units of force with which a is pushed.

The pressure across any surface being normal to the surface, it follows from the general equations of internal stress (see ELASTICITY) that at a point the pressure is the same in all directions about the point. This may be proved independently by considering the equilibrium of a tetrahedron ABCD. Let p, p' be the pressures on the faces ABC, BCD, and resolve the forces parallel to the edge AD; the face ABC will be pushed by a force $p \times$ area ABC, and the face BCD will be pushed by a force $p' \times$ area BCD; and the projections of the areas ABC, BCD on a plane perpendicular to AD being equal, it follows that $p = p'$.

If forces act throughout the fluid so that the pressure varies from one point to another, we must suppose the tetrahedron taken indefinitely small, and then the impressed forces, depending on the volume, may be neglected in comparison with the forces acting on the faces, which depend on the surface of the tetrahedron.

When fluids such as exist in nature are in motion, the stresses across any surfaces are no longer normal, but tangential stresses are called into play, the intensities of which depend upon the relative motion of the parts of the fluid; those tangential stresses are said to be due to the viscosity of the fluid.

The difference between a solid and a fluid is that in a solid the tangential stress must exceed a certain amount before permanent shearing takes place, otherwise the stress being removed the solid regains its shape; in a fluid the slightest tangential stress produces a permanent deformation, and if continued long enough will cause a complete change of form, however great the viscosity of the fluid may be.[1] But little progress has been made in the theory of the motion of viscous fluids, those cases which have been worked out mostly falling under the head of the practical subject of hydraulics. In the theoretical subject of hydrodynamics the motion of the so-called *perfect* fluids only is considered,—fluids in which no viscosity is supposed to exist, and in which therefore the pressure at a point is the same in all directions.

Fluids are divided into two classes, incompressible fluids called liquids, and compressible fluids called gases. The so-called incompressible fluids are in reality compressible, but the compressibility being small is neglected in ordinary problems.

The *compression* of a substance is defined to be the ratio of the diminution of the volume to the original volume; and the *compressibility* is defined to be the ratio of the compression to the pressure producing it. The *elasticity* or *resilience of volume* is the ratio of the pressure to the compression produced, and is therefore the reciprocal of the compressibility. Fluids, from the definition, possess only elasticity of volume; an elastic solid possesses in addition an elasticity of figure, called also the *rigidity*.

A table of the elasticities and compressibilities of liquids is given in Everett's *Units and Physical Constants*, expressed in C. G. S. units; for instance, at 8° C. the elasticity of water is $2{\cdot}08 \times 10^{10}$, and the compressibility per atmosphere is $4{\cdot}81 \times 10^{-5}$. The elasticity of water is also proved to exist, and can be determined from the velocity of sound in water; for instance, in water of density unity, the velocity is the square root of the elasticity, and therefore 144,000 centimetres per second, which agrees closely with the velocity determined by experiment.

[1] For examples of the difference between a soft solid and a very viscous fluid see Maxwell's *Heat*, chap. xxi.

Compressible fluids or gases are assumed to obey the two gaseous laws.

The first gaseous law, discovered by Boyle, and generally called Boyle's law, asserts that the pressure of a given quantity of a gas at a given temperature varies inversely as the volume, or directly as the density.

The *density* is defined to be the number of units of mass in the unit of volume, and the *specific volume* is the volume of the unit of mass. Hence Boyle's law asserts that the pressure of a gas at a given temperature varies as the density, or inversely as the specific volume.

Dalton generalized Boyle's law for a mixture of gases by enunciating the law that the pressure of a mixture of gases is the sum of the separate pressures each gas would have if it existed alone in the containing vessel.

If we suppose all the gases the same, we are led to Boyle's law, since, if a gramme of air in a centimetre cube produces a certain pressure, then two grammes will produce double the pressure, three grammes treble the pressure, and so on; hence the pressure varies as the density. This method of exhibiting Boyle's law is due to Rankine (Maxwell, *Heat*, p. 27).

The second gaseous law was discovered by Charles, but it generally goes by Gay-Lussac's name. It asserts that under constant pressure the volume of a given quantity of every gas increases by about $\frac{1}{273}$ of its volume at 0° C. for a rise of temperature of 1° C. Therefore, if v be the volume at τ° C. and v_0 the volume at 0° C., then

$$\frac{v}{v_0} = 1 + \frac{\tau}{273} = \frac{273 + \tau}{273}.$$

If we reckon temperature from −273° C., and put $273 + \tau = t$, then t is called the absolute temperature, and −273° C. is called the absolute zero; and the second gaseous law asserts that at a constant pressure the volume of a given quantity of gas is proportional to the absolute temperature.

Combined with Boyle's law, this leads to the result that

$$pv \propto t, = Rt \text{ suppose,}$$

where p is the pressure, v the specific volume, and t the absolute temperature; also, if ρ denote the density,

$$\rho = \frac{1}{v}, \text{ and } p = R\rho t.$$

To determine the numerical value of $\frac{pv}{t} = R$, in C.G.S. units, suppose at 80° C. a centimetre cube of air is ·001 of a gramme, the height of the barometer being 76 centimetres, and the numerical value of g to be 981; then

$$p = 981 \times 1342 \times 76 = 10^6 \text{ very nearly,}$$
$$t = 273 + 80 = 353,$$
$$v = 1.$$
$$\therefore \quad R = \frac{10^6}{353} = 2833.$$

If the temperature is kept constant, then, an increment of pressure dp producing a compression $-\frac{dv}{v}$, the elasticity of volume

$$= -v\frac{dp}{dv} = \rho\frac{dp}{d\rho} = p;$$

and therefore at a constant temperature the elasticity is equal to the pressure.

Professor Maxwell (*Heat*, p. 171) has proved from first principles that the ratio of the elasticity of volume when no heat escapes is to the elasticity at constant temperature as the specific heat at constant pressure to the specific heat at constant volume.

Consequently if γ denotes the ratio of the specific heat at constant pressure to the specific heat at constant volume, and if the gas be compressed and no heat allowed to escape, then

$$-v\frac{dp}{dv} = \gamma p,$$

or

$$\frac{dp}{p} + \gamma\frac{dv}{v} = 0,$$

or

$$pv^\gamma = \text{constant}.$$

Consequently, if p, p' be the pressures, v, v' the specific volumes, ρ, ρ' the densities, and t, t' the absolute temperatures at two different states of a gas, when no heat has been allowed to escape, then

$$\frac{p}{p_1}=\left(\frac{v'}{v}\right)^{\gamma}=\left(\frac{\rho}{\rho'}\right)^{\gamma}=\left(\frac{t}{t'}\right)^{\frac{\gamma}{\gamma-1}};$$

since

$$\frac{pv}{p'v'}=\frac{t}{t'}.$$

The value of γ for air is about 1·4; for instance, the velocity of sound is $\sqrt{\frac{dp}{d\rho}}=\sqrt{\gamma\frac{p}{\rho}}$; and, for dry air at τ° C.,

$$\frac{p}{\rho}=7\cdot8376\times10^{8}\left(1+\frac{\tau}{273}\right);$$

and therefore the velocity of sound in centimetres per second

$$=33240\sqrt{\left(1+\frac{\tau}{273}\right)}=33240+60\tau,\text{ nearly.}$$

We have defined the *density* of a substance to be the number of units of mass in the unit of volume; for instance, with English units the density is the number of pounds in a cubic foot, and the density of water would be 62·5, a cubic foot of water being 1000 oz. But the densities of substances are generally tabulated relatively to water, and the old-fashioned name for the density relative to water was *specific gravity*. With French units of the centimetre and the gramme, a centimetre cube of water being a gramme, the density of water is unity.

PART I.—HYDROSTATICS.

Hydrostatics is the science of the equilibrium of fluids. When a fluid has come to rest there can be no tangential stress, and consequently the stress across any surface is normal to the surface, and therefore the same in all directions about a point. We shall begin with a few elementary propositions about the equilibrium of liquids like water under gravity, and afterwards proceed to the consideration of the equilibrium of any fluid under any forces.

Prop. I. The pressure is the same at all points in a horizontal plane of a liquid at rest under gravity.

For, taking any two points in the same horizontal plane, and joining them, and describing about the joining line as axis an indefinitely thin cylinder, then, since the weight and the pressures on the sides of the cylinder are normal to the axis of the cylinder, resolving parallel to the axis of the cylinder, the pressures on the ends must be equal for equilibrum, and must therefore be of equal intensity.

Corollary.—It follows that the free surface must be a horizontal plane, supposing the pressure uniform over it, and gravity to act in parallel vertical lines.

That the free surface is a plane is verified experimentally by the fact that objects are seen by reflexion at the surface undisturbed as in a plane mirror; and that it is a horizontal plane is verified by the fact that a plumb line and its image by reflexion at the surface always appear in the same straight line.

Prop. II. The pressure at any point of a liquid at rest under gravity is proportional to the depth.

For, let P (fig. 1) be any point at a depth $AP=z$ in the liquid, and about AP as axis describe a cylinder, of sectional area α suppose. Then, considering the equilibrium of the liquid in this cylinder, and resolving vertically, the pressure, p suppose, at P acting over the area α must balance the weight of the liquid in the cylinder, neglecting the atmospheric pressure, and therefore

$$p\alpha=\rho z\alpha,$$

or

$$p=\rho z,$$

ρ denoting the weight of the liquid per unit of volume.

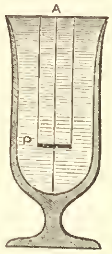


Fig. 1.

In practical hydrostatics the gravitation measure of forces is employed, and p the pressure is generally estimated in lb per square inch, and then, an inch being the unit of length, z is given in inches, and ρ is the number of pounds to a cubic inch of the liquid considered.

Thus with water, taking a cubic foot of water to be 62·4 lb,

$$p=\frac{62\cdot4}{1728}z=0\cdot036\times z.$$

If, however, z be measured in feet and p in lb per square inch,

$$p=\frac{62\cdot4}{144}z=0\cdot433\times z.$$

Consequently the head of each foot of water produces a pressure of 0·433 lb to the square inch.

With the French metric system of units, a centimetre cube of water is one gramme, and therefore with the centimetre as the unit of length and gramme as unit of weight, using gravitation units of force, $\rho=1$, and $p=z$.

Even if the point C considered (fig. 2) should not be vertically below the actual free surface, it still follows that the pressure at C is proportional to the depth below the free surface. For the pressure at C is equal to the pressure at D in the same horizontal plane, and this is proportional to the depth DE, that is, to the depth CF.

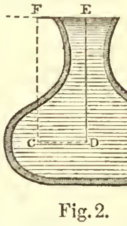


Fig. 2.

If the atmospheric pressure ϖ be taken into account, then

$$p=\varpi+\rho z,$$

and generally, at different depths z and z',

$$p-p'=\rho(z-z');$$

or the difference of the pressures at any two points of a liquid at rest under gravity is proportional to the difference of the depths.

Corollary.—It follows from this that a liquid rises to the same level in a series of communicating vessels (fig. 3), since the fluid must have one horizontal plane as the free surface.

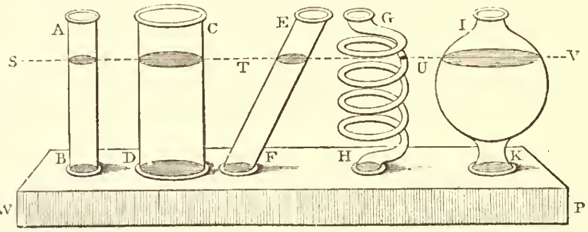


Fig. 3.

If liquids of different densities ρ and ρ' be poured into the two branches of a bent tube, the heights of the free surfaces above the plane of separation will be inversely as the densities. For the pressure at the level of the common surface being constant, and in one case due to a height h of liquid of density ρ and in the other case to a height h' of liquid of density ρ', therefore

$$\rho h=\rho' h',$$

or

$$h:h'=\rho':\rho.$$

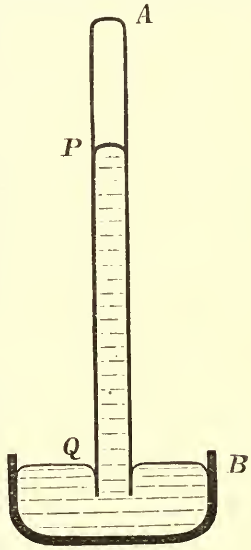


Fig. 4.

The barometer (fig. 4) is in reality an instrument of this character, for a column of mercury, of density σ and height h suppose, supports a column of air, which is of density ρ suppose, and, if homogeneous, would reach to a height H. Hence the pressure at the level of the common surface

$$p=\sigma h=\rho H,$$

estimated in gravitation measure.

If the tube AB should not be exactly vertical, then h must be taken to denote the vertical distance between the level of the mercury at P and Q, which becomes difficult to estimate at sea when the ship is rolling.

When h is observed the temperature must also be observed; for at the same pressure the coefficient of linear expansion of h is the coefficient of cubical expansion of mercury. For, if the density of mercury were halved, the height h would be doubled, and so on in any proportion.

H is called the pressure height (Everett, *Units and Physical Constants*). For dry air at 0° C.,

$$H = 7{\cdot}988 \times 10^5 \text{ centimetres.}$$

Prop. III. To find the pressure on the bottom of a vessel of any form containing liquid, the bottom of the vessel being supposed a horizontal plane.

The pressure at any point of the base being the same and due to the depth below the free surface, whatever be the shape of the sides of the vessel, as in fig. 5, it follows that the pressure on the base AB is equal to the weight of the liquid contained in an imaginary cylinder, traced out by vertical lines round the base AB reaching to the surface.

In order to illustrate this, let there be four vessels A, B, C, D (fig. 6), having bottoms all of the same area, and closed by plates E, F, G, H, of the same weight. Let the plates also be kept in their places by means of strings passing over pulleys and supporting equal weights w, w', w'', w'''. The weights will measure the vertical forces acting on the plates, *i.e.*, the bases of the vessels. It will be found that water must be poured into each vessel to the same height to cause the plates to descend. The same will be the case whatever be the shapes of the vessels, and the extreme cases of a very large base acted upon by the pressure of water in a very contracted vessel, and of a very small area kept closed by a very small weight when the vessel is very much enlarged above, constitute what used to be called the *hydrostatic paradox*. Another kind of hydrostatic paradox is the hydraulic press, where water, pumped in with small exertion by a forcing pump of which the plunger is of small diameter, causes a second plunger of very much greater diameter to rise and produce a very great pressure.

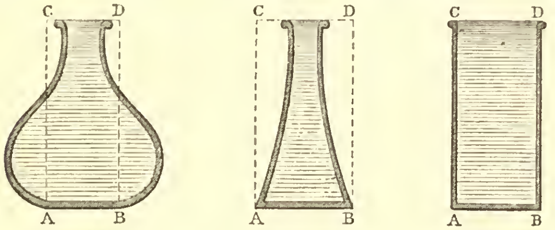


Fig. 5.

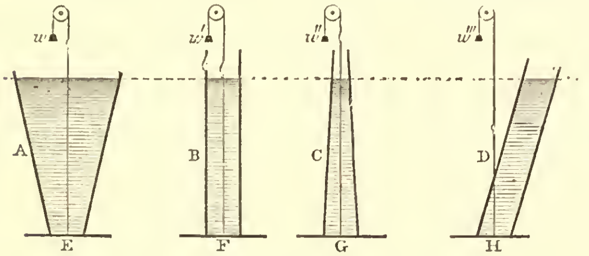


Fig. 6.

Prop. IV. (*Archimedes's Principle*).—The resultant pressure of a fluid on a body immersed in it acts vertically upwards through the centre of gravity, and is equal to the weight of the displaced liquid.

For, suppose the body removed and its place filled up with fluid as it would be at rest, and imagine for clearness this fluid solidified. The fluid pressures which act upon this solidified fluid are the same as before, and since the fluid is in equilibrium under its own weight and the fluid pressures, the resultant of the fluid pressures must be a single vertical force equal to the weight of the displaced liquid, and acting upwards through the centre of gravity of the displaced liquid.

Corollary.—If a body float at rest in fluid, the weight of the body must be equal to the weight of the displaced fluid, and the C.G.s of the body and displaced fluid must be in the same vertical line. For instance, the weight of water displaced by a ship is equal to the weight of the whole ship, masts, rigging and all. When a balloon is at rest in the air, the weight of the balloon is equal to the weight of air displaced.

Archimedes's principle is employed to determine the densities of bodies; for, if w be the weight of a body weighed in a balance in air (strictly speaking *in vacuo*), and if w' be its apparent weight when immersed in water, then $w - w'$, the resultant upward pressure of the water, is equal to the weight of water displaced, and the density relative to water is therefore

$$\frac{w}{w - w'}.$$

In very accurate weighings the weight of air displaced must be taken into account, the real weight of a body being its apparent weight in air plus the weight of air displaced. Thus, if in air a pound of lead and a pound of feathers balance in a pair of scales, if placed under a receiver and the air exhausted the feathers would preponderate.

The densities of liquids and solids are also determined by hydrometers, for a description of which consult the article HYDROMETER.

The numerical measure of the density of a substance being the quotient of the number of units of mass (or weight) by the number of units of volume, it follows that in a mixture of fluids the density of the mixture is the quotient of the number of units of mass in the component fluids by the volume of the mixture.

The volume of the mixture will in general be the sum of the volumes of the component fluids, except in some cases where the fluids combine chemically with each other. If equal volumes of the component fluids be taken, the density of the mixture will therefore be the arithmetical mean of the densities of the component fluids; but if equal weights be taken, the density of the mixture will be the harmonical mean of the densities of the component fluids, no change of volume being supposed to take place.

Prop. V. To find the resultant vertical and horizontal pressures on one side of a portion of a surface immersed in fluid at rest under gravity.

The resultant vertical pressure is the weight of the superincumbent fluid contained by vertical lines drawn round the bounding curve of the surface to the free surface. If, however, the free surface does not extend over the surface, we must suppose it made to do so by filling up the empty space with fluid. The line of action of the resultant vertical pressure passes through the centre of gravity of this superincumbent fluid.

The resultant horizontal pressure in any direction is equal to the resultant pressure on the plane area traced out on a plane perpendicular to the given horizontal direction by horizontal lines drawn through the bounding line of the surface in the given direction; this plane area is called the orthogonal projection of the surface on a plane perpendicular to the given direction. For, resolving in the given direction the weight of the enclosed liquid and the pressures on the cylindrical surface traced out by the horizontal lines acting in a direction at right angles, the horizontal components of the pressures on the ends balance, which proves the proposition. The line of action of this horizontal pressure passes through the centre of pressure of the plane area (*vide* "Centre of Pressure").

If a plane area be immersed in homogeneous liquid at rest under gravity, the resultant force acting on one side of the area will be the product of the area and the pressure at the centre of gravity of the area.

For, dA denoting an element of the area, and z its depth, the resultant pressure

$$= \int \rho z dA = \rho \bar{z} A$$

which proves the proposition.

General Equations of Equilibrium of any Fluid at rest under any Forces.

If we take any arbitrary origin O, and three rectangular axes of reference Ox, Oy, Oz, then, if p be the pressure, ρ the density, and X, Y, Z the components of the impressed force per unit of mass at the point xyz, the equilibrium of the fluid in any closed surface S requires, resolving parallel to the axis of x,

$$\iint lp dS = \iiint \rho X dx dy dz,$$

the integrations extending respectively over the surface and through the volume of the space S, and l, m, n denoting the direction-cosines of the outward drawn normal at the surface element dS.

But by Green's transformation

$$\iint lp dS = \iiint \frac{dp}{dx} dx dy dz,$$

and therefore
$$\iiint \frac{dp}{dx} dx dy dz = \iiint \rho X dx dy dz,$$

leading to the differential relation

$$\frac{dp}{dx} = \rho X.$$

Similarly,
$$\frac{dp}{dy} = \rho Y, \quad \frac{dp}{dz} = \rho Z.$$

The three equations of equilibrium obtained by taking moments about the axis will be found to be satisfied identically.

Hence the space variation of the pressure in any direction is equal to the resolved force per unit of volume in that direction. The resultant force is therefore in the direction of the greatest space variation of the pressure, that is, normal to the surface of equal pressure; and the lines of force must therefore be capable of being cut orthogonally by a system of surfaces, which will be the surfaces of equal pressure.

If we neglect changes of temperature, then, the density at any point being a function of the pressure, it follows that surfaces of equal pressure are also surfaces of equal density, and therefore $\frac{1}{\rho}\frac{dp}{dx}$, $\frac{1}{\rho}\frac{dp}{dy}$, $\frac{1}{\rho}\frac{dp}{dz}$ are the partial differential coefficients with respect to x,y,z of some function P of x,y,z such that $P=\int\frac{dp}{\rho}$; and therefore also X,Y,Z must be the partial differential coefficients of some function $-V$, called the potential, such that the force in any direction is rate of diminution of V in that direction, and the conditions of equilibrium $\frac{1}{\rho}\frac{dp}{dx}=X$, &c., are equivalent to

$$\frac{dP}{dx}+\frac{dV}{dx}=0\,,\quad \frac{dP}{dy}+\frac{dV}{dy}=0\,,\quad \frac{dP}{dz}+\frac{dV}{dz}=0\,;$$

or

$$P+V=\text{constant}.$$

If the temperature be variable, then the surfaces of equal pressure and density need not be coincident; but, since the pressure is a function of the density and temperature only, it follows that the surfaces of equal temperature and of equal density must intersect in curves which lie on surfaces of equal pressure.

As an example of the use of the general equations, take the simplest case of a homogeneous liquid at rest under gravity; then, the axis of z being directed vertically downwards, the equations become

$$\frac{1}{\rho}\frac{dp}{dx}=0\,,\quad \frac{1}{\rho}\frac{dp}{dy}=0\,,\quad \frac{1}{\rho}\frac{dp}{dz}=g\,,$$

and therefore $p=\varpi+g\rho z$, ϖ being the pressure at the level of the origin.

We are here employing a new unit of force—the absolute unit—which is defined as the force which causes unit acceleration in the unit of mass. With the same units of length, time, and mass, the gravitation unit of force is g times the absolute unit of force; for instance, in the equations $p=\rho z$, and $p=g\rho z$, the p in the first equation is measured in gravitation units of force per unit of area, and in the second equation in absolute units of force per unit of area.

Again, suppose the density to vary as any power of the depth, and put

$$\rho=\mu z^n\,;$$

then

$$\frac{dp}{dz}=g\rho=g\mu z^n\,;$$

and

$$p=\varpi+\frac{g\mu}{n+1}z^{n+1}.$$

If the fluid be elastic, and the temperature uniform, $p=k\rho$, and

$$\frac{1}{\rho}\frac{dp}{dz}=\frac{k}{p}\frac{dp}{dz}=g\,;$$

and integrating,

$$\log\frac{p}{\varpi}=\frac{gz}{k}\,;$$

$$p=\varpi e^{\frac{gz}{k}}\,;$$

$$\rho=\frac{\varpi}{k}e^{\frac{gz}{k}}.$$

Consequently, as we go up in the air, if the temperature be uniform, as the heights increase in arithmetical progression, the pressures and densities diminish in geometrical progression.

If H denote the pressure height, then

$$p=k\rho=g\rho H\,,$$

and therefore

$$H=\frac{k}{g}\,;$$

and if p_1, p_2 denote the pressures at levels z_1, z_2, then

$$\frac{p_1}{p_2}=e^{\frac{z_1-z_2}{H}}\,,$$

or

$$z_1-z_2=H\log\frac{p_1}{p_2}\,,$$

$$=H\times 2{\cdot}3026\log_{10}\frac{p_1}{p_2}.$$

For dry air at 0° C., taking H = 26,000 feet,

$$z_1-z_2=60{,}000\log_{10}\frac{p_1}{p_2}\ \text{nearly.}$$

—(Maxwell, *Heat*, chap. xiv.)

The Figure of the Earth.

Suppose a fluid mass arranged under the gravitation of its parts in concentric spherical strata, the density increasing towards the centre for stability of equilibrium, and ρ being the density at a distance k from the centre. If we suppose this mass to be rotating without relative motion of its parts about an axis, and to be slightly disturbed in consequence of the rotation from the spherical arrangement of the strata, we can gain an idea of the figure of the earth on the hypothesis of original fluidity.

If ω be the angular velocity, we must suppose a disturbing function, whose potential is $\frac{1}{2}\omega^2r^2\sin^2\theta$, added to the gravitation potential, θ being the angular distance from the axis of revolution and of figure. Denoting the zonal surface harmonic of the second degree $\frac{3}{2}\mu^2-\frac{1}{2}$, where $\mu=\cos\theta$, by Q_2, the disturbing function may be written

$$\tfrac{1}{3}\omega^2r^2(1-Q_2)\,;$$

and we shall assume in consequence that the disturbance of each stratum from the spherical form is also a zonal harmonic of the second degree, so that when disturbed the equation of a stratum will be

$$r=k(1-\tfrac{2}{3}\epsilon Q_2)\,;$$

and ϵ, which is the ratio of the difference of the equatorial and polar axes to the mean axis, is called the ellipticity of the stratum.

The gravitation potential of a homogeneous spheroid of density ρ, and bounded by

$$r=k(1-\tfrac{2}{3}\epsilon Q_2),$$

is the same as that of a homogeneous sphere of radius k and density ρ, and of a distribution of matter on the sphere of radius k, of surface density $-\frac{2}{3}k\epsilon Q_2\rho$, neglecting ϵ^2.

Therefore, for an internal point the potential is

$$2\pi\rho k^2-\tfrac{2}{3}\pi\rho r^2-\tfrac{8}{15}\pi\rho\epsilon r^2Q_2\,;$$

and for an external point the potential is

$$\tfrac{4}{3}\pi\rho\frac{k^3}{r}-\tfrac{8}{15}\pi\rho\frac{k^5\epsilon}{r^3}Q_2.$$

Therefore, for the shell of density ρ, enclosed by the stratum

$$r=k(1-\tfrac{2}{3}\epsilon Q_2)$$

and the consecutive stratum, the potential dU

$$=4\pi\rho k\,dk-\tfrac{8}{15}\pi\rho\frac{d\epsilon}{dk}r^2Q_2dk$$

for an internal point, and

$$=4\pi\rho\frac{k^2}{r}-\tfrac{8}{15}\pi\rho\frac{d}{dk}(k^5\epsilon)\frac{1}{r^3}Q_2dk$$

for an external point; and, therefore, for any point in the interior of the whole mass on the stratum

$$r=k(1-\tfrac{2}{3}\epsilon Q_2),$$

$$U=4\pi\int_k^K\rho k\,dk-\tfrac{8}{15}\pi r^2Q_2\int_k^K\rho\frac{d\epsilon}{dk}dk+\frac{M}{r}-\tfrac{8}{15}\pi\frac{Q_2}{r^3}\int_0^k\rho\frac{d}{dk}(k^5\epsilon)dk\,,$$

M denoting the mass enclosed by the stratum of mean radius k, and K being the mean radius of the exterior stratum. Neglecting ϵ^2,

$$U=4\pi\int_k^K\rho k\,dk-\tfrac{8}{15}\pi k^2Q_2\int_k^K\rho\frac{d\epsilon}{dk}dk$$
$$+\frac{M}{k}\left(1+\tfrac{2}{3}\epsilon Q_2\right)-\tfrac{8}{15}\pi\frac{Q_2}{k^3}\int_0^k\rho\frac{d}{dk}(k^5\epsilon)dk.$$

The equation of equilibrium is, since the force in any direction is the rate of *increase* of the gravitation potential,

$$\int\frac{dp}{\rho}-U-\tfrac{1}{3}\omega^2r^2(1-Q_2)=\text{constant}\,;$$

and, supposing surfaces of equal pressure to be also surfaces of equal density, we must have to our order of approximation

$$U+\tfrac{1}{3}\omega^2k^2(1-Q_2)=\text{constant},$$

over a surface of equal density, or, equating to zero the coefficient of Q_2,

$$\frac{M\epsilon}{k}-\tfrac{4}{5}\pi k^2\int_k^K\rho\frac{d\epsilon}{dk}dk-\tfrac{4}{5}\frac{\pi}{k^3}\int_0^k\rho\frac{d}{dk}(k^5\epsilon)dk+\tfrac{1}{2}\omega^2k^2=0.$$

Dividing by k^2, and differentiating with respect to k, ω^2 disappears, and we obtain

$$k^3\frac{d\,.\,M\epsilon}{dk}-3k^2M\epsilon-4\pi\rho k^5\epsilon+4\pi\int_0^k\rho\frac{d}{dk}(k^5\epsilon)dk=0\,;$$

and, differentiating again with respect to k,

$$k^3\frac{d^2\,.\,M\epsilon}{dk^2}-6kM\epsilon-4\pi k^5\epsilon\frac{d\rho}{dk}=0\,,$$

or

$$k^2\frac{d^2\,.\,M\epsilon}{dk^2}-\left(6+\frac{4\pi k^4}{M}\frac{d\rho}{dk}\right)M\epsilon=0\,;$$

a differential equation of the second order to determine $M\epsilon$, and therefore ϵ, provided we know what function ρ and therefore M is of k.

Properly speaking, from the elasticities of the substances of the various strata we should know the relation between the pressure and the density, and then from the conditions of equilibrium of the strata when undisturbed and in this spherical shape we could determine what function ρ is of k,—the pressure and density at a stratum with our approximations being the same in the undisturbed and disturbed states; and therefore

$$\frac{1}{\rho}\frac{dp}{dk}=-\frac{M}{k^2}.$$

Laplace, on the assumption that the cubical elasticity is double the pressure, and therefore the pressure proportional to the square of the density, has integrated the differential equation for the ellipticity,—his assumption amounting to putting

$$\frac{4\pi k^2}{M}\frac{d\rho}{dk}=-q^2, \text{ a constant.}$$

More generally, to make the equation for the ellipticity integrable, we may put

$$\frac{4\pi k^4}{M}\frac{d\rho}{dk}=-\left(\frac{k}{a}\right)^n,$$

where a and n are constants, the negative sign being taken because $\frac{d\rho}{dk}$ is negative for stability. This assumption reduces the differential equations for ρ, M, and $M\epsilon$ to equations reducible to Bessel's differential equation, and therefore ρ, M, and ϵ can be expressed by Bessel's functions.

Laplace's assumption amounts to putting $n=2$, and then the Bessel's functions which occur are of the order $\frac{1}{2}$, $\frac{3}{2}$, and $\frac{5}{2}$.

Then $\rho=\sigma\frac{\sin qk}{qk}$, where σ is the density at the centre of the earth, and therefore

$$M=\frac{4\pi\sigma}{q^3}(\sin qk-qk\cos qk),$$

and $$\epsilon=\frac{5\omega^2}{8\pi\sigma}\,\frac{\sin a-a\cos a}{\frac{2}{a^3}\sin^2 a-\frac{1}{a^2}\sin a\cos a-\frac{1}{a}}\cdot\frac{\left(\frac{3}{q^2k^2}-1\right)\sin qk-\frac{3}{qk}\cos qk}{\sin qk-qk\cos qk},$$

where $a=qK$, and the value of q must be determined from the condition that the mean density of the earth is twice the density at the surface.

Centre of Pressure.

When a plane area is exposed to fluid pressure on one side, the resultant force experienced by the area is a single force perpendicular to the area, the sum of all the separate pressures, and acts through a definite point called the *centre of pressure*.

If p be the pressure at the point xy, the axes being taken in the plane of the area, then the resultant force

$$R=\iint p\,dxdy,$$

and, if $\bar{x}$, $\bar{y}$ denote the coordinates of the centre of pressure,

$$\bar{x}=\frac{\iint xp\,dxdy}{\iint p\,dxdy},\quad \bar{y}=\frac{\iint yp\,dxdy}{\iint p\,dxdy}.$$

The centre of pressure is therefore the C.G. of the plane area, supposed a lamina of variable density p. If p is uniform, the centre of pressure is obviously the C.G. of the area.

For a homogeneous liquid at rest under gravity, p is proportional to the depth below the surface, that is, proportional to the perpendicular distances from the line of intersection of the plane of the area with the free surface of the liquid. If the equation of this line be

$$x\cos\alpha+y\sin\alpha-p=0,$$

then $$\bar{x}=\frac{\iint x(p-x\cos\alpha-y\sin\alpha)dxdy}{\iint(p-x\cos\alpha-y\sin\alpha)dxdy},$$

$$\bar{y}=\frac{\iint y(p-x\cos\alpha-y\sin\alpha)dxdy}{\iint(p-x\cos\alpha-y\sin\alpha)dxdy}.$$

If the origin be taken at the centre of gravity of the area, and if the axes be the principal axes of the area, then

$$\iint dxdy=A, \text{ the area},$$

$$\iint xdxdy=0,\ \iint ydxdy=0,\ \iint xydxdy=0$$

and $$\iint y^2dxdy=Aa^2,\ \iint x^2dxdy=Ab^2;$$

a and b being the semi-axes of the momental ellipse of the area. Therefore

$$\bar{x}=-\frac{a^2}{p}\cos\alpha,\ \bar{y}=-\frac{b^2}{p}\sin\alpha;$$

and therefore the centre of pressure is the antipole of the line of intersection with the free surface, with respect to the momental ellipse.

The centre of pressure of a rectangular area, with a side in the free surface, is at $\frac{2}{3}$ of the depth of the lower side; of a triangle with vertex in the free surface and base horizontal is $\frac{3}{4}$ of the depth of the base; of a triangle with base in the surface is $\frac{1}{2}$ the depth of the vertex.

Metacentre.

We have found from Archimedes's principle the conditions of equilibrium of a floating body, and we must now examine whether the equilibrium is stable or unstable.

Let ACB (fig. 7) represent the cross section of a floating body, like a ship, and let G be the C.G. of the body, and H that of the liquid displaced, supposed homogeneous. Let the body be turned through a small angle in the plane of the paper, whose circular measure is θ, so that the volume of liquid displaced remains the same. Then, if W denote the weight of the body, and therefore also of the liquid displaced, the resultant force due to the liquid on the body in the displaced position is a vertical force W acting vertically upwards through H′, the new C.G. of the displaced liquid.

In order that the volume displaced may remain unaltered, it is necessary that the line of intersection of the two planes of flotation AB and DE should pass through the C.G. of the area of the curve of flotation. For dA denoting an element of the area A of flotation, and x its distance from the line of intersection of the planes AB and DE, the element of volume traced out by dA when the body is displaced being $\theta x dA$, we must have

$$\int\theta x dA=0,$$

or $$\int x dA=0;$$

which proves that the line of intersection of the planes of AB and DE passes through the C.G. of the area of flotation.

The force W acting upwards through H′ is therefore equivalent to an equal force W acting upwards through H, and a couple, due to the moment of the weight of AOD upwards and BOE downwards, the moment of which is therefore, in gravitation units,

$$\rho\int\theta x^2 dA=\rho\theta Ak^2,$$

k denoting the radius of gyration of the area A about the line whose projection on the plane is O.

Since HH′ is the arc of a curve, such that the tangent at H is

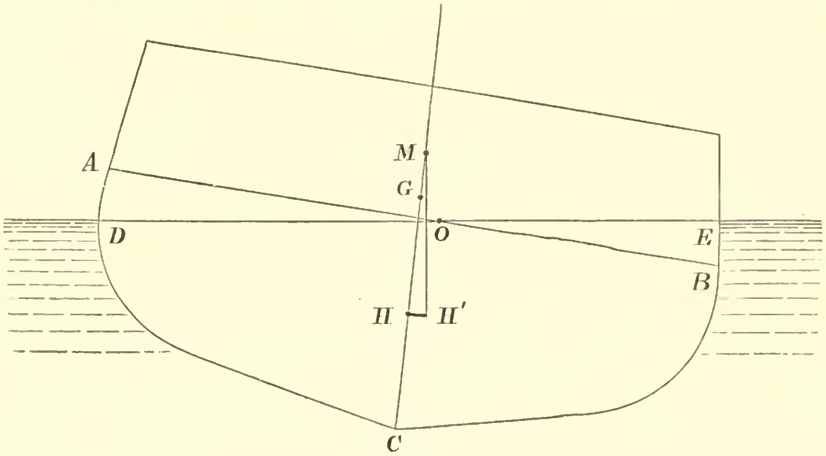


Fig. 7

parallel to AB, therefore HH′ is ultimately a straight line perpendicular to GH, and

$$W\ .\ HH'=\rho\theta Ak^2,$$

or $$HH'=\theta\frac{\rho Ak^2}{W}=\theta\frac{Ak^2}{V}$$

if V be the volume of liquid displaced.

If H′M be drawn vertically upwards to meet HG in M, then M is ultimately the centre of curvature of the locus of H in the body, and is called the metacentre, and

$$HM=\mathrm{lt}\frac{HH'}{\theta}=\frac{Ak^2}{V}.$$

If M lies above G, the fluid pressure tends to restore the body to its position of equilibrium, and the equilibrium is therefore stable; but if M lies below G the equilibrium is unstable.

Generally we see that, if planes be drawn cutting off constant volumes from a solid, the principal radii of curvature of the locus of H, the centre of gravity of the volume cut off, will be $\frac{Ak_1^2}{V}$ and $\frac{Ak_2^2}{V}$, where V is the volume cut off, A the area of the cutting plane intercepted by the surfaces, and k_1, k_2 the principal radii of gyration of this area about the centre of gravity of the area. The vertical through H′ will intersect HG only when the plane of displacement is a plane of symmetry, that is, if it is perpendicular to k_1 or k_2.

Generally for finite displacements in a plane the locus of M will be the evolute of the curve which is the intersection of the plane with the locus of H.

The surface the locus of H is called the surface of buoyancy, and the surface which is the envelope of the planes of flotation is called the surface of flotation.

If r_1, r_2 be the principal radii of curvature of the surface of buoyancy, then

$$r_1 = \frac{Ak_1^2}{V} = \frac{I_1}{V}\ ;\ r_2 = \frac{Ak_2^2}{V} = \frac{I_2}{V}.$$

If R_1, R_2 be the principal radii of gyration of the surface of flotation, Mons. E. Leclert has proved that

$$R_1 = \frac{dI_1}{dV} = r_1 + \frac{Vdr_1}{dV},\ R_2 = \frac{dI_2}{dV} = r_2 + \frac{Vdr_2}{dV}.$$ [1]

For small oscillations, if we suppose the liquid pressure the same as if the liquid were at rest, the body oscillates as if the surface of buoyancy moved upon a horizontal plane.

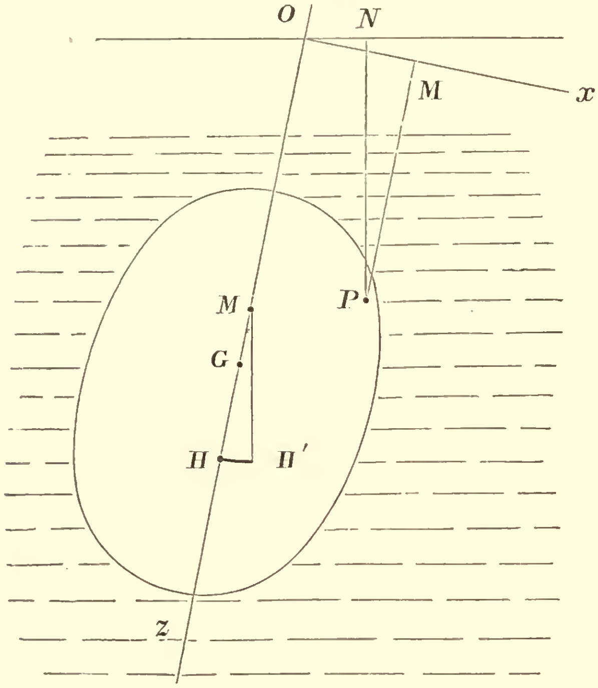


Fig. 8.

Next, suppose a body completely immersed in heterogeneous liquid, which must for equilibrium be arranged in horizontal strata of equal density, and suppose $\rho = f(z)$ the density of the liquid at any depth z; let G be the centre of gravity of the body and H that of the liquid displaced (fig. 8). When the body is in equilibrium, we must have G and H in the same vertical line, and

$$\iiint \rho\, dxdydz = W,$$

the weight of the liquid displaced, using gravitation units of force again.

Suppose the axes of coordinates fixed in the body, and take GM as the axis of z; suppose the body turned through a small angle θ about the axis Oy, and let H′ be the centre of gravity of the displaced liquid in the new position. The density of the liquid displaced at a point P, whose coordinates are x, y, z, is now

$$\begin{aligned} f(\text{NP}) &= f(z\cos\theta + x\sin\theta) \\ &= f(z + x\theta) \\ &= f(z) + \theta x f'(z), \end{aligned}$$

neglecting θ^2; and, to the same order of approximation,

$$\text{HH}' = \frac{\iiint x\{f(z) + \theta x f'(z)\}\, dxdydz}{W} = \theta \frac{\iiint x^2 f'(z)\, dxdydz}{W},$$

since

$$\iiint x f(z)\, dxdydz = 0,$$

H lying in the axis of z.

If the vertical through H′ meet Oz in M, M is called the metacentre, and is the centre of curvature of the locus of H, and

$$\text{HM} = \frac{\text{HH}''}{\theta} = \frac{\iiint x^2 f'(z)\, dxdydz}{W} = \frac{\int Ak^2 \frac{d\rho}{dz}\, dz}{W},$$

if Ak^2 denote the moment of inertia of a horizontal plane section of the body at a depth z, about the line of intersection with the plane of yz.

We have here supposed that H′ lies in the plane of xz; but this will only be true for two directions of displacement.

In general for any displacement, if $\bar{x}$, $\bar{y}$, $\bar{z}$ be the coordinates of H′,

$$\bar{y} = \frac{\iiint y\{f(z) + \theta x f'(z)\}\, dxdydz}{W} = \theta \frac{\iiint xy f'(z)\, dxdydz}{W};$$

and therefore $\bar{y} = 0$, only when the axis of y is a principal axis of the body, supposed of density $\frac{d\rho}{dz}$.

When ρ is discontinuous, as in the case of the body floating in homogeneous fluid, then the integral $\int Ak^2 d\rho$ will have a term $Ak^2\rho$, due to the discontinuity at the surface, and the rest of the integral will vanish, because $\frac{d\rho}{dz} = 0$.

For a body floating wholly immersed in two liquids, the upper of uniform density ρ' and the lower of uniform density ρ,

$$\text{HM} = \frac{(\rho - \rho')Ak^2}{W}.$$

Tension of Flexible Surfaces exposed to Pressure.

In hydrostatics it is usual to determine the circumferential and longitudinal tension produced in a thin circular cylinder, due to uniform internal pressure, and also to determine the tension of a spherical surface, like a soap-bubble, due to the excess of the internal pressure over the atmospheric pressure.

Let r be the internal radius of the cylinder, c the thickness (supposed small), p the internal pressure, and t, t' the circumferential and longitudinal tension per unit of area caused by the pressure p.

If we suppose the cylinder divided into two halves by a diametral plane, and consider the equilibrium of unit length of either half under the resultant of the fluid pressure over the half-cylinder and the tensions at the ends of the diameters, the resultant of the tensions must balance the resultant of the fluid pressures, which is the resultant pressure on the diametral plane, since the resultant of the uniform pressure on a closed surface is zero. Therefore

$$2tc = 2pr;$$

or

$$\frac{t}{p} = \frac{r}{c}.$$

To determine the longitudinal tension t', consider that the resultant pressure on the end of the cylinder, which is $p.\pi r^2$, is balanced by the resultant of the tensions round a circumferential seam, which is $t'c.2\pi r$; and therefore

$$2\pi t'cr = \pi pr^2;$$

or

$$\frac{t'}{p} = \frac{1}{2}\frac{r}{c};$$

and therefore

$$t' = \tfrac{1}{2}t.$$

Thus in a boiler, half an inch thick, and 3 feet in diameter, a pressure of 150 lb to the square inch makes $t = 5400$, $t' = 2700$.

For a sphere of internal radius r, and small thickness c, supposing it divided by a diametral plane, then the resultant tension round the circumference, $tc.\ 2\pi r$, must balance the resultant fluid pressure $p.\pi r^2$, supposing p the excess of the internal over the external pressure; and therefore

$$2\pi tcr = \pi pr^2;$$

or

$$\frac{t}{p} = \frac{1}{2}\frac{r}{c}.$$

In the experiment with the Magdeburg hemispheres, where two hemispheres were joined by an air-tight joint and the air say half exhausted, then, with a pound and inch as units, $p = 7\cdot5$, supposing 15 the atmospheric pressure; and if the diameter of the hemispheres be 3 feet, then $r = 18$; and the force required to separate the hemispheres would be

$$\pi \times 18^2 \times 7\cdot5 = 7634 \text{ lb}.$$

The tension of flexible surfaces is considered more fully in the article CAPILLARY ACTION.

[1] Drawings of the curves of buoyancy and of flotation, and of the metacentric curves, are given in the plates of illustration of a paper on the "Calculation of the Stability of Ships," by W. H. White and W. John, read before the Institution of Naval Architects, March 1871.

PART II.—HYDRODYNAMICS.

In considering the motion of fluids we shall suppose them non-viscous, so that whatever be the state of motion, the stress across any section is normal to the section, and therefore the stress is a pressure and the same in all directions about a point, as in Hydrostatics.

Two methods are employed in hydrodynamics, called the Eulerian and Lagrangian, although both are due to Euler; in the Eulerian we fix our attention on particular points of space, and observe the changes of pressure, density, and velocity which take place there, and in the Lagrangian we follow a particle of fluid and observe its changes. The first may be called the statistical and the second the historical method, according to Prof. J. C. Maxwell. The Eulerian method is generally employed except where the fluid has a moving boundary.

The Eulerian Form of the Equations of Motion.

The first equation to be established is the equation of continuity, which expresses the fact that the increase of matter inside a fixed surface is due to the flow of fluid across the surface into the interior, supposing there are no hypothetical sources or sinks in the interior of the surface.

Lemma.—The quantity of fluid, estimated in units of mass, which flows across a plane area in a given time is equal to the product of the area, the density, the time, and the resolved part of the velocity perpendicular to the area.

Fig. 9.

For if q be the velocity, the quantity of fluid which flows across the area A in the time t will form an oblique cylinder of length qt, with its generating lines in the direction of motion (fig. 9). If θ denote the angle between the normal to the area and the velocity, the mass of the cylinder

$$=A\rho t q \cos\theta,$$

which is therefore the flux across the area A in the time t.

Generally, if S denote any fixed surface, M the mass of the fluid inside it, and θ the angle which the normal drawn outwards at any point of the surface makes with the velocity q at that point, then

$\frac{dM}{dt}$ = rate of increase of quantity of fluid inside the surface per unit of time

= flux across the surface per unit of time

$$= -\int \rho q \cos\theta\, dS;$$

or
$$\frac{dM}{dt}+\int\rho q\cos\theta\, dS=0 \quad . \quad . \quad . \quad . \quad . \quad (1),$$

the integral equation of continuity.

In the Eulerian equations of motion u, v, w are taken to denote the components of the velocity q parallel to the coordinate axes at the point xyz at the time t; u, v, w are therefore functions of x, y, z, t the independent variables, and d is used to denote partial differentiation with respect to these four independent variables.

To transfer the integral equation into the differential equation of continuity, we require Green's transformation, namely,

$$\iiint\left(\frac{d\xi}{dx}+\frac{d\eta}{dy}+\frac{d\zeta}{dz}\right)dxdydz=\iint(l\xi+m\eta+n\zeta)dS\,;$$

or, individually,

$$\iiint\frac{d\xi}{dx}dxdydz=\iint l\xi dS,\ \iiint\frac{d\eta}{dy}dxdydz=\iint m\eta dS,$$

$$\iiint\frac{d\zeta}{dz}dxdydz=\iint n\zeta dS\,;$$

where the integrations extend respectively through the volume and over the surface of a closed space S; l,m,n denote the direction-cosines of the outward drawn normal at the surface element dS, and ξ, η, ζ are continuous functions of x, y, z.

The integral equation of continuity may now be written

$$\iiint\frac{d\rho}{dt}dxdxdy+\iint(l\rho u+m\rho v+n\rho w)dS=0,$$

which by Green's transformation becomes

$$\iiint\left(\frac{d\rho}{dt}+\frac{d\rho u}{dx}+\frac{d\rho v}{dy}+\frac{d\rho w}{dz}\right)dxdydz=0,$$

leading to the differential equation of continuity

$$\frac{d\rho}{dt}+\frac{d\rho u}{dx}+\frac{d\rho v}{dy}+\frac{d\rho w}{dz}=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

It is customary to establish the differential equation of continuity immediately by considering the fluid which enters and leaves an infinitesimal parallelepiped, whose edges are dx, dy, dz, in the time dt, but this requires us to suppose in succession each of the elements dx, dy, dz, though infinitesimal, to be infinite compared with the other two, and with the infinitesimal element of time dt; this violation of the principles of the differential calculus is avoided by establishing the equation in its integral form first.

We shall establish the equations of motion in a similar way by considering the rate of increase of momentum in a fixed direction of the fluid inside the surface, and equating it to the momentum generated by the forces acting throughout the space S and by the pressures acting at the surface S.

Taking the fixed direction parallel to the axis of x, the rate of increase of momentum in that direction per unit of time, due to the fluid which crosses the surface, is

$$\iint(l\rho u^2+m\rho uv+n\rho uw)dS\,,$$

which by Green's transformation

$$=\iiint\left(\frac{d\rho u^2}{dx}+\frac{d\rho uv}{dy}+\frac{d\rho uw}{dz}\right)dxdydz\,;$$

and, adding this to the rate of increase of momentum per unit of time of the fluid inside the surface

$$\iiint\frac{d\rho u}{dt}\,dxdydz,$$

we obtain, as the total rate of increase of momentum per unit of time of the fluid which fills the space S,

$$\iiint\left(\frac{d\rho u}{dt}+\frac{d\rho u^2}{dx}+\frac{d\rho uv}{dy}+\frac{d\rho uw}{dz}\right)dxdydz$$

in the direction of the axis of x.

The rate of generation of momentum in this direction by the forces of components X, Y, Z per unit of mass in the interior is

$$\iiint\rho X dxdydz,$$

and by the pressures at the surface is

$$-\int lp dS\,,$$

which by Green's transformation is equal to

$$-\iiint\frac{dp}{dx}\,dxdydz\,;$$

and therefore

$$\iiint\left(\frac{d\rho u}{dt}+\frac{d\rho u^2}{dx}+\frac{d\rho ur}{dy}+\frac{d\rho uw}{dz}\right)dxdydz$$

$$=\iiint\left(\rho X-\frac{dp}{dx}\right)\,dydxdz\,;$$

leading to the differential equation of motion

$$\frac{d\rho u}{dt}+\frac{d\rho u^2}{dx}+\frac{d\rho uv}{dy}+\frac{d\rho uw}{dz}=\rho X-\frac{dp}{dx} \quad . \quad . \quad . \quad (3);$$

with two similar equations in y and z.

These equations may be slightly simplified; for

$$\frac{d\rho u}{dt}+\frac{d\rho u^2}{dx}+\frac{d\rho uv}{dy}+\frac{d\rho uw}{dz}$$

$$=\rho\left(\frac{du}{dt}+u\frac{du}{dx}+v\frac{du}{dy}+w\frac{du}{dz}\right)$$

$$+u\left(\frac{d\rho}{dt}+\frac{d\rho u}{dx}+\frac{d\rho v}{dy}+\frac{d\rho w}{dz}\right),$$

which reduces to the first line, the second line vanishing in consequence of the equation of continuity; and therefore the equations of motion may be written

$$\frac{du}{dt}+u\frac{du}{dx}+v\frac{du}{dy}+w\frac{du}{dz}=X-\frac{1}{\rho}\frac{dp}{dx} \quad . \quad . \quad . \quad (4);$$

with the two similar equations

$$\frac{dv}{dt}+u\frac{dv}{dx}+v\frac{dv}{dy}+w\frac{dv}{dz}=Y-\frac{1}{\rho}\frac{dp}{dy} \quad . \quad . \quad . \quad (5),$$

$$\frac{dw}{dt}+u\frac{dw}{dx}+v\frac{dw}{dy}+w\frac{dw}{dz}=Z-\frac{1}{\rho}\frac{dp}{dz} \quad . \quad . \quad . \quad (6).$$

As a rule these equations are established immediately by determining the component accelerations of the fluid particle which is at xyz at the instant of time t considered, and saying that these accelerations reversed, combined with the impressed forces per unit of mass, will form a system in equilibrium according to D'Alembert's principle.

To determine the component accelerations, suppose F any function of x, y, z, t, and determine the rate of change of F per unit of time for a moving particle; denoting this change by $\frac{DF}{dt}$, we have

$$\frac{DF}{dt} = \text{lt}\,\frac{F(x+u\delta t,\ y+v\delta t,\ z+w\delta t,\ t+\delta t) - F(x,y,z,t)}{\delta t}$$

$$= \frac{dF}{dt} + u\frac{dF}{dx} + v\frac{dF}{dy} + w\frac{dF}{dz},$$

so that

$$\frac{D}{dt} = \frac{d}{dt} + u\frac{d}{dx} + v\frac{d}{dy} + w\frac{d}{dz}.$$

$\frac{D}{dt}$ is called particle differentiation, because we follow the rate of change of the particle as it leaves the point xyz; but $\frac{dF}{dt}$, $\frac{dF}{dx}$, $\frac{dF}{dy}$, $\frac{dF}{dz}$ are the rates of change of F at the time t at the point xyz, fixed in space. Consequently the component accelerations parallel to the axes of coordinates of a particle of fluid are

$$\frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz},$$

$$\frac{dv}{dt} + u\frac{dv}{dx} + v\frac{dv}{dy} + w\frac{dv}{dz},$$

$$\frac{dw}{dt} + u\frac{dw}{dx} + v\frac{dw}{dy} + w\frac{dw}{dz},$$

leading to the equations of motion last established.

If $F(x,y,z,t)=0$ be the equation of a surface containing always the same particles of fluid, it follows from the preceding that

$$\frac{DF}{dt} = 0,$$

or

$$\frac{dF}{dt} + u\frac{dF}{dx} + v\frac{dF}{dy} + w\frac{dF}{dz} = 0 \quad . \quad . \quad . \quad . \quad . \quad (7).$$

This is called the differential equation of the bounding surface, as particles of fluid once in the bounding surface always remain in it.

To integrate the equations of motion (4), (5), and (6), suppose the impressed forces due to a potential V, such that the force in any direction is the rate of diminution of V in that direction, then

$$X = -\frac{dV}{dx}, \quad Y = -\frac{dV}{dy}, \quad Z = -\frac{dV}{dz};$$

and putting

$$\frac{dw}{dy} - \frac{dv}{dz} = 2\xi, \quad \frac{du}{dz} - \frac{dw}{dx} = 2\eta, \quad \frac{dv}{dx} - \frac{du}{dy} = 2\zeta,$$

the equations may be written

$$\frac{du}{dt} - 2v\zeta + 2w\eta + \frac{dR}{dx} = 0 \quad . \quad . \quad . \quad . \quad . \quad (8),$$

$$\frac{dv}{dt} - 2w\xi + 2u\zeta + \frac{dR}{dy} = 0 \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$\frac{dw}{dt} - 2u\eta + 2v\xi + \frac{dR}{dz} = 0 \quad . \quad . \quad . \quad . \quad (10),$$

where

$$R = \int\frac{dp}{\rho} + V + \frac{1}{2}q^2,$$

and $q^2 = u^2 + v^2 + w^2$ (Lamb, *Motion of Fluids*, Appendix D; also *Proc. London Math. Society*, vol. ix.).

A *stream line* is defined to be the actual path of a particle, and a *line of flow* to be a line such that the tangent at every point is in the direction of the velocity at the point; the stream lines and lines of flow are coincident only when the motion is steady; and when the motion is irrotational, the lines of flow are orthogonal to the surfaces obtained by equating the velocity function to a constant.

A *vortex line* is defined to be a line whose tangent at any point is in the direction of the resultant ω of the component angular velocities ξ, η, ζ at that point; and ω is called the *spin* (Clifford, *Kinematic*).

ξ, η, ζ are called the components of molecular rotation (or spin) at xyz, for a reason to be explained afterwards; and when they vanish the motion is said to be irrotational, and a function ϕ exists, called the velocity function, such that

$$u = \frac{d\phi}{dx}, \quad v = \frac{d\phi}{dy}, \quad w = \frac{d\phi}{dz};$$

and, generally, the velocity in any direction is then the space variation of ϕ.

When the motion is irrotational, equations (8), (9), and (10) become

$$\frac{d^2\phi}{dxdt} + \frac{dR}{dx} = 0, \quad \frac{d^2\phi}{dydt} + \frac{dR}{dy} = 0, \quad \frac{d^2\phi}{dzdt} + \frac{dR}{dz} = 0;$$

and therefore

$$\frac{d\phi}{dt} + R = H,$$

or

$$\int\frac{dp}{\rho} + V + \frac{1}{2}q^2 + \frac{d\phi}{dt} = H,$$

a constant throughout the fluid, which may, however, be a function of the time.

If, however, the motion be steady, that is, if the velocity at any point of space does not change with the time, then

$$\frac{du}{dt} = 0, \quad \frac{dv}{dt} = 0, \quad \frac{dw}{dt} = 0,$$

and the equations become

$$\frac{dR}{dx} - 2v\zeta + 2w\eta = 0,$$

$$\frac{dR}{dy} - 2w\xi + 2u\zeta = 0,$$

$$\frac{dR}{dz} - 2u\eta + 2v\xi = 0;$$

so that

$$u\frac{dR}{dx} + v\frac{dR}{dy} + w\frac{dR}{dz} = 0;$$

$$\xi\frac{dR}{dx} + \eta\frac{dR}{dy} + \zeta\frac{dR}{dz} = 0;$$

and therefore the surface R, = constant, contains both stream lines and vortex lines; and therefore

$$\int\frac{dp}{\rho} + V + \tfrac{1}{2}q^2 = \text{constant} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

along a stream line, and along a vortex line; and if the motion is irrotational, the constant is the same for all the space filled with the fluid; for then

$$\frac{dR}{dx} = 0, \quad \frac{dR}{dy} = 0, \quad \frac{dR}{dz} = 0.$$

Taking the axis of x for an instant in the direction of the normal to the surface R = constant, then $u=0$ and $\xi=0$, and (8), (9), and (10), if the motion is steady, reduce to $\frac{dR}{dn} = 2v\zeta - 2w\eta = 2q\omega \sin\theta$, where θ is the angle between the stream and the vortex line.

It is sometimes convenient to use moving axes of coordinates in Hydrodynamics, and the equations of motion then become

$$\frac{du}{dt} - v\omega_3 + w\omega_2 + (u + y\omega_3 - z\omega_2)\frac{du}{dx} + (v + z\omega_1 - x\omega_3)\frac{du}{dy}$$
$$+ (w + x\omega_2 - y\omega_1)\frac{du}{dz} = X - \frac{1}{\rho}\frac{dp}{dx},$$

with two similar equations; ω_1, ω_2, ω_3 denoting the component angular velocities of the moving axes, and u, v, w the components of the velocity of the fluid in space at the point xyz at the time t parallel to the axes.

For if q denote the component velocity of the particle xyz at the time t in a direction fixed in space whose direction-cosines are l, m, n, then

$$q = lu + mv + nw;$$

and in the infinitesimal element of time dt the coordinates of the particle will have become

$$x + (u + y\omega_3 - z\omega_2)dt, \ y + (v + z\omega_1 - x\omega_3)dt, \ z + (w + x\omega_2 - y\omega_1)dt;$$

so that

$$\frac{Dq}{dt} = \frac{dl}{dt}u + \frac{dm}{dt}v + \frac{dn}{dt}w$$
$$+ l\left\{\frac{du}{dt} + (u + y\omega_3 - z\omega_2)\frac{du}{dx} + (v + z\omega_1 - x\omega_3)\frac{du}{dy} + (w + x\omega_2 - y\omega_1)\frac{du}{dz}\right\}$$
$$+ m\left\{\frac{dv}{dt} + (u + y\omega_3 - z\omega_2)\frac{dv}{dx} + (v + z\omega_1 - x\omega_3)\frac{dv}{dy} + (w + x\omega_2 - y\omega_1)\frac{dv}{dz}\right\}$$
$$+ n\left\{\frac{dw}{dt} + (u + y\omega_3 - z\omega_2)\frac{dw}{dx} + (v + z\omega_1 - x\omega_3)\frac{dw}{dy} + (w + z\omega_2 - y\omega_1)\frac{dw}{dz}\right\}.$$

But, since l, m, n are the direction-cosines of a line fixed in space,

$$\frac{dl}{dt} = m\omega_3 - n\omega_2, \quad \frac{dm}{dt} = n\omega_1 - l\omega_3, \quad \frac{dn}{dt} = l\omega_2 - m\omega_1;$$

$$\therefore \frac{Dq}{dt} = l\left\{\frac{du}{dt} - v\omega_3 + w\omega_2 + (u + y\omega_3 - z\omega_2)\frac{du}{dx} + (v + z\omega_1 - x\omega_3)\frac{du}{dy}\right.$$
$$\left. + (w + x\omega_2 - y\omega_1)\frac{du}{dz}\right\}$$
$$+ m\left\{\frac{dv}{dt} - w\omega_1 + u\omega_3 + (u + y\omega_3 - z\omega_2)\frac{dv}{dx} + (v + z\omega_1 - x\omega_3)\frac{dv}{dy}\right.$$
$$\left. + (w + x\omega_2 - y\omega_1)\frac{dv}{dz}\right\}$$
$$+ n\left\{\frac{dw}{dt} - u\omega_2 + v\omega_1 + (u + y\omega_3 - z\omega_2)\frac{dw}{dx} + (v + z\omega_1 - x\omega_3)\frac{dw}{dy}\right.$$
$$\left. + (w + x\omega_2 - y\omega_1)\frac{dw}{dz}\right\}$$
$$= l\left(X - \frac{1}{\rho}\frac{dp}{dx}\right) + m\left(Y - \frac{1}{\rho}\frac{dp}{dy}\right) + n\left(Z - \frac{1}{\rho}\frac{dp}{dz}\right)$$

for all values of l, m, n, leading to the equations of motion.

As an example of the use of moving axes in hydrodynamics, consider the liquid filling the ellipsoidal case

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1;$$

and first suppose the liquid to be frozen, and to have component angular velocities ξ, η, ζ about the axes, then

$$u=-y\zeta+z\eta,\ v=-z\xi+x\zeta,\ w=-x\eta+y\xi.$$

If the liquid now be suddenly melted, and additional component angular velocities Ω_1, Ω_2, Ω_3 communicated to the ellipsoid about the axes, then (*vide infra*)

$$u=-y\zeta+z\eta+\frac{c^2-a^2}{c^2+a^2}\Omega_2 z+\frac{a^2-b^2}{a^2+b^2}\Omega_3 y,$$

$$v=-z\xi+x\zeta+\frac{a^2-b^2}{a^2+b^2}\Omega_3 x+\frac{b^2-c^2}{b^2+c^2}\Omega_1 z,$$

$$w=-x\eta+y\xi+\frac{b^2-c^2}{b^2+c^2}\Omega_1 y+\frac{c^2-a^2}{c^2+a^2}\Omega_2 x;$$

and if U, V, W denote the component velocities of the liquid relative to the axes,

$$U=u+y\omega_3-z\omega_2=\frac{2a^2}{a^2+b^2}\Omega_3 y-\frac{2a^2}{c^2+a^2}\Omega_2 z,$$

$$V=v+z\omega_1-x\omega_3=\frac{2b^2}{b^2+c^2}\Omega_1 z-\frac{2b^2}{a^2+b^2}\Omega_3 x,$$

$$W=w+x\omega_2-y\omega_1=\frac{2c^2}{c^2+a^2}\Omega_2 x-\frac{2c^2}{b^2+c^2}\Omega_1 y,$$

since $\omega_1=\Omega_1+\xi,\ \omega_2=\Omega_2+\eta,\ \omega_3=\Omega_3+\zeta,$

ω_1, ω_2, ω_3 being the component angular velocities of the axes.

We see that

$$U\frac{x}{w}+V\frac{y}{b^2}+W\frac{z}{c^2}=0,$$

so that a liquid particle always remains on a similar ellipsoid.

The hydrodynamical equations with moving axes, taking into account the mutual gravitation of the liquid, are

$$\frac{1}{\rho}\frac{dp}{dx}+Ax+\frac{du}{dt}-v\omega_3+w\omega_2+U\frac{du}{dx}+V\frac{du}{dy}+W\frac{du}{dz}=0 \quad (1),$$

$$\frac{1}{\rho}\frac{dp}{dy}+By+\frac{dv}{dt}-w\omega_1+u\omega_3+U\frac{dv}{dx}+V\frac{dv}{dy}+W\frac{dv}{dz}=0 \quad (2),$$

$$\frac{1}{\rho}\frac{dp}{dz}+Cz+\frac{dw}{dt}-u\omega_2+v\omega_1+U\frac{dw}{dx}+V\frac{dw}{dy}+W\frac{dw}{dz}=0 \quad (3);$$

where

$$A=\tfrac{3}{2}M\int_0^\infty\frac{d\lambda}{(a^2+\lambda)P},$$

$$B=\tfrac{3}{2}M\int_0^\infty\frac{d\lambda}{(b^2+\lambda)P},$$

$$C=\tfrac{3}{2}M\int_0^\infty\frac{d\lambda}{(c^2+\lambda)P},$$

and $P^2=(a^2+\lambda)(b^2+\lambda)(c^2+\lambda).$

With the above values of u, v, w, U, V, W, the hydrodynamical equations are of the form

$$\frac{1}{\rho}\frac{dp}{dx}+Ax+\alpha x+hy+gz=0,$$

$$\frac{1}{\rho}\frac{dp}{dy}+By+hx+\beta y+fz=0,$$

$$\frac{1}{\rho}\frac{dp}{dx}+Cz+gx+fy+\gamma z=0.$$

The component accelerations in space of the liquid particle at xyz parallel to the axes are therefore

$$\alpha x+hy+gz,\ hx+\beta y+fz,\ gx+fy+\gamma z;$$

and by the dynamical equations the rates of change of angular momentum about the coordinate axes are zero, and therefore

$$\Sigma m\left\{(gx+fy+\gamma z)y-(hx+\beta y+fz)z\right\}=0;$$

or $f\Sigma m(y^2-z^2)=0,$

or $f(b^2-c^2)=0;$

and therefore $f=0;$

and similarly g and h vanish.

Therefore the hydrodynamical equations become

$$\frac{1}{\rho}\frac{dp}{dx}+(A+\alpha)x=0,$$

$$\frac{1}{\rho}\frac{dp}{dy}+(B+\beta)y=0,$$

$$\frac{1}{\rho}\frac{dp}{dz}+(C+\gamma)z=0;$$

where

$$\alpha=\frac{4c^2(c^2-a^2)}{(c^2+a^2)^2}\Omega_2^2-\left(\frac{c^2-a^2}{c^2+a^2}\Omega_2-\eta\right)^2$$
$$-\frac{4b^2(a^2-b^2)}{(a^2+b^2)^2}\Omega_3^2-\left(\frac{a^2-b^2}{a^2+b^2}\Omega_3+\zeta\right)^2,$$

$$\beta=\frac{4a^2(a^2-b^2)}{(a^2+b^2)^2}\Omega_3^2-\left(\frac{a^2-b^2}{a^2+b^2}\Omega_3-\zeta\right)^2$$
$$-\frac{4c^2(b^2-c^2)}{(b^2+c^2)^2}\Omega_1^2-\left(\frac{b^2-c^2}{b^2+c^2}\Omega_1+\xi\right)^2,$$

$$\gamma=\frac{4b^2(b^2-c^2)}{(b^2+c^2)^2}\Omega_1^2-\left(\frac{b^2-c^2}{b^2+c^2}\Omega_1-\xi\right)^2$$
$$-\frac{4a^2(c^2-a^2)}{(c^2+a^2)^2}\Omega_2^2-\left(\frac{c^2-a^2}{c^2+a^2}\Omega_2+\eta\right)^2.$$

Therefore, integrating,

$$\frac{p}{\rho}+\tfrac{1}{2}\left\{(A+\alpha)x^2+(B+\beta)y^2+(C+\gamma)z^2\right\}=\text{constant};$$

and therefore the surfaces of equal pressure are the similar and co-axial quadrics

$$(A+\alpha)x^2+(B+\beta)y^2+(C+\gamma)z^2=\text{constant}.$$

If we can make α, β, γ constant, and $(A+\alpha)a^2=(B+\beta)b^2=C+\gamma)c^2$, the surfaces of equal pressure are similar to the external case, which can therefore be removed without affecting the motion.

This is the case when the axis of revolution is a principal axis; and, supposing it the axis of z, then

$$\Omega_1=0,\ \Omega_2=0,\ \xi=0,\ \eta=0.$$

If in addition we put $\Omega_3=0$, or $\omega_3=\zeta$, we obtain the solution of the particular case considered by Jacobi, of a liquid ellipsoid of three unequal axes, rotating about its least axis in relative equilibrium; or, putting $a=b$, we obtain Maclaurin's solution of the equilibrium of a rotating spheroid (*Cam. Phil. Soc. Proc.*, iii.).

Equation (11) is called Bernoulli's equation, and for homogeneous liquids under gravity is a very useful principle in hydraulics; the equation may be established from first principles by considering the energy which enters and leaves a certain portion of a tube of flow. (Lamb, *Motion of Fluids*, p. 23).

If homogeneous liquid be drawn off from a vessel, so large that the motion of the free surface may be neglected, then Bernoulli's equation becomes, P being the atmospheric pressure and h the height of the free surface,

$$\frac{p}{\rho}+gz+\tfrac{1}{2}q^2=\frac{P}{\rho}+gh;$$

and in particular, for a jet issuing into the atmosphere, where $p=P$,

$$\tfrac{1}{2}q^2=g(h-z);$$

or the velocity is due to the depth below the free surface. This is Torricelli's theorem (*De Motu gravium Projectorum*, 1643).

If we suppose fluid to escape according to this law from a large closed vessel in which the pressure is p where the motion is insensible, and neglect the variations of velocity due to variations of level, p being sufficiently great, then

$$\tfrac{1}{2}q^2=\frac{p-P}{\rho};\ \text{or } q=\sqrt{\left(2\frac{p-P}{\rho}\right)}.$$

If A be the sectional area of the jet (at the *vena contracta*), the quantity of fluid which escapes per unit of time is

$$A\rho q=A\sqrt{\{2\rho(p-P)\}};$$

the momentum per unit of time is

$$A\rho q^2=2A(p-P);$$

and the energy per unit of time is

$$\tfrac{1}{2}A\rho q^3=A(p-P)^{\frac{3}{2}}\sqrt{\frac{2}{\rho}}.$$

Suppose, for instance, two equal pipes leading one from the steam space and the other from the water space of a steam boiler at a pressure p, and suppose Torricelli's theorem to hold for the rate of efflux of the steam and water, then, if σ denote the density of steam, and ρ the density of water,

(1) $\dfrac{\text{The velocity of steam jet}}{\text{The velocity of water jet}}=\sqrt{\dfrac{\rho}{\sigma}}$,

(2) $\dfrac{\text{The quantity of steam jet}}{\text{The quantity of water jet}}=\sqrt{\dfrac{\sigma}{\rho}}$,

(3) $\dfrac{\text{The momentum of steam jet}}{\text{The momentum of water jet}}=1$,

(4) $\dfrac{\text{The energy of steam jet}}{\text{The energy of water jet}}=\sqrt{\dfrac{\rho}{\sigma}}$.

For instance, with steam at 8 atmospheres, or 120 lb to the square inch,

$$\sqrt{\frac{\rho}{\sigma}}=15\text{ nearly}.$$

—(Rankine, *Steam Engine*, appendix).

These principles assumed enable us to give a general explanation of the working of Giffard's injector. For, if the steam jet and water jet be directed at each other, with a small interval between, the superior energy and equal momentum of the steam jet will overcome the water jet, and the steam will flow back into the boiler. But the steam jet, without losing its momentum, is capable of being mixed with water to such an extent as to become a condensed water jet, moving with the velocity of the water jet, and still entering the boiler, a valve preventing the reversal of the motion. Consequently, the amount of water carried into the boiler per unit of time will theoretically be at most the difference between the quantities which would escape by the water and the steam jets, and therefore

$$=A\sqrt{(p-P)}(\sqrt{2\rho}-\sqrt{2\sigma})\ ;$$

and the efficiency of the injector, that is, the ratio of the water pumped in to the quantity of steam used, will be

$$\sqrt{\frac{\rho}{\sigma}}-1,$$

the efficiency of a pump being $\frac{\rho}{\sigma}$.

With C.G.S. units, and a pressure of 8 atmospheres, for instance,

$$p-P=7\times10^6 \text{ very nearly}, \quad \sqrt{\frac{\rho}{\sigma}}=15, \text{ and } \rho=1.$$

Therefore, if the diameter of the nozzles of the injector be d centimetres, the delivery in grammes per second

$$=\tfrac{1}{4}\pi d^2\sqrt{14}\cdot10^3(1-\sqrt{\tfrac{1}{15}})$$
$$=2180d^2\ ;$$

and since 1 gallon is 4541 cubic centimetres, the delivery in gallons per minute

$$=\frac{2180\times60}{4541}d^2$$
$$=28\cdot78d^2 \text{ nearly}.$$

The Lagrangian Form of the Equations.

Here the independent variables which define a particle are the time t, and a, b, c, the initial values of the coordinates x, y, z of a particle of fluid (or else functions of the initial coordinates, but it is best to consider a, b, c as the initial coordinates themselves).

Here x, y, z do not refer to a fixed point in space, but are the variable coordinates of a fluid particle, and are functions of a, b, c, t, the independent variables; and consequently

$$u=\frac{dx}{dt},\quad v=\frac{dy}{dt},\quad w=\frac{dz}{dt}\ ;$$

and the component accelerations of the fluid particle are

$$\frac{du}{dt},\ \frac{dv}{dt},\ \frac{dw}{dt}.$$

Consequently the equations of motion, assuming the existence of the potential V, and putting $P=\int\frac{dp}{\rho}$, and $P+V=Q$, ar

$$\frac{dQ}{dx}+\frac{du}{dt}=0,\quad \frac{dQ}{dy}+\frac{dv}{dt}=0,\quad \frac{dQ}{dz}+\frac{dw}{dt}=0\ ;$$

or multiplying by $\frac{dx}{da}$, $\frac{dy}{da}$, $\frac{dz}{da}$, and adding,

$$\frac{dQ}{da}+\frac{du}{dt}\frac{dx}{da}+\frac{dv}{dt}\frac{dy}{da}+\frac{dw}{dt}\frac{dz}{da}=0 \quad . \quad . \quad . \quad (1);$$

with two similar equations

$$\frac{dQ}{db}+\frac{du}{dt}\frac{dx}{db}+\frac{dv}{dt}\frac{dy}{db}+\frac{dw}{dt}\frac{dz}{db}=0 \quad . \quad . \quad . \quad (2),$$

$$\frac{dQ}{dc}+\frac{du}{dt}\frac{dx}{dc}+\frac{dv}{dt}\frac{dy}{dc}+\frac{dw}{dt}\frac{dz}{dc}=0 \quad . \quad . \quad . \quad (3).$$

Since the elementary parallelepiped whose edges were initially da, db, dc, becomes strained into a parallepiped of volume

$$\frac{d(x,y,z)}{d(a,b,c)}da\,db\,dc$$

therefore the equation of continuity is

$$\rho\frac{d(x,y,z)}{d(a,b,c)}=\rho_0,$$

or, if the fluid be a homogeneous liquid,

$$\frac{d(x,y,z)}{d(a,b,c)}=1.$$

When a, b, c are not the coordinates of a point actually occupied by the fluid particle, this equation of continuity must be replaced by

$$\frac{d}{dt}\left\{\rho\frac{d(x,y,z)}{d(a,b,c)}\right\}=0.$$

Cauchy's Integrals of Lagrange's Equations.

Eliminating Q by differentiation between (2) and (3)

$$\frac{d^2u}{dtdb}\frac{dx}{dc}-\frac{d^2u}{dtdc}\frac{dx}{db}+\frac{d^2v}{dtdb}\frac{dy}{dc}-\frac{d^2v}{dtdc}\frac{dy}{db}+\frac{d^2w}{dtdb}\frac{dz}{dc}-\frac{d^2w}{dtdc}\frac{dz}{db}=0\ ;$$

and integrating with respect to t,

$$\frac{du}{db}\frac{dx}{dc}-\frac{du}{dc}\frac{dx}{db}+\frac{dv}{db}\frac{dy}{dc}-\frac{dv}{dc}\frac{dy}{db}+\frac{dw}{db}\frac{dz}{dc}-\frac{dw}{dc}\frac{dz}{db}=\frac{dw_0}{db}-\frac{dv_0}{dc},$$

u_0, v_0, w_0 being the initial values of u, v, w, and a, b, c the initial values of x, y, z. Now

$$\frac{du}{da}=\frac{du}{dx}\frac{dx}{da}+\frac{du}{dy}\frac{dy}{da}+\frac{du}{dz}\frac{dz}{da},$$

and therefore

$$\left(\frac{dw}{dy}-\frac{dv}{dz}\right)\frac{d(y,z)}{d(b,c)}+\left(\frac{du}{dz}-\frac{dw}{dx}\right)\frac{d(z,x)}{d(b,c)}+\left(\frac{dv}{dx}-\frac{du}{dy}\right)\frac{d(x,y)}{d(b,c)}=\frac{dw_0}{db}-\frac{dv_0}{dc}\ ;$$

or putting

$$\frac{dw}{dy}-\frac{dv}{dz}=2\xi,\quad \frac{du}{dz}-\frac{dw}{dx}=2\eta,\quad \frac{dv}{dx}-\frac{du}{dy}=2\zeta,$$

$$\xi\frac{d(y,z)}{d(b,c)}+\eta\frac{d(z,x)}{d(b,c)}+\zeta\frac{d(x,y)}{d(b,c)}=\xi_0\ ;$$

with two similar equations

$$\xi\frac{d(y,z)}{d(c,a)}+\eta\frac{d(z,x)}{d(c,a)}+\zeta\frac{d(x,y)}{d(c,a)}=\eta_0,$$

$$\xi\frac{d(y,z)}{d(a,b)}+\eta\frac{d(z,x)}{d(a,b)}+\zeta\frac{d(x,y)}{d(a,b)}=\zeta_0.$$

Therefore

$$J\xi=\xi_0\frac{dx}{da}+\eta_0\frac{dx}{db}+\zeta_0\frac{dx}{dc},$$

$$J\eta=\xi_0\frac{dy}{da}+\eta_0\frac{dy}{db}+\zeta_0\frac{dy}{dc},$$

$$J\zeta=\xi_0\frac{dz}{da}+\eta_0\frac{dz}{db}+\zeta_0\frac{dz}{dc},$$

where

$$J=\frac{d(x,y,z)}{d(a,b,c)}\ ;$$

or, since $J=\frac{\rho_0}{\rho}$, therefore

$$\frac{\xi}{\rho}=\frac{\xi_0}{\rho_0}\frac{dx}{da}+\frac{\eta_0}{\rho_0}\frac{dx}{db}+\frac{\zeta_0}{\rho_0}\frac{dx}{dc} \quad . \quad . \quad . \quad . \quad . \quad (4),$$

$$\frac{\eta}{\rho}=\frac{\xi_0}{\rho_0}\frac{dy}{da}+\frac{\eta_0}{\rho_0}\frac{dy}{db}+\frac{\zeta_0}{\rho_0}\frac{dy}{dc} \quad . \quad . \quad . \quad . \quad . \quad (5),$$

$$\frac{\zeta}{\rho}=\frac{\xi_0}{\rho_0}\frac{dz}{da}+\frac{\eta_0}{\rho_0}\frac{dz}{db}+\frac{\zeta_0}{\rho_0}\frac{dz}{dc} \quad . \quad . \quad . \quad . \quad . \quad (6).$$

Consequently if ξ,η,ζ are ever zero they are always zero, and then

$$u=\frac{d\phi}{dx},\quad v=\frac{d\phi}{dy},\quad w=\frac{d\phi}{dz},$$

and a velocity function ϕ exists.

For instance, if motion be generated from rest in a non-viscous fluid under forces due to a potential, a velocity function always exists, and the discovery of this velocity function for different cases is one of the chief problems to be solved in hydrodynamics.

A good example of the use of the Lagrangian equations of motion is given by the state of wave motion in deep water invented by Rankine; he puts

$$x=\alpha+ce^{-\frac{\beta}{c}}\sin\left(\omega t+\frac{\alpha}{c}\right),$$

$$y=\beta+ce^{-\frac{\beta}{c}}\cos\left(\omega t+\frac{\alpha}{c}\right)\ ;$$

and therefore the coordinates of a particle are given in terms of t and α and β.

But α and β are not the initial coordinates of a particle; for putting $t=0$, then the coordinates are

$$a=\alpha+ce^{-\frac{\beta}{c}}\sin\frac{\alpha}{c},$$

$$b=\beta+ce^{-\frac{\beta}{c}}\cos\frac{\alpha}{c}.$$

Therefore

$$\frac{d(x,y)}{d(\alpha,\beta)}=1-e^{-2\frac{\beta}{c}},$$

and

$$\frac{d(a,b)}{d(\alpha,\beta)}=1-e^{-2\frac{\beta}{c}}\ ;$$

therefore

$$\frac{d(x,y)}{d(a,b)}=1\ ;$$

and the equation of continuity is satisfied.

Cauchy's integrals reduce to the single equation

$$\zeta\frac{d(x,y)}{d(a,b)}=\zeta_0,$$

or

$$\zeta=\zeta_0,$$

where

$$2\zeta_0=\frac{dv_0}{da}-\frac{du_0}{db},$$

and therefore

$$2\zeta_0\frac{d(a,b)}{d(\alpha,\beta)}=\frac{d(v_0,b)}{d(\alpha,\beta)}-\frac{d(u_0,a)}{d(\beta,\alpha)}.$$

Now

$$u=\frac{dx}{dt}=c\omega e^{-\frac{\beta}{c}}\cos\left(\omega t+\frac{\alpha}{c}\right),$$

$$\frac{dy}{dt}=-c\omega e^{-\frac{\beta}{c}}\sin\left(\omega t+\frac{\alpha}{c}\right);$$

therefore

$$u_0=c\omega e^{-\frac{\beta}{c}}\cos\frac{\alpha}{c},\quad v_0=-c\omega e^{-\frac{\beta}{c}}\sin\frac{\alpha}{c};$$

and

$$2\zeta_0\frac{d(a,b)}{d(\alpha,\beta)}=2\omega e^{-\frac{\beta}{c}};$$

therefore

$$\zeta=\zeta_0=\frac{e^{-\frac{\beta}{c}}}{1-e^{-2\frac{\beta}{c}}}\omega=\frac{\omega}{2\sinh\frac{\beta}{c}}:$$

and the motion cannot therefore have been generated from rest by natural forces; the fluid must have been created with the proper amount of spin at every point.

We have

$$\frac{du}{dt}=-c\omega^2e^{-\frac{\beta}{c}}\sin\left(\omega t+\frac{\alpha}{c}\right),$$

$$\frac{dv}{dt}=-c\omega^2e^{-\frac{\beta}{c}}\cos\left(\omega t+\frac{\alpha}{c}\right);$$

and therefore the dynamical equations (1) and (2) become

$$\frac{dQ}{d\alpha}-c\omega^2e^{-\frac{\beta}{c}}\sin\left(\omega t+\frac{\alpha}{c}\right)=0,$$

$$\frac{dQ}{d\beta}-c\omega^2e^{-\frac{\beta}{c}}\cos\left(\omega t+\frac{\alpha}{c}\right)+c\omega^2e^{-2\frac{\beta}{c}}=0;$$

and therefore the integral of these two equations is

$$Q+c^2\omega^2e^{-\frac{\beta}{c}}\cos\left(\omega t+\frac{\alpha}{c}\right)-\tfrac{1}{2}c^2\omega^2e^{-2\frac{\beta}{c}}=H,\ \text{a constant.}$$

Now

$$Q=\int\frac{dp}{\rho}+V,\ =\frac{p}{\rho}-gy,$$

$$=\frac{p}{\rho}-g\beta-gce^{-\frac{\beta}{c}}\cos\left(\omega t+\frac{\alpha}{c}\right);$$

and therefore

$$\frac{p}{\rho}-g\beta+c(c\omega^2-g)e^{-\frac{\beta}{c}}\cos\left(\omega t+\frac{\alpha}{c}\right)-\tfrac{1}{2}c^2\omega^2e^{-2\frac{\beta}{c}}=H.$$

A free surface is possible if

$$c\omega^2=g,$$

and then

$$\frac{p}{\rho}=g\beta+\tfrac{1}{2}c^2\omega^2e^{-2\frac{\beta}{c}}+H,$$

and the pressure at a particle is constant.

The wave length $\lambda=2\pi c$; and the velocity of propagation

$$c\omega=\sqrt{gc}=\sqrt{\frac{g\lambda}{2\pi}}.$$

The surfaces of equal pressure are trochoids, obtained by rolling a circle of radius c on the under side of a line at a depth $\beta-c$, the distance of the carried point from the centre being $ce^{-\frac{\beta}{c}}$.

Irrotational Motion.

If liquid originally at rest be contained in a singly-connected space, then forces due to a singly-valued function V are not capable of setting up any motion in the liquid, and any motion must be due to the motion of the bounding surface.

For, ϕ denoting the velocity function, by Green's theorem the kinetic energy

$$T=\tfrac{1}{2}\rho\iiint\left\{\left(\frac{d\phi}{dx}\right)^2+\left(\frac{d\phi}{dy}\right)^2+\left(\frac{d\phi}{dz}\right)^2\right\}dxdydz$$

$$=\tfrac{1}{2}\rho\iint\phi\frac{d\phi}{dn}dS;$$

and therefore, if $\frac{d\phi}{dn}=0$, then $T=0$, and therefore

$$\left(\frac{d\phi}{dx}\right)^2+\left(\frac{d\phi}{dy}\right)^2+\left(\frac{d\phi}{dz}\right)^2=0,$$

or

$$\frac{d\phi}{dx}=0,\ \frac{d\phi}{dy}=0,\ \frac{d\phi}{dz}=0.$$

If we suppose the actual motion at any instant to have been instantaneously generated from rest by the application of proper impulses at the bounding surface, then, since no natural forces can act impulsively throughout the liquid, the equations of impulse are

$$\frac{1}{\rho}\frac{d\varpi}{dx}=-u,\ \frac{1}{\rho}\frac{d\varpi}{dy}=-v,\ \frac{1}{\rho}\frac{d\varpi}{dz}=-w,$$

ϖ denoting the impulsive pressure at any point of the liquid; and therefore, if ϕ denote the velocity function, we can put

$$\phi=-\frac{\varpi}{\rho}.$$

Since the work done by an impulse is the product of the impulse into half the sum of the initial and final velocities, we see how it is that the kinetic energy of the liquid

$$=-\frac{1}{2}\iint\varpi\frac{d\phi}{dn}dS$$

$$=\frac{1}{2}\rho\iint\phi\frac{d\phi}{dn}dS.$$

Also the kinetic energy acquired thus due to the velocity function ϕ will be less than the kinetic energy of any other motion, wholly or partially rotational, but satisfying the equation of continuity, and the condition at the boundary that the normal velocity of the liquid is the normal velocity of the boundary.

For, if u_1, v_1, w_1 be the velocities at any point of this new motion, and T_1 the whole kinetic energy,

$$T_1-T=\tfrac{1}{2}\rho\iiint(u_1^2-u^2+v_1^2-v^2+w_1^2-w^2)dxdydz$$

$$=\tfrac{1}{2}\rho\iiint\left\{(u_1-u)^2+(v_1-v)^2+(w_1-w)^2\right\}dxdydz$$

$$+\rho\iiint\left\{u(u_1-u)+v(v_1-v)+w(w_1-w)\right\}dxdydz.$$

But

$$\iiint\left\{u(u_1-u)+v(v_1-v)+w(w_1-w)\right\}dxdydz$$

$$=\iiint\left\{\frac{d\phi}{dx}(u_1-u)+\frac{d\phi}{dy}(v_1-v)+\frac{d\phi}{dz}(w_1-w)\right\}dxdydz$$

$$=\iint\phi\left\{l(u_1-u)+m(v_1-v)+n(w_1-w)\right\}dS$$

$$-\iiint\phi\left\{\frac{d}{dx}(u_1-u)+\frac{d}{dy}(v_1-v)+\frac{d}{dz}(w_1-w)\right\}dxdydz$$

$$=0.$$

Then

$$T_1-T=\tfrac{1}{2}\rho\iiint\left\{(u_1-u)^2+(v_1-v)^2+(w_1-w)^2\right\}dxdydz,$$

a positive quantity; and therefore T_1 is always greater than T, a theorem due to Sir W. Thomson. If, however, ϕ be multiply-valued, and the space occupied by the liquid multiply-connected, we can have circulation existing in the different circuits of the space even when the bounding surface is at rest, and the motion may still be differentially irrotational, and any motion of the bounding surface will not affect these circulations. For instance, we may have $\phi=\frac{m}{2\pi}\tan^{-1}\frac{y}{x}$, and the liquid circulating in any ring-shaped surface, whose axis of figure is the axis of z.

To find the kinetic energy of a liquid in a multiply-connected space, the motion being differentially irrotational, but circulations existing in the circuits, the space occupied by the liquid must be rendered acyclic by barriers, which may be supposed to be membranes, moving with the velocity of the liquid; and then, if k be the cyclic constant of the value of ϕ in any circuit, we must suppose the value of ϕ on one side of the membrane to exceed the value of ϕ on the other side by k, so that the integral $\iint\phi\frac{d\phi}{dn}dS$ over the membrane must be replaced by $k\iint\frac{d\phi}{dn}dS$; so that to the term $\frac{1}{2}\rho\iint\phi\frac{d\phi}{dn}$ over the outside surface must be added a number of terms of the form $\frac{1}{2}\rho k\iint\frac{d\phi}{dn}dS$, to express the energy due to the circulation in the circuits; and the condition of continuity shows that $\iint\frac{d\phi}{dn}dS$ over one of these membranes which render a circuit acyclic is independent of the form of the membrane.

On Flow, Circulation, and Vortex Motion.

The line integral of the tangential velocity $\int\left(u\frac{dx}{ds}+v\frac{dy}{ds}+w\frac{dz}{ds}\right)ds$ or $\int(udx+vdy+wdz)$, from one point to another of a curve, is called the *flow* along the curve from the initial to the final point; and, if the curve be closed, the line integral round the curve is called the *circulation* in the curve.

If a velocity function ϕ exist, then the flow $=\int d\phi=\phi_2-\phi_1$, where ϕ_1 and ϕ_2 are the initial and final values of ϕ; and therefore the flow is independent of the curve for all mutually reconcilable curves; and the circulation in any closed curve, capable of being reduced to a point without leaving space for which ϕ is single-valued, is zero.

If through every point of a small closed curve the vortex lines be drawn, a tube is obtained and the fluid contained is called a *vortex filament*.

By analogy with the spin of a rigid body the component spin of the fluid in any plane at any point is defined as the circulation round any infinitesimal area in the plane enclosing the point divided by twice the area. For in a rigid body, rotating about the axis of x with angular velocity ξ suppose, the circulation round a curve in the plane of yz is

$$\int\omega\left(x\frac{dy}{ds}-y\frac{dx}{ds}\right)ds$$

$=\omega$ times twice the area of the curve.

Now if, in the fluid at the point xyz, we take the circulation round the elementary area $dydz$, it is equal to

$$vdy+\left(w+\frac{dw}{dy}dy\right)dz-\left(v+\frac{dv}{dz}\right)dz-wdz$$
$$=\left(\frac{dw}{dy}-\frac{dv}{dz}\right)dydz,$$

and therefore the component spin in the plane yz is $\frac{1}{2}\left(\frac{dw}{dy}-\frac{dv}{dz}\right)$, which we have denoted by ξ. Similarly the component spins in the planes of zx and xy are $\frac{1}{2}\left(\frac{du}{dz}-\frac{dw}{dx}\right)=\eta$ and $\frac{1}{2}\left(\frac{dv}{dx}-\frac{du}{dy}\right)=\zeta$ respectively.

Since the circulation round any triangular area is the sum of the circulations round the projections of the area on the coordinate planes, the composition of the component spins ξ, η, ζ is according to the vector law. Hence in any infinitesimal part of the fluid the circulation is zero round every small plane curve passing through a certain line, the resultant axis of spin of ξ, η, ζ at that point of the fluid. Consequently the circulation round any closed curve drawn on the surface of a vortex filament is zero; and therefore, if at any two points of a vortex filament we draw the cross sections ABC, A′B′C′, joined by the line AA′, then, since the flow in AA′ in the complete circuit ABCAA′B′C′A′A is taken in opposite directions, the resultant flow in AA′ vanishes, and therefore the circulations in ABC, A′B′C′, estimated in the same direction, are equal. This is expressed by saying that, at all points of a vortex filament, $\omega\alpha$ is constant, where α is the sectional area of the filament, and ω the spin (Clifford, *Kinematic*, Book iii.).

So far the theorems about vortex motion are kinematical; but, introducing Euler's equation of motion

$$\frac{\mathrm{D}u}{dt}+\frac{d\mathrm{Q}}{dx}=0,\ \frac{\mathrm{D}v}{dt}+\frac{d\mathrm{Q}}{dy}=0,\ \frac{\mathrm{D}w}{dt}+\frac{d\mathrm{Q}}{dz}=0,$$

where
$$\mathrm{Q}=\int\frac{dp}{\rho}+\mathrm{V},$$

then
$$\frac{\mathrm{D}}{dt}(udx+vdy+wdz)$$
$$=u\frac{\mathrm{D}dx}{dt}+v\frac{\mathrm{D}dy}{dt}+w\frac{\mathrm{D}dz}{dt}+\frac{\mathrm{D}u}{dt}dx+\frac{\mathrm{D}v}{dt}dy+\frac{\mathrm{D}w}{dt}dz$$
$$=udu+vdv+wdw-\frac{d\mathrm{Q}}{dx}dx-\frac{d\mathrm{Q}}{dy}dy-\frac{d\mathrm{Q}}{dz}dz$$
$$=\tfrac{1}{2}dq^2-d\mathrm{Q};$$

and therefore, by integration round a closed curve,

$$\frac{\mathrm{D}}{dt}\int(udx+vdy+wdz)=0;$$

and therefore the circulation in any circuit composed of the same fluid particles is constant, and, if the motion is differentially irrotational, is zero round all reconcilable paths.

The circulation round any small plane curve passing through the axis of spin at any point being always zero, it follows conversely that a vortex filament is always composed of the same fluid particles; and, since the circulation round any cross section is constant for different times, it follows from the previous kinematical propositions that $\alpha\omega$ is constant for all the time, and the same at all points of a vortex filament.

Professor Clifford (*Proc. London Mathematical Society*, vol. ix.) has given a simple quaternion proof of the theorem—To determine the velocity at any point of a fluid, when the spin is given.

If σ denote the velocity and ω the spin at any point, then

$$2\omega=\mathrm{V}\nabla\sigma;$$

also, if k denote the cubical expansion,

$$k=-\mathrm{S}\nabla\sigma.$$

Hence the quaternion q or $-k+2\omega$ is simply $\nabla\sigma$; consequently the problem to be solved is to determine σ from the equation

$$q=\nabla\sigma,$$

q being given.

Operating by ∇,

$$\nabla q=\nabla^2\sigma;$$

therefore σ is the potential of ∇q; and therefore

$$\sigma_a=\tfrac{1}{4\pi}\int\frac{\nabla q_b\,dv_b}{\mathrm{D}_{ab}},$$

where σ_a means the value of σ at the point a, dv_b means an element of volume at the point b, and D_{ab} the distance between the points a, b.

Returning to Euler's equations of motion,

$$\frac{du}{dt}+u\frac{du}{dx}+v\frac{du}{dy}+w\frac{du}{dz}+\frac{d\mathrm{Q}}{dx}=0,$$

. . . .

and eliminating Q,

$$\frac{\mathrm{D}\xi}{dt}-\xi\frac{du}{dx}-\eta\frac{dv}{dx}-\zeta\frac{dw}{dx}+\xi\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}\right)=0;$$

and, since by the equation of continuity

$$\frac{1}{\rho}\frac{\mathrm{D}\rho}{dt}+\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=0,$$

therefore

$$\frac{\mathrm{D}}{dt}\left(\frac{\xi}{\rho}\right)=\frac{\xi}{\rho}\frac{du}{dx}+\frac{\eta}{\rho}\frac{dv}{dx}+\frac{\zeta}{\rho}\frac{dw}{dx};$$

and similarly

$$\frac{\mathrm{D}}{dt}\left(\frac{\eta}{\rho}\right)=\frac{\xi}{\rho}\frac{du}{dy}+\frac{\eta}{\rho}\frac{dv}{dy}+\frac{\zeta}{\rho}\frac{dw}{dy},$$
$$\frac{\mathrm{D}}{dt}\left(\frac{\zeta}{\rho}\right)=\frac{\xi}{\rho}\frac{du}{dz}+\frac{\eta}{\rho}\frac{dv}{dz}+\frac{\zeta}{\rho}\frac{dw}{dz}.$$

These equations, first given by Professor Stokes for homogeneous liquid, were generalized for any fluid by Professor Nanson, *Messenger of Mathematics*, 1873. They may also be obtained immediately by the differentiation of Cauchy's integrals (4), (5), and (6), given above.

Plane Vortex Motion.

When a series of straight vertical vortices (called columnar vortices by Sir W. Thomson) are present in homogeneous liquid, bounded by two horizontal planes, we can determine the motion of any vortex by supposing it due to the remaining vortices.

A single vortex will remain at rest, and cause a velocity at any point perpendicular to the plane through the point and the vortex inversely as the distance from the vortex.

If m denote the strength of the vortex, *i.e.*, the circulation in any circuit enclosing the vortex once, then the velocity at a distance r from the vortex will be $\frac{m}{2\pi r}$, and the current function ψ will be $\frac{m}{2\pi}\log r$, and the velocity function ϕ will be $\frac{m}{2\pi}\theta$, where θ is the angle between any fixed plane and the plane through the vortex and the point.

The surface of equal pressure under gravity will be of the form

$$(x^2+y^2)(z-a)=\frac{m^2}{4\pi^2g},$$

the axis of the vortex being the axis of z.

When there are more than one vortex present, each vortex moving with the velocity due to the other vortices will describe the curve whose equation is

$$\Sigma\frac{m}{2\pi}\log r=\text{constant},$$

where m is the strength of one of the remaining vortices, and r the distance between it and the vortex whose motion is considered; this equation may also be written

$$\Pi r^m=\text{constant}.$$

When the liquid is bounded by a vertical cylindrical surface, the motion of a vortex may be determined as due to a series of vortices considered as images of the original vortex, and so arranged as to make the velocity across the boundary zero at every point of the boundary.

When the boundaries are plane surfaces, the images are the optical images by reflexion of the original vortex, considered as positive or negative, according as formed by an even or odd number of reflexions.

Thus the curve described by a vortex inside the angle bounded by the planes $\theta = \pm\frac{\pi}{2n}$ is the Cotes's spiral

$$r \cos n\theta = C,$$

and inside the space bounded by the planes $x=0$, $x=a$, $y=0$, $y=b$ is

$$\cot^2 \text{am}\left(K\frac{x}{a}, k\right) + \cot^2 \text{am}\left(K'\frac{y}{b}, k'\right) = \text{constant},$$

where

$$\frac{K}{K'} = \frac{a}{b}$$

(*Quarterly Journal of Mathematics*, vol. xv.).

A single vortex of strength m in a circular cylinder of radius a at a distance c from the centre will move with the velocity due to an image of strength $-m$ at a distance $\frac{a^2}{c}$ from the centre, and therefore describe a circle of radius c with velocity

$$\frac{m}{2\pi}\frac{a}{\frac{a^2}{c} - c} = \frac{m}{2\pi}\cdot\frac{c}{a^2 - c^2},$$

and therefore in the periodic time $\frac{4\pi^2}{m}(a^2 - c^2)$.

A single circular vortex in infinite fluid will move with a certain velocity in the direction of its axis ("Vortex Motion," *Trans. R.S.E.*, 1869; "Vortex Motion," Helmholtz, *Crelle*, 1858); and, if another equal circular vortex be projected coaxially after the first, the motion of the first must be compounded with that due to the second. Consequently the first vortex will dilate and move slower till the second vortex passes through it, when it will contract and move faster till it passes through the second, and so on. This can be verified experimentally with smoke rings projected from the same circular hole, or with half vortex rings, formed on the surface of water by drawing a semi-circular blade a short distance through the water.

The motion of a vortex ring projected perpendicularly against a plane boundary will be determined by compounding it with the motion due to an equal and opposite vortex ring, its optical image in the wall. The vortex ring will therefore spread out and move more slowly in the direction of its axis as it approaches the wall; at the same time the molecular rotation, being inversely proportional to the cross section of the vortex, will be seen to increase.

Plane Motion of Liquids.

When the velocity of the fluid is always parallel to a fixed plane, we take this plane as the plane of xy, and then $w=0$, and u and v are functions of x and y, and the stream lines are plane curves.

Considering only the cases where the fluid is incompressible, the equation of continuity becomes

$$\frac{du}{dx} + \frac{dv}{dy} = 0,$$

and therefore a function ψ exists, called the stream function, such that

$$u = -\frac{d\psi}{dy}, \quad v = \frac{d\psi}{dx};$$

and ψ = constant is the equation of a line of flow.

The spin at any point

$$\zeta = \frac{1}{2}\left(\frac{dv}{dx} - \frac{du}{dy}\right)$$

$$= \frac{1}{2}\left(\frac{d^2\psi}{dx^2} + \frac{d^2\psi}{dy^2}\right).$$

If the motion is irrotational, then $\zeta = 0$, and a velocity function ϕ exists such that

$$u = \frac{d\phi}{dx} = -\frac{d\psi}{dy},$$

$$v = \frac{d\phi}{dy} = +\frac{d\psi}{dx};$$

therefore ψ and ϕ are conjugate functions of x and y, and

$$\psi + i\phi = f(x + iy).$$

By assigning particular values to this function, Helmholtz and Kirchhoff have discovered the solution of various problems of discontinuous plane liquid motion, an account of which is given in Lamb's *Motion of Fluids*.

The kinetic energy of the liquid bounded by two planes perpendicular to the axis of z at unit distance is

$$T = \frac{1}{2}\rho\iint\left\{\left(\frac{d\phi}{dx}\right)^2 + \left(\frac{d\phi}{dy}\right)^2\right\}dxdy$$

$$= \frac{1}{2}\rho\iint\left\{\left(\frac{d\psi}{dx}\right)^2 + \left(\frac{d\psi}{dy}\right)^2\right\}dxdy$$

$$= \frac{1}{2}\rho\int\phi\frac{d\phi}{dn}ds = \frac{1}{2}\rho\int\psi\frac{d\psi}{dn}ds,$$

when $\frac{d\phi}{dn}$, $\frac{d\psi}{dn}$ are the rates of change of ϕ and ψ in the direction of the outward drawn normal to the bounding curve at the element ds.

Since $\frac{d\psi}{dn} = \frac{d\phi}{ds}$, $\frac{d\phi}{dn} = -\frac{d\psi}{ds}$,

therefore $T = -\frac{1}{2}\rho\int\phi d\psi = \frac{1}{2}\rho\int\psi d\phi.$

We can interchange ϕ and ψ, and make ϕ the stream function and ψ the velocity function; thus from any given irrotational motion in two dimensions another may be derived by turning the velocity through a right angle without altering its magnitude.

For instance, if the axis of z be a line source of delivery m, then, since the flow across any cylinder of radius r is m, the velocity must be $\frac{m}{2\pi r}$; and therefore

$$\phi = \frac{m}{2\pi}\log r, \text{ and } \psi = \frac{m}{2\pi}\theta;$$

where θ is the angle made by a plane through the axis of z and the point with a fixed plane.

If the values of ϕ and ψ be interchanged, we obtain a vortex round the axis of z, of strength m.

Plane Motion in a Liquid due to the Motion of Rigid Cylinders perpendicular to their Axes.

Suppose a rigid cylindrical surface moving in the direction of the axis of x with velocity V, and other fixed rigid cylindrical surfaces to be present in the liquid, which is supposed for simplicity to be bounded also by two fixed planes perpendicular to the axis of z at unit distance from each other, the generating lines of the cylinders being supposed parallel to the axis of z; then at all points of the boundary of the moving surface

$$-\frac{d\psi}{ds} = \text{normal velocity of fluid}$$

$$= \text{velocity of boundary normal to itself}$$

$$= V\frac{dy}{ds};$$

and therefore $\psi = -Vy + \text{constant}$; and at all points of the fixed surfaces $\frac{d\psi}{ds} = 0$, and therefore ψ = constant.

We must therefore discover a function ψ which satisfies the equation

$$\frac{d^2\psi}{dx^2} + \frac{d^2\psi}{dy^2} = 0,$$

and is equal to a constant round a fixed boundary, and equal to $-Vy + \text{constant}$ round a moving boundary, moving with velocity V in the direction of the axis of x; and ϕ, the conjugate function, can then easily be written down.

Ex. 1. The moving cylinder a circular cylinder of radius a, and the fixed cylinder a circular cylinder of radius b, both having the axis of z as axis. Then

$$\psi = -Va\sin\theta\frac{\frac{b^2}{r} - r}{\frac{b^2}{a} - a}$$

$$= -V\frac{a^2}{b^2 - a^2}\left(\frac{b^2}{r} - r\right)\sin\theta,$$

and therefore

$$\phi = -V\frac{a^2}{b^2 - a^2}\left(\frac{b^2}{r} + r\right)\cos\theta.$$

If ϕ' denote the velocity function of liquid filling the cylinder $r=a$,

$$\phi' = Vr\cos\theta,$$

and therefore, when $r=a$,

$$\frac{\phi}{\phi'} = -\frac{b^2 + a^2}{b^2 - a^2}.$$

In determining the kinetic energy of the liquid intermediate to the cylinders, $\frac{d\phi}{dr} = 0$ when $r=b$; and when $r=a$, $\frac{d\phi}{dr} = \frac{d\phi'}{dr}$; and therefore the kinetic energy of the liquid intermediate to the cylinders is $\frac{b^2 + a^2}{b^2 - a^2}$ of the kinetic energy of the liquid filling the cylinder $r=a$. Consequently, if the cylinder $r=a$ be moved, the inertia to be overcome will be its own inertia, together with the inertia of a mass of a liquid $\frac{b^2+a^2}{b^2-a^2}$ times the volume of the cylinder; this is called the effective inertia of the cylinder.

In particular, if $b=\infty$, the effective inertia is the mass of the cylinder, increased by a mass of liquid of equal volume with the cylinder; and then

$$\psi=-V\frac{a^2}{r}\sin\theta,\quad \phi=-V\frac{a^2}{r}\cos\theta,$$

so that

$$\psi+i\phi=\frac{Va^2}{i(x+iy)}.$$

Ex. 2. The moving cylinder an elliptic cylinder, and the fixed cylinder a confocal elliptic cylinder.

Using elliptic coordinates ξ, η, such that $c\cosh\eta$, $c\sinh\eta$ are the semi-axes of the confocal ellipse, $c\cos\xi$, $c\sin\xi$ of the confocal hyperbola passing through a point, $2c$ being the distance between the foci; then $x=c\cosh\eta\cos\xi$, $y=c\sinh\eta\sin\xi$; and if $\eta=\alpha$ is the equation of the moving ellipse, $\eta=\beta$ of the fixed ellipse, then

$$\psi=-Vc\sinh\alpha\frac{\sinh(\beta-\eta)}{\sinh(\beta-\alpha)}\sin\xi$$

satisfies the conditions that

(i) $$\frac{d^2\psi}{d\xi^2}+\frac{d^2\psi}{d\eta^2}=0,$$

(ii) $\psi=-Vc\sinh\alpha\sin\xi=-Vy$, when $\eta=\alpha$,

(iii) $\psi=0$, when $\eta=\beta$.

Therefore the conjugate function

$$\phi=Vc\sinh\alpha\frac{\cosh(\beta-\eta)}{\sinh(\beta-\alpha)}\cos\xi;$$

so that

$$\psi+i\phi=Vc\frac{\sinh\alpha}{\sinh(\beta-\alpha)}\cos(\xi+i\eta-i\beta).$$

If ϕ' denote the velocity function of the liquid filling the elliptic cylinder $\eta=\alpha$, then

$$\phi'=Vx=Vc\cosh\eta\cos\xi;$$

and round the ellipse $\eta=\alpha$,

$$\frac{\phi}{\phi'}=\frac{\tanh\alpha}{\tanh(\beta-\alpha)};$$

while $\frac{d\phi}{dn}$ is the same for each, and $\frac{d\phi}{dn}$ vanishes when $\eta=\beta$; therefore the kinetic energy of the liquid between $\eta=\alpha$ and $\eta=\beta$ is $\frac{\tanh\alpha}{\tanh(\beta-\alpha)}$ of the kinetic energy of the liquid inside $\eta=\alpha$, which is

$$\tfrac{1}{2}\pi\rho V^2c^2\sinh\alpha\cosh\alpha.$$

Hence the mass of the cylinder $\eta=\alpha$ must be increased by $\frac{\tanh\alpha}{\tanh(\beta-\alpha)}$ times the mass of an equal volume of liquid to give the effective inertia for motion in the direction of the major axis, the space between the cylinder $\eta=\alpha$ and a fixed cylinder $\eta=\beta$ being filled with liquid.

Similarly for motion parallel to the minor axis,

$$\psi=Vc\cosh\alpha\frac{\sinh(\beta-\eta)}{\sinh(\beta-\alpha)}\cos\xi,$$

$$\phi=Vc\cosh\alpha\frac{\cosh(\beta-\eta)}{\sinh(\beta-\alpha)}\sin\xi$$

(*Quarterly Journal of Mathematics*, vol. xvi.).

Ex. 3. When the moving and fixed cylinders are any two circular cylinders, not co-axial, the limiting points are taken as the foci of reference; and, supposing $2c$ the distance between them, and ξ, η the dipolar system of coordinates, we have

$$x=c\frac{\sinh\eta}{\cosh\eta-\cos\xi},\quad y=c\frac{\sin\xi}{\cosh\eta-\cos\xi},$$

and then $$\eta=\frac{1}{2}\log\frac{(x+c)^2+y^2}{(x-c)^2+y^2},$$

$$\xi=\tan^{-1}\frac{y}{x-c}-\tan^{-1}\frac{y}{x+c};$$

so that $\xi=$constant is the equation of a circle passing through the two limiting points, and $\eta=$constant is the equation of an orthogonal circle.

If $\eta=\alpha$ be the moving cylinder, moving in the direction of the axis of x (the line of centres) with velocity V, and if $\eta=\beta$ be the fixed cylinder, we must make

$$\psi=-Vc\frac{\sinh\alpha}{\cosh\alpha-\cos\xi}+\text{constant},$$

when $\eta=\alpha$; $\psi=0$ when $\eta=\beta$; and $\frac{d^2\psi}{d\xi^2}+\frac{d^2\psi}{d\eta^2}=0$ in the intervening space.[1]

[1] For various expressions for ψ, consult the articles by Mr W. M. Hicks in the *Quarterly Journal of Mathematics*, vol. xvi

Now, expanding,

$$\frac{\sinh\alpha}{\cosh\alpha-\cos\xi}=1+2\sum_{n=1}^{n=\infty}e^{-n\alpha}\cos n\xi,$$

and therefore

$$\psi=-2Vc\sum_{n=1}^{n=\infty}e^{-n\alpha}\frac{\sinh n(\eta-\beta)}{\sinh n(\alpha-\beta)}\cos n\xi,$$

and $$\phi=2Vc\sum e^{-n\alpha}\frac{\cosh n(\eta-\beta)}{\sinh n(\alpha-\beta)}\sin n\xi.$$

Similarly for a velocity V of the cylinder $\eta=\alpha$ perpendicular to the line of centres, the cylinder $\eta=\beta$ being fixed,

$$\psi=2Vc\sum e^{-n\alpha}\frac{\sinh n(\eta-\beta)}{\sinh n(\alpha-\beta)}\sin n\xi,$$

$$\phi=2Vc\sum e^{-n\alpha}\frac{\cosh n(\eta-\beta)}{\sinh n(\alpha-\beta)}\cos n\xi.$$

Next, suppose a rigid cylindrical surface to be rotating about the axis of z with angular velocity ω; we must have $-\frac{d\psi}{ds}=$ velocity of boundary normal to itself

$$=-\omega x\frac{dx}{ds}-\omega y\frac{dy}{ds},$$

and therefore $\psi=\frac{1}{2}\omega(x^2+y^2)+$constant, at all points of the moving boundary, and $\psi=$constant, at all points of a fixed cylindrical boundary.

Ex. 4. Take the two elliptic cylinders of Ex. 2, and suppose the cylinder $\eta=\alpha$ to be rotating with angular velocity ω, and the cylinder $\eta=\beta$ to be fixed; since

$$x^2+y^2=\tfrac{1}{2}c^2(\cosh 2\eta+\cos 2\xi),$$

if we put

$$\psi=\tfrac{1}{4}\omega c^2\frac{\sinh 2(\beta-\eta)}{\sinh 2(\beta-\alpha)}\cos 2\xi,$$

then (i) when $\eta=\alpha$, $\psi=\frac{1}{4}\omega c^2\cos 2\xi$
$=\frac{1}{2}\omega(x^2+y^2)+$constant;

(ii) when $\eta=\beta$, $\psi=0$;

(iii) $$\frac{d^2\psi}{d\xi^2}+\frac{d^2\psi}{d\eta^2}=0;$$

and therefore ψ satisfies the required conditions.

Then $$\phi=-\tfrac{1}{4}\omega c^2\frac{\cosh 2(\beta-\eta)}{\sinh 2(\beta-\alpha)}\sin 2\xi,$$

and from the value of the kinetic energy of the intermediate liquid the instantaneous value of the effective moment of inertia can be inferred.

If the cylinder $\eta=\beta$ be also rotating with angular velocity ω, the cylinders will remain confocal, and the values of ψ and ϕ will not change; then

$$\psi=\tfrac{1}{4}\omega c^2\frac{\sinh 2(\eta-\alpha)+\sinh 2(\beta-\eta)}{\sinh 2(\beta-\alpha)}\cos 2\xi$$

$$=\tfrac{1}{4}\omega c^2\frac{\cosh(2\eta-\alpha-\beta)}{\cosh(\beta-\alpha)}\cos 2\xi;$$

and $$\phi=\tfrac{1}{4}\omega c^2\frac{\sinh(2\eta-\alpha-\beta)}{\cosh(\beta-\alpha)}\sin 2\xi.$$

To find the kinetic energy of the liquid, since

$$\int\phi\frac{d\phi}{dn}ds=-\int\phi\frac{d\psi}{ds}ds$$

$$=-\int\phi\frac{d\psi}{d\xi}d\xi=\int\phi\frac{d\phi}{d\eta}d\xi,$$

therefore $$T=\tfrac{1}{2}\rho\int\phi\frac{d\phi}{d\eta}d\xi;$$

and when $\eta=\alpha$, and $\eta=\beta$,

$$\phi\frac{d\phi}{d\eta}=\tfrac{1}{4}\omega^2c^4\tanh(\beta-\alpha)\sin^2 2\xi;$$

therefore $$T=\tfrac{1}{8}\rho\omega^2c^4\tanh(\beta-\alpha)\int_0^{2\pi}\sin^2 2\xi d\xi$$

$$=\tfrac{1}{8}\pi\rho\omega^2c^4\tanh(\beta-\alpha);$$

and, if k denote the effective radius of gyration of the liquid,

$$T=\tfrac{1}{2}\pi\rho\omega^2c^2k^2(\sinh\beta\cosh\beta-\sinh\alpha\cosh\alpha);$$

therefore $$k^2=\tfrac{1}{4}c^2\frac{\tanh(\beta-\alpha)}{\sinh\beta\cosh\beta-\sinh\alpha\cosh\alpha}$$

$$=\tfrac{1}{4}c^4\frac{ab_1-a_1b}{(aa_1-bb_1)(a_1b_1-ab)},$$

where a_1, b_1 are the semi-axes of the ellipse $\eta=\beta$, and a, b of the ellipse $\eta=\alpha$.

Ex. 5. Suppose a sector, bounded by $r=a$ and $\theta=\pm\alpha$, rotating about the axis with angular velocity ω; we must put

$$\psi = \tfrac{1}{2}\omega r^2 \frac{\cos 2\theta}{\cos 2\alpha} + \sum_{n=0}^{n=\infty} A_{2n+1}\left(\frac{r}{a}\right)^{(2n+1)\frac{\pi}{2\alpha}} \cos(2n+1)\frac{\pi\theta}{2\alpha},$$

which satisfies the conditions $\nabla^2\psi = 0$, and $\psi = \frac{1}{2}\omega r^2$ when $\theta = \pm\alpha$; in order that $\psi = \frac{1}{2}\omega r^2$ when $r = a$, we must have

$$\sum_{n=0}^{n=\infty} A_{2n+1} \cos(2n+1)\frac{\pi\theta}{2\alpha} = \tfrac{1}{2}\omega a^2\left(1 - \frac{\cos 2\theta}{\cos 2\alpha}\right),$$

and therefore, by Fourier's theorem,

$$A_{2n+1} = \omega a^2(-1)^{n+1}\left\{\frac{1}{(2n+1)\pi - 4\alpha} - \frac{2}{(2n+1)\pi} + \frac{1}{(2n+1)\pi + 4\alpha}\right\}.$$

When all the cylinders present rotate, as if rigidly connected, about the axis of z with angular velocity ω at any instant, then $\psi = \frac{1}{2}\omega(x^2+y^2)$ + constant round the boundary of every cylinder; and if we put $\chi = \psi - \frac{1}{2}\omega(x^2+y^2)$, then χ is the stream function of the relative motion, relative to the cylinders, and satisfies the conditions $\frac{d^2\chi}{dx^2} + \frac{d^2\chi}{dy^2} = -2\omega$ at every point of the liquid, and χ = constant round the boundaries.

Since χ involves ω as a factor, which is a function of t only, it follows that $\frac{\chi}{\omega}$ = constant is the equation of a *stream line* of the relative motion, and any alteration in ω does not affect the shape of the relative stream lines, the liquid being frictionless, and the motion generated from rest.

Ex. 6. Put

$$\chi = -\omega \frac{\frac{x^2}{a^2} + \frac{y^2}{b^2}}{\frac{1}{a^2} + \frac{1}{b^2}};$$

then

$$\frac{d^2\chi}{dx^2} + \frac{d^2\chi}{dy^2} = -2\omega;$$

and the relative stream lines are similar ellipses.

Then

$$\psi = \chi + \frac{1}{2}\omega(x^2+y^2)$$

$$\frac{1}{2}\omega\frac{a^2-b^2}{a^2+b^2}(x^2-y^2);$$

and therefore

$$\phi = \omega\frac{a^2-b^2}{a^2+b^2}xy,$$

for the motion between two similar elliptic cylinders, rotating with angular velocity ω.

The velocity of any liquid particle is $\frac{a^2-b^2}{a^2+b^2}$ of what it would be if rigidly connected to the cylinders; hence the effective radius of gyration of the liquid is $\frac{a^2-b^2}{a^2+b^2}$ of the radius of gyration of the homogenous rigid body occupying the space.

Ex. 7. Put

$$\chi = -\tfrac{1}{2}\frac{\omega}{a^2+b^2}\{\sqrt{2}(x^2-y^2) + x^2 + y^2 - a^2\}\{\sqrt{2}(x^2-y^2) - x^2 - y^2 + b^2\};$$

then $\nabla^2\chi = -2\omega$, and $\chi = 0$, when

$$\sqrt{2}(x^2-y^2) + x^2 + y^2 - a^2 = 0,$$
$$\sqrt{2}(x^2-y^2) - x^2 - y^2 + b^2 = 0,$$

which may therefore be taken as boundaries of the liquid. This problem is due to Mr Ferrers.

Again put

$$\chi = \tfrac{1}{2}\frac{\omega}{a^2+b^2}\{2x(x-y) - a^2\}\{2y(x+y) - b^2\};$$

then $\nabla^2\chi = -2\omega$, and the hyperbolas

$$2x(x-y) - a^2 = 0,\ 2y(x+y) - b^2 = 0$$

may be taken as boundaries, but these hyperbolas are only the previous ones turned through a quarter of a right angle.

Ex. 8. When the liquid fills a rectangular cylinder bounded by $x = \pm a$, and $y = \pm b$ the conditions

$$\frac{d^2\chi}{dx^2} + \frac{d^2\chi}{dy^2} = -2\omega,$$

and

$$u = -\frac{d\chi}{dy} = 0 \text{ when } x = \pm a,$$

$$v = \frac{d\chi}{dx} = 0 \text{ when } y = \pm b,$$

are satisfied by putting

$$\frac{du}{dy} = -\frac{d^2\chi}{dy^2} = \frac{4\omega}{\pi}\tan^{-1}\frac{k\,\mathrm{cn}\left(K\frac{x}{a}, k\right)}{k'\mathrm{cn}\left(K'\frac{y}{b}, k'\right)}$$

$$\frac{dv}{dx} = \frac{d^2\chi}{dx^2} = -\frac{4\omega}{\pi}\tan^{-1}\frac{k'\mathrm{cn}\left(K'\frac{y}{b}, k'\right)}{k\,\mathrm{cn}\left(K\frac{x}{a}, k\right)},$$

where

$$\frac{K}{K'} = \frac{a}{b}$$

(*Quarterly Journal of Mathematics*, vol. xv.).

In fact, if

$$\psi = \omega\frac{16}{\pi^3}a^2\sum_{i=0}^{i=\infty}(-1)^i\frac{\cosh(2i+1)\frac{\pi y}{2a}\cos(2i+1)\frac{\pi x}{2a}}{(2i+1)^3\cosh(2i+1)\frac{\pi b}{2a}}$$

$$+\omega\frac{16}{\pi^3}b^2\sum_{i=0}^{i=\infty}(-1)^i\frac{\cosh(2i+1)\frac{\pi x}{2b}\cos(2i+1)\frac{\pi y}{2b}}{(2i+1)^3\cosh(2i+1)\frac{\pi a}{2b}},$$

then

(1) $\frac{d^2\psi}{dx^2} + \frac{d^2\psi}{dy^2} = 0$;

(2) $\psi = \frac{1}{2}\omega(b^2 - y^2)$ when $x = \pm a$;

(3) $\psi = \frac{1}{2}\omega(a^2 - x^2)$ when $y = \pm b$;

and therefore ψ satisfies the required conditions, and is therefore the value of ψ required.

Ex. 9. Consider liquid filling the interior of a cylinder, whose cross section is an equilateral triangle of altitude h, and let α, β, γ denote the perpendicular distances of a point in the interior from the sides. If we put

$$\chi = 2\omega\frac{\alpha\beta\gamma}{h},$$

then

$$\frac{d^2\chi}{dx^2} + \frac{d^2\chi}{dy^2} = -2\omega,$$

and χ is the stream function of the relative motion, supposing the cylinder rotating with angular velocity ω.

Therefore the cubic $\alpha\beta\gamma$ = constant is the equation of the path of a liquid particle relative to the cylinder, when it is moved in any manner; and also for the cylinder bounded by $\alpha\beta\gamma = c_1$ and $\alpha\beta\gamma = c_2$.[1]

We have supposed the liquid motion to have been generated from rest by the motion of the moving cylinders, but we might also have supposed the liquid to have been of infinite extent, and streaming past the cylinders as fixed obstacles; in that case, the stream function of the relative motion $\chi = \psi + Vy$, and χ satisfies the relations

$$\frac{d^2\chi}{dx^2} + \frac{d^2\chi}{dy^2} = 0,$$

and χ = constant, the equation of a stream line, and therefore also of a boundary; also at infinity

$$\frac{d\chi}{dx} = 0,\ \frac{d\chi}{dy} = V.$$

For instance, if in liquid, moving with velocity $-V$ parallel to the axis of x, the fixed circular cylinder $r = a$ be introduced, then

$$\chi = -V\frac{a^2}{r}\sin\theta + Vy$$
$$= V\left(r - \frac{a^2}{r}\right)\sin\theta.$$

If the elliptic cylinder $\eta = \alpha$ be introduced, then, since $\beta = \infty$,

$$\chi = Vy - Vc\sinh\alpha\frac{\sinh\eta - \cosh\eta}{\sinh\alpha - \cosh\alpha}\sin\xi$$
$$= Vc\sinh\eta\sin\xi - Vc\sinh\alpha\, e^{-\eta+\alpha}\sin\xi$$
$$= Vce^{\alpha}\sinh(\eta-\alpha)\sin\xi$$
$$= V(a+b)\sinh(\eta-\alpha)\sin\xi.$$

If the axis of z be horizontal, and the liquid supposed of infinite extent, and originally at rest, then a circular cylinder of density σ, projected in any manner perpendicular to its length, will describe a parabola with vertical acceleration $\frac{\sigma-\rho}{\sigma+\rho}g$.

If, however, previously to projection, a vortex exist in the liquid, co-axial with the cylinder and of strength m, then any motion of the cylinder will not affect the circulation of the liquid round the cylinder due to the vortex, and inequalities of pressure round the cylinder will arise from the vortex motion.

Lord Rayleigh has shown (*Messenger of Mathematics*, vol. vii.) that, if no forces act, the cylinder will describe a circle in the same direction as the circulation of the vortex in the periodic time $\frac{\pi}{\omega}\frac{\sigma+\rho}{\rho}$, where the circulation of the vortex is $2\pi a^2\omega$, a being the radius of the cylinder.

If the axis of the cylinder be horizontal, and the influence of the boundaries of the liquid neglected, then the cylinder will describe a trochoid, and for a particular velocity of projection can be made to describe a horizontal straight line (*Messenger of Mathematics*, vol. ix. p. 113).

[1] For the analogy between the motion of a liquid in a cylinder and the torsion of an elastic bar, pointed out by St Venant, consult Thomson and Tait's *Natural Philosophy*, § 704.

On the Motion of a Solid through a Liquid.

If we take an origin O, and axes Ox, Oy, Oz fixed in the body, then, if u, v, w, p, q, r denote the component linear and angular velocities of the body at any instant, the velocity function

$$\phi = u\psi_1 + v\psi_2 + w\psi_3 + p\chi_1 + q\chi_2 + r\chi_3,$$

where the ψ's and χ's are functions of x, y, z, depending only upon the shape of the body.

To determine ψ_1, we may suppose the velocity u only to exist, and thus ψ_1 must satisfy the conditions—

(i) $\nabla^2\psi_1 = 0$;

(ii) $\frac{d\psi_1}{dn} = l$, the cosine of the angle between the normal to the surface and the axis of x, at the surface of the moving body ;

(iii) $\frac{d\psi_1}{dn} = 0$, over a fixed surface.

Similarly for ψ_2 and ψ_3.

To determine χ_1, we may suppose the velocity p only to exist, and and then, l, m, n being the direction-cosines of the normal to the surface, χ_1 satisfies the conditions—

(i) $\nabla^2\chi_1 = 0$;

(ii) $\frac{d\chi_1}{dn} = ny - mz$ at the surface of the moving body ;

(iii) $\frac{d\chi_1}{dn} = 0$ at a fixed surface.

Similarly for χ_2 and χ_3.

For a cavity filled with liquid in the interior of a moving body, since the liquid moves as if solid when the moving body has a motion of translation only, therefore

$$\psi_1 = x \;,\; \psi_2 = y \;,\; \psi_3 = z.$$

The only cases practically solved are those where the bounding surfaces are similar or confocal surfaces of the second degree.

Ex. 1. Consider the space between the ellipsoid $\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$ and a similar and similarly situated ellipsoid rigidly connected with it ; then obviously $\chi_1 = \frac{b^2 - c^2}{b^2 + c^2} yz$, as for plane motion ; and therefore

$$\phi = ux + vy + wz + p\,\frac{b^2 - c^2}{b^2 + c^2}\,yz + q\,\frac{c^2 - a^2}{c^2 + a^2}\,zx + r\,\frac{a^2 - b^2}{a^2 + b^2}\,xy.$$

The liquid filling this space will behave therefore like a body of equal mass, and of principal radii of gyration $\frac{b^2 - c^2}{b^2 + c^2}$, $\frac{c^2 - a^2}{c^2 + a^2}$, $\frac{a^2 - b^2}{a^2 + b^2}$ of the radii of gyration if the liquid were solidified.

Ex. 2. Consider the liquid filling the space between the ellipsoids

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1 \quad . \quad . \quad . \quad . \quad (1)$$

and

$$\frac{x^2}{a_1^2} + \frac{y^2}{b_1^2} + \frac{z^2}{c_1^2} = 1 \,. \quad . \quad . \quad . \quad (2),$$

the ellipsoids being confocal, such that

$$a_1^2 = a^2 + \lambda_1,\; b_1^2 = b^2 + \lambda_1,\; c_1^2 = c^2 + \lambda_1.$$

Put $A = \int_\lambda^\infty \frac{d\lambda}{(a^2 + \lambda)P}$, $B = \int_\lambda^\infty \frac{d\lambda}{(b^2 + \lambda)P}$, $C = \int_\lambda^\infty \frac{d\lambda}{(c^2 + \lambda)P}$

where $P^2 = (a^2 + \lambda)(b^2 + \lambda)(c^2 + \lambda)$,

and
$$\frac{x^2}{a^2 + \lambda} + \frac{y^2}{b^2 + \lambda} + \frac{z^2}{c^2 + \lambda} = 1 \quad . \quad . \quad . \quad . \quad . \quad (3),$$

so that $a^2 + \lambda$, $b^2 + \lambda$, $c^2 + \lambda$ are the squares of the semi-axis of the confocal ellipsoid passing through xyz. Then

$$A + B + C = \frac{2}{P} \;;$$

also, if p be the length of the perpendicular from the centre on the tangent plane to (3),

$$p^2 = (a^2 + \lambda)l^2 + (b^2 + \lambda)m^2 + (c^2 + \lambda)n^2,$$

and therefore
$$\frac{d\lambda}{dp} = 2p = \frac{d\lambda}{dn} \,.$$

Suppose the ellipsoid (1) moving with velocity u, and the ellipsoid (2) fixed, then ψ_1 can be made to satisfy the required conditions by putting

$$\psi_1 = Mx + NAx \,,$$

where M and N are constants.

For
$$\nabla^2\psi_1 = 0,$$

and
$$\begin{aligned} \frac{d\psi_1}{dn} &= M\frac{dx}{dn} + NA\frac{dx}{dn} + N\frac{dA}{dn}x \\ &= Ml + NAl - \frac{2px}{(a^2 + \lambda)P}N \\ &= \left(M + NA - 2\frac{N}{P}\right)l \\ &= \{M - N(B + C)\}\, l \,. \end{aligned}$$

Consequently, when $\lambda = 0$, we must have

$$M - N(B_0 + C_0) = 1,$$

and when $\lambda = \lambda_1$,

$$M - N(B_1 + C_1) = 0 \,,$$

where A_0, B_0, C_0 are the values of A, B, C, when $\lambda = 0$, and A_1, B_1, C_1 when $\lambda = \lambda_1$.

Hence

$$N = -\frac{1}{B_0 + C_0 - B_1 - C_1} \,,$$

$$M = -\frac{B_1 + C_1}{B_0 + C_0 - B_1 - C_1} \;;$$

and
$$\psi = -\frac{A + B_1 + C_1}{B_0 + C_0 - B_1 - C_1}x \,.$$

Similarly

$$\psi_2 = -\frac{A_1 + B + C_1}{C_0 + A_0 - C_1 - A_1}y \,,$$

$$\psi_3 = -\frac{A_1 + B_1 + C}{A_0 + B_0 - A_1 - B_1}z \,.$$

If the inner ellipsoid had been fixed and the outer moved, we should have had

$$\psi_1 = \frac{A + B_0 + C_0}{B_0 + C_0 - B_1 - C_1}x \,,$$

$$\psi_2 = \frac{A_0 + B + C_0}{C_0 + A_0 - C_1 - A_1}y \,,$$

$$\psi_3 = \frac{A_0 + B_0 + C}{A_0 + B_0 - A_1 - B_1}z \,.$$

Next suppose the outer ellipsoid fixed, and the inner to have the angular velocity p ; then χ_1 can be made to satisfy the required conditions by putting

$$\chi_1 = Myz + N(B - C)yz \,,$$

where M and N are constants.

For then $\nabla^2\chi_1 = 0$, and

$$\begin{aligned} \frac{d\chi_1}{dn} &= \{M + N(B - C)\}\left(\frac{dy}{dn}z + y\frac{dz}{dn}\right) + N\left(\frac{dB}{dn} - \frac{dC}{dn}\right)yz \,, \\ &= \{M + N(B - C)\}\left(\frac{py}{b^2 + \lambda}z + y\frac{pz}{c^2 + \lambda}\right) - N\left(\frac{1}{b^2 + \lambda} - \frac{1}{c^2 + \lambda}\right)\frac{2pyz}{P} \\ &= \left[\{M + N(B - C)\}\left(\frac{1}{b^2 + \lambda} + \frac{1}{c^2 + \lambda}\right)\right. \\ &\qquad \left. - N(A + B + C)\left(\frac{1}{b^2 + \lambda} - \frac{1}{c^2 + \lambda}\right)\right]pyz \,, \end{aligned}$$

which when $\lambda = 0$ must

$$= ny - mz = \frac{pz}{c^2}y - \frac{py}{b^2}z = \left(\frac{1}{c^2} - \frac{1}{b^2}\right)pyz \,,$$

and when $\lambda = \lambda_1$ must $= 0$.

Therefore M and N must be determined from the equations

$$\{M + N(B_0 - C_0)\}\left(\frac{1}{b^2} + \frac{1}{c^2}\right) - N(A_0 + B_0 + C_0)\left(\frac{1}{b^2} - \frac{1}{c^2}\right) = \frac{1}{c^2} - \frac{1}{b^2} \,,$$

and

$$\{M + N(B_1 - C_1)\}\left(\frac{1}{b_1^2} + \frac{1}{c_1^2}\right) - N(A_1 + B_1 + C_1)\left(\frac{1}{b_1^2} - \frac{1}{c_1^2}\right) = 0 \,.$$

Similarly χ_2 and χ_3 can be determined, and also χ_1, χ_2, and χ_3 when the inner ellipsoid is fixed and the outer moved with given angular velocities.

When the outer ellipsoid is indefinitely great, then A_1, B_1, C_1 are zero, as also is M. Then

$$N = \frac{\frac{1}{c^2} - \frac{1}{b^2}}{(B_0 - C_0)\left(\frac{1}{b^2} + \frac{1}{c^2}\right) - (A_0 + B_0 + C_0)\left(\frac{1}{b^2} - \frac{1}{c^2}\right)} \,,$$

and
$$\chi_1 = N(B - C)yz.$$

To find the effective inertia of the inner ellipsoid, when the outer ellipsoid is fixed, and first for motion parallel to the axis of x ; when $\lambda = \lambda_1$, $\frac{d\psi_1}{dn} = 0$; but when $\lambda = 0$, $\frac{d\psi_1}{dn} = l$, and the ψ_1 for the liquid in the interspace is $-\frac{A_0 + B_1 + C_1}{B_0 + C_0 - B_1 - C_1}$ of the ψ_1 for the liquid filling the inner ellipsoid ; and hence, since the kinetic energy $= \frac{1}{2}\rho\int\phi\frac{d\phi}{dn}dS$, it follows that the kinetic energy of the liquid in the interspace is $\frac{A_0 + B_1 + C_1}{B_0 + C_0 - B_1 - C_1}$ of the liquid filling the interior ellipsoid for motion parallel to the axis of x, and therefore the effective inertia parallel to the axis of x is

$$\tfrac{4}{3}\pi\rho abc\frac{A_0+B_1+C_1}{B_0+C_0-B_1-C_1};$$

with similar expressions for the effective inertia parallel to the axes of y and z.

If the outer ellipsoid be indefinitely large, then the effective inertia of the liquid parallel to the axis of x (since $A_1=B_1=C_1=0$)

$$=\tfrac{4}{3}\pi\rho abc\frac{A_0}{B_0+C_0},$$

which, in the case of the sphere, is half the effective inertia of the liquid inside the sphere, since in the sphere $A_0=B_0=C_0$.

For a rotation about the axis of x of the inner ellipsoid, it follows in the same way that the effective inertia of the liquid in the interspace is to the effective inertia of the liquid filling the inner ellipsoid in the ratio of the χ's of the two motions, which, supposing the outer ellipsoid indefinitely large,

$$\frac{\left(\frac{1}{c^2}-\frac{1}{b^2}\right)(B_0-C_0)}{\left(\frac{1}{c^2}+\frac{1}{b^2}\right)(B_0-C_0)-(A_0+B_0+C_0)\left(\frac{1}{b^2}-\frac{1}{c^2}\right)}\cdot\frac{b^2+c^2}{b^2-c^2}$$
$$=\frac{(B_0-C_0)(b^2+c^2)}{(B_0-C_0)(b^2+c^2)+(A_0+B_0+C_0)(b^2-c^2)};$$

and therefore the effective moment of inertia of the liquid about the axis of x

$$=\tfrac{4}{15}\pi\rho abc\frac{(B_0-C_0)(b^2-c^2)^2}{(B_0-C_0)(b^2+c^2)+(A_0+B_0+C_0)(b^2-c^2)},$$

with similar expressions for the effective moment of inertia about the other axes.

Ex. 3. In the case of two spheres and the liquid between, the χ's are all zero, and, if the spheres be instantaneously concentric,

$$\psi_1=\frac{a^3}{a^3-a_1^3}\left\{x+\frac{a_1^3x}{2(x^2+y^2+z^2)^{\frac{3}{2}}}\right\}$$
$$=\frac{a^3}{a^3-a_1^3}\left(r+\frac{a_1^3}{2r^2}\right)l,$$

supposing a the radius of the moving, and a_1 that of the fixed sphere.

This is a particular case of the confocal ellipsoids, when $a=b=c$. For then

$$\psi_1=-\frac{A+2A_1}{2(A_0-A_1)}x,$$

and
$$A=\int_\lambda^\infty\frac{d\lambda}{(a^2+\lambda)^{\frac{5}{2}}}=\tfrac{2}{3}\frac{1}{(a^2+\lambda)^{\frac{3}{2}}}=\frac{2}{3r^3}.$$

Therefore

$$\psi_1=-\frac{\frac{1}{r^3}+\frac{2}{a_1^3}}{2\left(\frac{1}{a^3}-\frac{1}{a_1^3}\right)}x=\frac{a^3}{a^3-a_1^3}\left(x+\frac{a_1^3x}{2r^3}\right).$$

When the spheres are not concentric, expressions for the effective inertias have been obtained by the method of images by Mr W. M. Hicks (*Philosophical Transactions*, 1880).

The image of a source at P of strength μ outside a sphere is a source inside the sphere of strength $\frac{a\mu}{OP}$ at a distance $\frac{a^2}{OP}$ from the centre, a being the radius of the sphere, and a line sink reaching from the image to the centre of line strength $-\frac{\mu}{a}$; this combination will be found to produce no flow across the surface of the sphere.

Again for a source P of strength μ inside the sphere, the images will be a source of strength $\frac{a\mu}{OP}$ at the inverse point of P, that is, at a distance $\frac{a^2}{OP}$ from the centre, and a line sink $-\frac{\mu}{a}$ thence to infinity.

In order that there should be no flow across the spherical boundary, another sink of equal strength must exist inside the sphere, and the infinite parts of the line sinks will then cancel.

The determination of the ψ's and χ's is a kinematical problem, as yet solved only for the cases we have mentioned, and the discovery of the solution of fresh problems is at present engaging the attention of mathematicians.

But supposing them determined for the motion of a body through liquid, then T, the kinetic energy of the body and the liquid, will be a quadratic function of u, v, w, p, q, r; so that we may put

$$2T=c_{11}u^2+c_{22}v^2+c_{33}w^2+c_{44}p^2+c_{55}q^2+c_{66}r^2$$
$$+2c_{23}vw+\ .\ .\ .\ .\ +2c_{56}qr+\ .\ .\ .\ .\ +2c_{14}up+\ .\ .\ .\ .$$

in all twenty-one terms; and, in order to determine the c's, we may suppose all the velocities except one or two to vanish, and then we see that

$$c_{11}=M+\rho\iint l\psi_1 dS,\ .\ .\ .\ .$$

where M is the mass of the body,

$$c_{44}=A+\rho\iint\chi_1(ny-mz)dS,\ .\ .\ .\ .$$

where A is the moment of inertia of the body about the axis of x; these are obtained by supposing all to vanish except u or p.

If we suppose all to vanish except v and w, we find

$$\phi=\psi_2v+\psi_3w,$$

and
$$2T=\rho\iint\phi\frac{d\phi}{dn}dS+M(v^2+w^2)$$
$$=c_{22}v^2+c_{33}w^2+\rho vw\iint\left(\psi_2\frac{d\psi_3}{dn}+\psi_3\frac{d\psi_2}{dn}\right)dS,$$

or
$$c_{23}=\tfrac{1}{2}\rho\iint\left(\psi_2\frac{d\psi_3}{dn}+\psi_3\frac{d\psi_2}{dn}\right)dS$$
$$=\rho\iint\psi_2\frac{d\psi_3}{dn}dS=\rho\iint\psi_3\frac{d\psi_2}{dn}dS$$
$$=\rho\iint\psi_2 n dS=\rho\iint\psi_3 m dS.$$

Similarly the other coefficients may be determined (Kirchhoff, *Vorlesungen über Mathematische Physik*, p. 240).

In particular cases of symmetry, the coefficients of the products of u, v, w, p, q, r can be made to vanish by a proper choice of axes; and in the case of the ellipsoid, the only case for which the coefficients have as yet been determined,

$$c_{11}=M+4\pi\rho abc\frac{A_0}{B_0+C_0}$$

. . . .

$$c_{44}=A+\tfrac{4}{15}\pi\rho abc\frac{(B_0-C_0)(b^2-c^2)^2}{(B_0-C_0)(b^2+c^2)+(A_0+B_0+C_0)(b^2-c^2)},$$

. . . .

while c_{12}, . . . vanish, the origin O being at the centre of the ellipsoid, and the axes of the ellipsoid its principal axes.

In the case of a sphere of mean density σ, projected in infinite liquid of density ρ, and subject to gravity, the sphere will describe a parabola, with vertical acceleration $\frac{\sigma-\rho}{\sigma+\frac{1}{2}\rho}g$.

Having expressed T now as a quadratic function of u, v, w, p, q, r, the coefficients being functions of the shape but independent of the position and orientation of the body, the Hamiltonian equations of motion lead to the equations

$$\frac{d}{dt}\left(\frac{dT}{du}\right)-r\frac{dT}{dv}+q\frac{dT}{dw}=X.$$

. . . .

$$\frac{d}{dt}\left(\frac{dT}{dp}\right)-r\frac{dT}{dq}+q\frac{dT}{dr}-w\frac{dT}{dv}+v\frac{dT}{dw}=L.$$

. . . .

For if P denote the resultant linear impulse in the direction, *fixed in space*, whose direction-cosines are l, m, n, then

$$P=l\frac{dT}{du}+m\frac{dT}{dv}+n\frac{dT}{dw};$$

and, differentiating with respect to the time, since

$$\frac{dl}{dt}=mr-nq,\quad\frac{dm}{dt}=np-rl,\quad\frac{dn}{dt}=lq-mp,$$

$$\therefore\quad\frac{dP}{dt}=l\left\{\frac{d}{dt}\left(\frac{dT}{du}\right)-r\frac{dT}{dv}+q\frac{dT}{dw}\right\}$$
$$+m\left\{\frac{d}{dt}\left(\frac{dT}{dv}\right)-p\frac{dT}{dw}+r\frac{dT}{du}\right\}$$
$$+n\left\{\frac{d}{dt}\left(\frac{dT}{dw}\right)-q\frac{dT}{du}+p\frac{dT}{dv}\right\}$$
$$=lX+mY+nZ,$$

for all values of l, m, n.

Again, taking a fixed origin, and supposing G the impulsive couple about a straight line through the origin fixed in space whose direction-cosines are l, m, n;

$$G=l\left(\frac{dT}{dp}+y\frac{dT}{dw}-z\frac{dT}{dv}\right)$$
$$+m\left(\frac{dT}{dq}+z\frac{dT}{du}-x\frac{dT}{dw}\right)$$
$$+n\left(\frac{dT}{dr}+x\frac{dT}{dv}-y\frac{dT}{du}\right),$$

where x, y, z are the coordinates of the centre of the body.

Differentiating with respect to the time, and supposing afterwards that the centre of the body and the fixed origin are coincident, then, since $\frac{dx}{dt}=u$, $\frac{dy}{dt}=v$, $\frac{dz}{dt}=w$, but $x=0$, $y=0$, $z=0$,

$$\begin{aligned}\frac{dG}{dt}&=l\left\{\frac{d}{dt}\left(\frac{dT}{dp}\right)-r\frac{dT}{dq}+q\frac{dT}{dr}-w\frac{dT}{dv}+v\frac{dT}{dw}\right\}\\&+m\left\{\frac{d}{dt}\left(\frac{dT}{dq}\right)-p\frac{dT}{dr}+r\frac{dT}{dp}-u\frac{dT}{dw}+w\frac{T}{du}\right\}\\&+n\left\{\frac{d}{dt}\left(\frac{dT}{dr}\right)-q\frac{dT}{dp}+p\frac{dT}{dq}-v\frac{dT}{du}+u\frac{dT}{dv}\right\}\\&=lL+mM+nN,\end{aligned}$$

for all values of l, m, n.

If no external forces act, then three integrals of the equations of motion are

(1) $T=\text{constant}$;

(2) $\left(\frac{dT}{du}\right)^2+\left(\frac{dT}{dv}\right)^2+\left(\frac{dT}{dw}\right)^2=\text{constant}$;

(3) $\frac{dT}{du}\frac{dT}{dp}+\frac{dT}{dv}\frac{dT}{dq}+\frac{dT}{dw}\frac{dT}{dr}=\text{constant}$;

expressing the fact that the energy is constant, and also the force and couple constituents of the resultant impulse.

For a body like an ellipsoid, using single suffixes,

$$T=\tfrac{1}{2}(c_1u^2+c_2v^2+c_3w^2+c_4p^2+c_5q^2+c_6r^2);$$

and the integration of the equations of motion under no forces leads to hyperelliptic and double θ functions (Weber, *Mathematische Annalen*, vol. xiv.).

The equations of motion become

$$c_1\frac{du}{dt}-c_2vr+c_3wq=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

$$c_2\frac{dv}{dt}-c_3wp+c_1ur=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

$$c_3\frac{dw}{dt}-c_1uq+c_2rp=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3);$$

$$c_4\frac{dp}{dt}-(c_5-c_6)qr-(c_2-c_3)vw=0 \quad . \quad . \quad (4),$$

$$c_5\frac{dq}{dt}-(c_6-c_4)rp-(c_3-c_1)wu=0 \quad . \quad . \quad (5),$$

$$c_6\frac{dr}{dt}-(c_4-c_5)pq-(c_1-c_2)uv=0 \quad . \quad . \quad (6).$$

Multiplying the equations by u, v, w, p, q, r, and adding,

$$c_1u\frac{du}{dt}+c_2v\frac{dv}{dt}+c_3w\frac{dw}{dt}+c_4p\frac{dp}{dt}+c_5q\frac{dq}{dt}+c_6r\frac{dr}{dt}=0,$$

or $\tfrac{1}{2}(c_1u^2+c_2v^2+c_3w^2+c_4p^2+c_5q^2+c_6r^2)=T$, a constant . . (7).

Multiply (1) by c_1u, (2) by c_2v, and (3) by c_3w, and add; then

$$c_1^2u\frac{du}{dt}+c_2^2v\frac{dv}{dt}+c_3^2w\frac{dw}{dt}=0,$$

and $$c_1^2u^2+c_2^2v^2+c_3^2w^2=F^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8),$$

F being a constant, the resultant linear impulse of the motion.

Again, multiplying the equations (1 to 6) by c_4p, c_5q, c_6r, c_1u, c_2v, c_3w, adding and integrating,

$$c_1c_4up+c_2c_5vq+c_3c_6wr=G, \text{ a constant} \quad . \quad . \quad . \quad (9).$$

Equations (4), (5), (6) show that the body is acted upon by component couples about the principal axes $(c_2-c_3)vw$, $(c_3-c_1)wu$, $(c_1-c_2)uv$, the principal moments of inertia being supposed to be c_4, c_5, c_6.

If the body be of revolution, $c_1=c_2$ and $c_4=c_5$, the motion can be expressed by elliptic functions. For equation (6) shows that r is constant, and equation (3) becomes

$$c_3^2\left(\frac{dw}{dt}\right)^2=c_1^2(uq-vp)^2=c_1^2\left\{(u^2+v^2)(p^2+q^2)-(up+vq)^2\right\}$$

$$=\frac{1}{c_4}(F^2-c_3^2w^2)\left\{2T-\frac{F^2}{c_1}-c_6r^2-\frac{c_3}{c_1}(c_1-c_3)w^2\right\}-\frac{(G-c_3c_6wr)^2}{c_4^2} \quad . \quad . (10),$$

a biquadratic function of w, and therefore w is an elliptic function of t, the time.

Put $u=s\cos f$, $v=-s\sin f$; then from (1) and (2)

$$c_1s^2\frac{df}{dt}=c_1(\dot{u}v-u\dot{v})=c_1rs^2-c_3(up+vq)w$$

or $$\frac{df}{dt}=r-\frac{c_3}{c_1}\frac{up+vq}{u^2+v^2}w;$$

a rational function of w; and therefore f is expressed in terms of the time by elliptic integrals of the third kind.

Again, put $p=\sigma\cos g$, $q=-\sigma\sin g$; then from (4) and (5)

$$c_4\sigma^2\frac{dg}{dt}=c_4(\dot{p}q-p\dot{q})=(c_4-c_6)\sigma^2r+(c_1-c_3)(up+vq)w;$$

or $$\frac{dg}{dt}=\left(1-\frac{c_6}{c_4}\right)r+\frac{c_1-c_3}{c_4}\frac{up+vq}{p^2+q^2}w,$$

a rational function of w; and therefore g is expressed in terms of the time by elliptic integrals of the third kind.

In a state of steady motion, w is constant, and $\frac{df}{dt}=\frac{dg}{dt}$; also $up+vq=s\sigma$; and therefore

$$\frac{c_6}{c_4}\frac{r}{w}=\frac{c_3}{c_1}\frac{\sigma}{s}+\frac{c_1-c_3}{c_4}\frac{s}{\sigma};$$

and we must therefore have

$$\frac{r^2}{w^2}>4\frac{c_3}{c_1}(c_1-c_3)\frac{c_4}{c_6^2}$$

for the roots of this quadratic in $s:\sigma$ to be real.

If we employ the Lagrangian coordinates x, y, z, θ, ϕ, ψ, and take OZ in the direction of the resultant linear impulse F, then

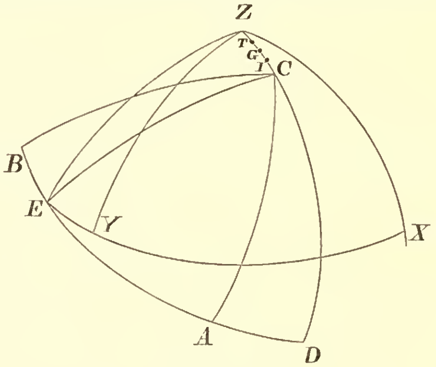


Fig. 10.

(fig. 10) the eye being supposed at O the centre of the sphere,

$c_1u=$ component momentum in direction $OA=-F\sin\theta\cos\phi$,
$c_1v=$,, ,, $OB=F\sin\theta\sin\phi$,
$c_3w=$,, ,, $OC=F\cos\theta$;

and therefore equation (10) gives $\cos\theta$ as an elliptic function of t.

Since

$$p=\sin\phi\dot{\theta}-\sin\theta\cos\phi\dot{\psi},$$
$$q=\cos\phi\dot{\theta}+\sin\theta\sin\phi\dot{\psi},$$

equation (9) becomes

$$c_4\sin^2\theta\dot{\psi}+c_6r\cos\theta=G \quad . \quad . \quad . \quad . \quad . \quad . \quad (11);$$

or $$\frac{d\psi}{dt}=\frac{G-c_6r\cos\theta}{c_4\sin^2\theta}$$

$$=\frac{1}{2}\frac{G-c_6r}{c_4}\frac{1}{1-\cos\theta}+\frac{1}{2}\frac{G+c_6r}{c_4}\frac{1}{1+\cos\theta};$$

and therefore ψ will consist of elliptic integrals of the third kind.

Equations (4), (5), (6) show that the body is acted upon at every instant by a couple whose axis is OE, of magnitude

$$=\frac{c_3}{c_1}(c_1-c_3)w^2\tan\theta,$$

c_4 being supposed to be the equatorial moment of inertia of the body.

If OT be the direction of motion of O, then OT lies in the plane ZOC, and

$$\tan COT=\frac{c_3}{c_1}\tan\theta.$$

We may determine the steady motion from elementary reasoning; for if OG be the axis of the resultant angular momentum (also lying in the plane ZOC) making an angle β with OC, and if μ be the constant value of $\dot{\psi}$, then

$$G\mu\sin(\theta-\beta)=\text{impressed couple}$$
$$=\frac{c_3}{c_1}(c_1-c_3)w^2\tan\theta.$$

But $$G\cos\beta=c_6r,\ G\sin\beta=-c_4p;$$

and $$p=-\mu\sin\theta;$$

therefore $$\tan\beta=\frac{c_4\mu}{c_6r}\sin\theta;$$

and if γ be the angle made by the axis of instantaneous rotation with OC, $\tan\gamma=\frac{\mu}{r}\sin\theta$.

Therefore

$$G\mu \sin(\theta-\beta) = c_6 r\mu \frac{\sin(\theta-\beta)}{\cos\beta}$$
$$= c_6 r\mu(\sin\theta - \cos\theta\tan\beta)$$
$$= c_6 r\mu \sin\theta - c_4\mu^2 \sin\theta\cos\theta$$
$$= \frac{c_3}{c_1}(c_1-c_3)w^2 \tan\theta\,;$$

and, dropping the factor $\sin\theta$,

$$c_4\cos\theta\mu^2 - c_6 r\mu + \frac{c_3}{c_1}(c_1-c_3)\frac{w^2}{\cos\theta} = 0,$$

a quadratic equation in μ, the condition for steady motion.

The least admissible value of r in order that the roots should be real is given by

$$c_6{}^2 r^2 = 4\frac{c_3}{c_1}(c_1-c_3)c_4 w^2,$$

or

$$r^2 = 4\frac{c_3}{c_1}(c_1-c_3)\frac{c_4}{c_6{}^2}w^2.$$

In an oblate solid of revolution c_1-c_3 is negative, and the roots of the quadratic in μ are always real for all values of r. In a prolate solid c_1-c_3 is positive, and a certain spin r is required to keep the motion stable.

An interesting application is to determine the proper amount of rifling of a gun. The following table has been calculated, from the formulæ given below, by Captain J. P. Cundill, R.A., and the results appear to agree very fairly with what is observed in practice.

Table calculated for Stability of Rotation of Projectiles.

Length of projectile in calibres $= \frac{c}{a}$	Value of $\alpha-\gamma$.	Minimum twist at muzzle of gun requisite to give stability of rotation = 1 turn in n calibres.			
		Cast-iron common shell. Cavity = $\frac{8}{27}$ths vol. of shell. Density of iron = 7·207.	Palliser shell. Cavity = $\frac{1}{8}$th vol. of shell. Density = 8·000.	Solid steel bullet. Density = 8·000.	Solid lead and tin bullets of similar composition to M.-H. bullets. Density = 10·9.
		Value of n.	Value of n.	Value of n.	Value of n.
2·0	·49418	63·87	71·08	72·21	84·29
2·1	·52032	59·84	66·59	67·66	78·98
2·2	·54431	56·31	62·67	63·67	74·32
2·3	·56643	53·19	59·19	60·14	70·20
2·4	·58679	50·41	56·10	57·00	66·53
2·5	·60561	47·91	53·32	54·17	63·24
2·6	·62315	45·65	50·81	51·62	60·26
2·7	·63938	43·61	48·53	49·30	57·55
2·8	·65454	41·74	46·45	47·19	55·09
2·9	·66868	40·02	44·54	45·25	52·72
3·0	·68192	38·45	42·79	43·47	50·74
3·1	·69434	36·99	41·16	41·82	48·82
3·2	·70598	35·64	39·66	40·30	47·04
3·3	·71693	34·39	38·27	38·84	45·38
3·4	·72724	33·22	36·97	37·56	43·84
3·5	·73697	32·13	35·75	36·33	42·40
3·6	·74615	31·11	34·62	35·17	41·05
3·7	·75483	30·15	33·55	34·09	39·79
3·8	·76303	29·25	32·55	33·07	38·61
3·9	·77082	28·40	31·61	32·11	37·48
4·0	·77820	27·60	30·72	31·21	36·43

Suppose the rifling at the muzzle makes one turn in n calibres, and $2a$ is the calibre and β the angle of the rifling; then

$$\tan\beta = \frac{\pi}{n} = \frac{ar}{w} = 2\sqrt{\left\{\frac{c_3}{c_1}(c_1-c_3)\frac{c_4}{c_6{}^2}\right\}}.$$

If W = weight of shot, and W′ = weight of air displaced, then

$$c_1 = W + W'\alpha,\ c_3 = W + W'\gamma,$$
$$c_4 = Wk_1{}^2 + W'k_1'{}^2\alpha',\ c_6 = Wk^2,$$

where k_1, k are the radii of gyration of the shot about an equatorial diameter and the axis, and k_1' of the air displaced, supposed rigidified, about an equatorial axis; and then α, γ, α' will be certain quantities depending only upon the external shape of the projectile, supposing the surrounding medium frictionless and incompressible.

When, as in practice, the fraction $\frac{W'}{W}$ is so small that its square may be neglected,

$$\tan^2\beta = \frac{\pi^2}{n^2} = 4\frac{c_3}{c_1}(c_1-c_3)\frac{a^2c_4}{c_6{}^2}$$
$$= 4\frac{W+W'\gamma}{W+W'\alpha}W'(\alpha-\gamma)a^2\frac{Wk_1{}^2+W'k_1'{}^2\alpha'}{W^2k^4}$$
$$= 4\frac{W'}{W}(\alpha-\gamma)\frac{a^2k_1{}^2}{k_4}\frac{1+\frac{W'}{W}\gamma}{1+\frac{W'}{W}\alpha}\left(1+\frac{W'}{W}\frac{k_1'{}^2}{k_1{}^2}\alpha'\right)$$
$$= 4\frac{W'}{W}(\alpha-\gamma)\frac{a^2k_1{}^2}{k^4}$$

+ higher powers of $\frac{W'}{W}$ which are neglected.

The only body for which α, γ, and α' have as yet been determined is the ellipsoid; and in the case of a prolate spheroid of semi-axes a and c,

$$\alpha = \frac{A}{A+C},\ \gamma = \frac{C}{2A},$$
$$\alpha' = \frac{(C-A)(c^2-a^2)^2}{\left\{(C-A)(c^2-a^2)+(2A+C)(c^2+a^2)\right\}(c^2+a^2)}$$

where

$$A = \int_0^\infty \frac{d\lambda}{(a^2+\lambda)^2(c^2+\lambda)^{\frac{1}{2}}}$$
$$= \frac{c}{a^2(c^2-a^2)} - \frac{1}{2(c^2-a^2)^{\frac{3}{2}}}\log_e\frac{c+\sqrt{(c^2-a^2)}}{c-\sqrt{(c^2-a^2)}},$$
$$C = \int_0^\infty \frac{d\lambda}{(a^2+\lambda)(c^2+\lambda)^{\frac{3}{2}}},$$
$$= \frac{1}{(c^2-a^2)^{\frac{3}{2}}}\log_e\frac{c+\sqrt{(c^2-a^2)}}{c-\sqrt{(c^2-a^2)}} - \frac{2}{c(c^2-a^2)};$$

and therefore $2A + C = \frac{2}{a^2c}$.

Wave Motion in Liquids.

First consider plane waves propagated in the direction of the axis of x in liquid of depth h, the undisturbed surface being taken as the plane of xy and the axis of z drawn vertically upwards.

The equation of continuity, supposing a velocity function ϕ to exist, being

$$\frac{d^2\phi}{dx^2} + \frac{d^2\phi}{dz^2} = 0,$$

we must first seek a solution of this equation, involving a periodic term of the form $\sin(mx-nt)$, where $m = \frac{2\pi}{\lambda}$, $n = \frac{2\pi V}{\lambda}$, λ being the wave length and V the velocity of propagation of the waves.

If we put $\phi = f(z)\sin(mx-nt)$, then

$$\frac{d^2f}{dz^2} - m^2f = 0,$$

the solution of which, under the condition that $\frac{d\phi}{dz} = 0$ when $z = -h$, is

$$f(z) = A\cosh m(z+h),$$

and therefore

$$\phi = A\cosh m(z+h)\sin(mx-nt).$$

We must now endeavour to make the free surface a surface of equal pressure, and in order to do this we must suppose A small enough for its square to be neglected; and therefore the square of the velocity is to be neglected too.

The dynamical equation then becomes

$$\frac{p}{\rho} + gz + \frac{d\phi}{dt} = H, \text{ a constant};$$

and at the surface where $z = 0$, $\frac{Dp}{dt} = 0$, and $\frac{dz}{dt}$ may be put $= \frac{d\phi}{dz}$,

therefore $g\frac{d\phi}{dz} + \frac{d^2\phi}{dt^2} = 0$, when $z = 0$.

Therefore

$$Amg\sinh mh - n^2A\cosh mh = 0,$$

or

$$n^2 = mg\tanh mh,$$

or

$$V^2 = \frac{g\lambda}{2\pi}\tanh\frac{2\pi h}{\lambda}.$$

If the depth h be very great compared with the wave length λ, then neglecting the square of $\frac{\lambda}{h}$,

$$V^2 = \frac{g\lambda}{2\pi}.$$

If the depth h be very small compared with the wave length λ, then, neglecting the square of $\frac{h}{\lambda}$,

$$V^2 = gh.$$

Next consider the more general case of wave motion propagated in the direction of the axis of x at the common surface $z=0$ of two liquids, the lower of density ρ and bounded below by the fixed plane $z = -h$, and the upper of density ρ' and bounded by the fixed plane $z = h'$, and suppose U and U′ the mean velocities of currents in the liquids making angles α and α' with the axis of x; suppose in addition there is a surface tension T at the common surface of the liquids.

Denoting the velocity functions by ϕ and ϕ',

$$\phi = \mathrm{U}\cos\alpha\,.\,x + \mathrm{U}\sin\alpha\,.\,y + \mathrm{A}\cosh m(z+h)\cos(mx-nt)$$

$$\phi' = \mathrm{U}'\cos\alpha'\,.\,x + \mathrm{U}'\sin\alpha'\,.\,y + \mathrm{A}'\cosh m(z-h')\cos(mx-nt)\;;$$

then ϕ and ϕ' satisfy the equations of continuity, and the conditions that $\frac{d\phi}{dz}=0$ when $z=-h$, and $\frac{d\phi'}{dz}=0$ when $z=h'$.

Supposing the equation of the moving surface of separation to be $z=b\sin(mx-nt)$, then the direction of motion of each liquid, relative to the moving surface of separation, must be a tangent to the surface, and therefore, when $z=0$,

$$\frac{\frac{d\phi}{dz}}{\frac{d\phi}{dx}-\mathrm{V}} = \frac{\frac{d\phi'}{dz}}{\frac{d\phi'}{dx}-\mathrm{V}} = \frac{dz}{dx}\;;$$

or, neglecting A^2 and A'^2,

$$\frac{\mathrm{A}\sinh mh}{\mathrm{U}\cos\alpha - \mathrm{V}} = \frac{-\mathrm{A}'\sinh mh'}{\mathrm{U}'\cos\alpha' - \mathrm{V}} = b,$$

dividing out by the common factor $m\cos(mx-nt)$, and therefore

$$\phi = \mathrm{U}\cos\alpha\,.\,x + \mathrm{U}\sin\alpha\,.\,y + (\mathrm{U}\cos\alpha - \mathrm{V})b\frac{\cosh m(z+h)}{\sinh mh}\cos(mx-nt),$$

$$\phi' = \mathrm{U}'\cos\alpha'.x + \mathrm{U}'\sin\alpha'.y - (\mathrm{U}'\cos\alpha' - \mathrm{V})b\frac{\cosh m(z-h')}{\sinh mh'}\cos(mx-nt).$$

The dynamical equations are

$$p + g\rho z + \rho\frac{d\phi}{dt} + \tfrac{1}{2}\rho q^2 = \mathrm{H},$$

$$p' + g\rho' z + \rho'\frac{d\phi'}{dt} + \tfrac{1}{2}\rho' q'^2 = \mathrm{H}'\;;$$

and at the surface of separation, where $z=0$, we must have

$$p - p' = -\mathrm{T}\frac{d^2z}{dx^2} = m^2\mathrm{T}b\sin(mx-nt)$$

$$= \mathrm{H} - \mathrm{H}' - g(\rho-\rho')b\sin(mx-nt)$$
$$-\rho(\mathrm{U}\cos\alpha - \mathrm{V})\coth mh\,.\,nb\sin(mx-nt)$$
$$-\rho'(\mathrm{U}'\cos\alpha' - \mathrm{V})\coth mh'\,.\,nb\sin(mx-nt)$$
$$-\tfrac{1}{2}\rho\left\{\mathrm{U}\cos\alpha - (\mathrm{U}\cos\alpha - \mathrm{V})\coth mh\,.\,mb\sin(mx-nt)\right\}^2$$
$$-\tfrac{1}{2}\rho\mathrm{U}^2\sin^2\alpha - \tfrac{1}{2}\rho(\mathrm{U}\cos\alpha - \mathrm{V})^2m^2b^2\cos^2(mx-nt)$$
$$+\tfrac{1}{2}\rho'\left\{\mathrm{U}'\cos\alpha' + (\mathrm{U}'\cos\alpha' - \mathrm{V}')\coth mh'\,.\,mb\sin(mx-nt)\right\}^2$$
$$+\tfrac{1}{2}\rho'\mathrm{U}'^2\sin^2\alpha' + \tfrac{1}{2}\rho'(\mathrm{U}'\cos\alpha' - \mathrm{V})^2m^2b^2\cos^2(mx-nt)\;;$$

and neglecting b^2 and equating to zero the coefficient of $\sin(mx-nt)$,

$$m^2\mathrm{T} + g(\rho-\rho') - (\mathrm{U}\cos\alpha - \mathrm{V})(m\mathrm{U}\cos\alpha - n)\rho\coth mh$$
$$-(\mathrm{U}'\cos\alpha' - \mathrm{V})(m\mathrm{U}'\cos\alpha' - n)\rho'\coth mh' = 0,$$

which, since $\frac{n}{m}=\mathrm{V}$, reduces to

$$m^2\mathrm{T} + g(\rho-\rho') - m(\mathrm{U}\cos\alpha - \mathrm{V})^2\rho\coth mh$$
$$-m(\mathrm{U}'\cos\alpha' - \mathrm{V})^2\rho'\coth mh' = 0,$$

or, since $m=\frac{2\pi}{\lambda}$,

$$\frac{4\pi^2}{\lambda^2}\mathrm{T} = \frac{2\pi}{\lambda}\left\{(\mathrm{U}\cos\alpha - \mathrm{V})^2\rho\coth\frac{2\pi h}{\lambda} + (\mathrm{U}'\cos\alpha' - \mathrm{V})^2\rho'\coth\frac{2\pi h'}{\lambda}\right\}$$
$$-g(\rho-\rho') = 0.$$

If $\mathrm{U}=0$, $\mathrm{U}'=0$, $\rho'=0$, we find

$$\mathrm{V}^2 = \left(\frac{g\lambda}{2\pi} + \frac{2\pi\mathrm{T}}{\lambda\rho}\right)\tanh\frac{2\pi h}{\lambda},$$

as at first, if $\mathrm{T}=0$.

A discussion of the different cases that can arise is given by Lord Rayleigh in his papers on the "Instability of Jets" published in the *Proceedings of the Royal Society* and of the *London Mathematical Society*; also in a paper by Sir W. Thomson in the *Phil. Mag.*, 1871.

In the last-mentioned paper an interesting application of the above equations is made to determine the ripples produced by wind blowing over the surface of still water.

Put $\mathrm{U}=0$, $h=\infty$, $h'=\infty$;

then $m^2\mathrm{T} + g(\rho-\rho') - m\mathrm{V}^2\rho - m(\mathrm{U}'-\mathrm{V})^2\rho' = 0.$

If W be the velocity of propagation of waves of the same length with no wind, then

$$m^2\mathrm{T} + g(\rho-\rho') - m\mathrm{W}^2(\rho+\rho') = 0\;;$$

or

$$\mathrm{W}^2 = \frac{g}{m}\frac{\rho-\rho'}{\rho+\rho'} + \frac{m\mathrm{T}}{\rho+\rho'}\;;$$

the minimum value of which for different values of m is given by

$$\mathrm{W}^2 = 2\sqrt{(g\mathrm{T})}\frac{\sqrt{(\rho-\rho')}}{\rho+\rho'},$$

and then

$$m^2 = \frac{g}{\mathrm{T}}(\rho-\rho')\;.$$

But

$$\mathrm{V}^2\rho + (\mathrm{U}'-\mathrm{V})^2\rho' = \mathrm{W}^2(\rho+\rho)$$

and therefore

$$\mathrm{V} = \frac{\rho'}{\rho+\rho'}\mathrm{U}' \pm \sqrt{\left\{\mathrm{W}^2 - \frac{\rho\rho'}{(\rho+\rho')^2}\mathrm{U}'^2\right\}}\;;$$

giving the velocities of propagation of waves with and against the wind.

The least value of U'^2 is less than $\frac{(\rho+\rho')^2}{\rho\rho'}$ times the least value of W^2, and is therefore

$$2\sqrt{(g\mathrm{T})}\frac{\rho+\rho'}{\rho\rho'}\sqrt{(\rho-\rho')}\;.$$

If the wind be blowing with a velocity greater than this minimum value of U′, the surface of the water as a plane level surface becomes unstable, and ripples are produced.

With C. G. S. units, $g=981$, $\mathrm{T}=81$, $\rho=1$, $\rho'=\cdot0012759$, and then the minimum value of U′ is about 664, equivalent to about 14·8 miles an hour. This velocity is of course much greater than what is required to ruffle the surface of water in reality, the discrepancy being due to the viscosity of the air.

In the case of standing waves in a circular tank, cylindrical coordinates r, θ, z being used, where

$$x = r\cos\theta,\quad y = r\sin\theta,$$

the equation of continuity becomes

$$\frac{d^2\phi}{dr^2} + \frac{1}{r}\frac{d\phi}{dr} + \frac{1}{r^2}\frac{d^2\phi}{d\theta^2} + \frac{d^2\phi}{dz^2} = 0\;.$$

If the liquid be of depth h, we must put

$$\phi = \phi_1\cosh k(z+h)\cos 2\pi nt,$$

where n is the number of oscillations per second, and then

$$\frac{d^2\phi_1}{dr^2} + \frac{1}{r}\frac{d\phi_1}{dr} + \frac{1}{r^2}\frac{d^2\phi_1}{d\theta^2} + k^2\phi_1 = 0\;.$$

If we put $\phi_1 = \psi\cos m\theta$, then

$$\frac{d^2\psi}{dr^2} + \frac{1}{r}\frac{d\psi}{dr} + \left(k^2 - \frac{m^2}{r^2}\right)\psi = 0\;,$$

Bessel's differential equation; and therefore

$$\psi = \mathrm{AJ}_m(kr),$$

and

$$\phi = \mathrm{AJ}_m(kr)\cos m\theta\cosh k(z+h)\cos 2\pi nt\;;$$

and k must be determined from the condition that

$$\frac{d\phi}{dr} = 0,\ \text{when } r=a\;;$$

or

$$\mathrm{J}'_m(ka) = 0\;.$$

At the free surface

$$g\frac{d\phi}{dz} + \frac{d^2\phi}{dt^2} = 0\;,$$

or

$$gk\sinh kh - 4\pi^2n^2\cosh kh = 0,$$

or

$$n^2 = \frac{gk}{4\pi^2}\tanh kh.$$

For circular waves, $m=0$, and the roots of $\mathrm{J}'_0(ka)=0$, are

$$ka = 3{\cdot}832,\ 7{\cdot}016,\ 10{\cdot}173,\ 13{\cdot}323,\ \ldots\ldots$$

(Rayleigh, *Sound*, p. 274).

When the tank is limited by the radial plane $\theta=0$, then the slowest oscillation corresponds to $m=\frac{1}{2}$, and then

$$\mathrm{J}_{\frac{1}{2}}(kr) = \frac{\sin kr}{\sqrt{kr}},$$

and

$$\mathrm{J}'_{\frac{1}{2}}(ka) = \sqrt{\frac{k}{a}}\left(\cos ka - \frac{\sin ka}{ka}\right) = 0\;,$$

gives

$$\tan ka = ka,$$

and therefore

$$\frac{ka}{\pi} = 1{\cdot}4303$$

(Rayleigh, *Sound*, p. 279).

When the tank is bounded by the radial planes $\theta=0$, $\theta=\frac{2}{3}\pi$, the slowest oscillation corresponds to $m=\frac{3}{2}$, and then

$$\mathrm{J}_{\frac{3}{2}}(kr) = \frac{1}{\sqrt{kr}}\left(\frac{\sin kr}{kr} - \cos kr\right),$$

and the equation $\mathrm{J}'(ka)=0$ leads to

$$\tan ka = \frac{3ka}{2k^2a^2-3}\;.$$

For the discussion of the free oscillations of an ocean of uniform depth, covering a central nucleus, under the gravitation of the parts, and the surface tension at this free surface, consult Lamb's *Motion of Fluids*, p. 196, and Lord Rayleigh's papers in the *Proceedings of the London Mathematical Society*.

The propagation of plane waves of longitudinal displacement in air, and the notes produced by open and closed pipes, have been considered under the heading ACOUSTICS.

When the air is limited by special surfaces, the problem of its vibrations is worked out by Lord Rayleigh in the *Proceedings of the London Mathematical Society*, 1872.

A list of references to the memoirs and treatises on the subject will be found at the end of Lamb's *Motion of Fluids*. (A. G. G.)

PART III.—HYDRAULICS.

I. THE DATA OF HYDRAULICS.

[*Units.*—Except where other units are given, the units throughout this article are feet, pounds, pounds per sq. ft., feet per second.]

1. *Properties of Fluids.*—The fluids to which the laws of practical hydraulics relate are substances the parts of which possess very great mobility, or which offer a very small resistance to distortion independently of inertia. Under the general heading Hydromechanics a fluid is defined to be a substance which yields continually to the slightest tangential stress, and hence in a fluid at rest there can be no tangential stress. But, further, in fluids such as water, air, steam, &c., to which the present division of the article relates, the tangential stresses that are called into action between contiguous portions during distortion or change of figure are always small compared with the weight, inertia, pressure, &c., which produce the visible motions it is the object of hydraulics to estimate. On the other hand, while a fluid passes easily from one form to another, it opposes considerable resistance to change of volume.

It is easily deduced from the absence or smallness of the tangential stress that contiguous portions of fluid act on each other with a pressure which is exactly or very nearly normal to the interface which separates them. The stress must be a pressure, not a tension, or the parts would separate. Further, at any point in a fluid the pressure in all directions must be the same; or, in other words, the pressure on any small element of surface is independent of the orientation of the surface.

2. Fluids are divided into liquids, or incompressible fluids, and gases, or compressible fluids. Very great changes of pressure change the volume of liquids only by a small amount, and if the pressure on them is reduced to zero they do not sensibly dilate. In gases or compressible fluids the volume alters sensibly for small changes of pressure, and if the pressure is indefinitely diminished they dilate without limit.

In ordinary Hydraulics, liquids are treated as absolutely incompressible. In dealing with gases the changes of volume which accompany changes of pressure must be taken into account.

3. Viscous fluids are those in which change of form under a continued stress proceeds gradually and increases indefinitely. A very viscous fluid opposes great resistance to change of form in a short time, and yet may be deformed considerably by a small stress acting for a long period. A block of pitch is more easily splintered than indented by a hammer, but under the action of the mere weight of its parts acting for a long enough time it flattens out and flows like a liquid.

All actual fluids are viscous. They oppose a resistance to the relative motion of their parts. This resistance diminishes with the velocity of the relative motion, and becomes zero in a fluid the parts of which are relatively at rest. When the relative motion of different parts of a fluid is small, the viscosity may be neglected without introducing important errors. On the other hand, where there is considerable relative motion, the viscosity may be expected to have an influence too great to be neglected.

Measurement of Viscosity. Coefficient of Viscosity.—Suppose the plane *ab*, fig. 11, of area ω, to move with the velocity V relatively to the surface *cd* and parallel to it. Let the space between be filled with liquid. The layers of liquid in contact with *ab* and *cd* adhere to them. The intermediate layers all offering an equal resistance to shearing or distortion, the rectangle of fluid *abcd* will take the form of the parallelogram *a′b′cd*. Further, the resistance to the motion of *ab* may be expressed in the form

$$R = \kappa\omega V \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

where κ is a coefficient the nature of which remains to be determined.

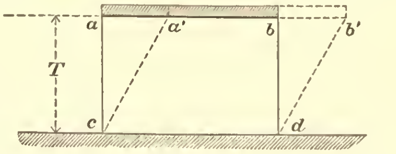


Fig. 11.

If we suppose the liquid between *ab* and *cd* divided into layers as shown in fig. 12, it will be clear that the stress R acts, at each dividing face, forwards in the direction of motion if we consider the upper layer, backwards if we consider the lower layer. Now suppose the original thickness of the layer T increased to nT; if the bounding plane in its new position has the velocity nV, the shearing at each dividing face will be exactly the same as before, and the resistance must therefore be the same. Hence,

$$R = \kappa'\omega\,(nV) \quad . \quad . \quad (2).$$

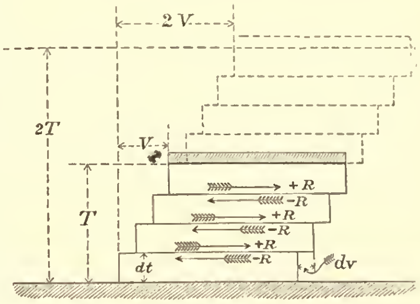


Fig. 12.

But equations (1) and (2) may both be expressed in one equation if κ and κ' are replaced by a constant varying inversely as the thickness of the layer. Putting $\kappa = \frac{\mu}{T}$, $\kappa' = \frac{\mu}{nT}$,

$$R = \mu\omega\frac{V}{T};$$

or, for an indefinitely thin layer,

$$R = \mu\omega\frac{dV}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3),$$

an expression first proposed by Navier. The coefficient μ is termed the coefficient of viscosity.

According to Maxwell, the value of μ for air at $\theta°$ Fahr. in pounds, when the velocities are expressed in feet per second, is

$$\mu = 0{\cdot}000\,000\,025\,6(461° + \theta);$$

that is, the coefficient of viscosity is proportional to the absolute temperature and independent of the pressure.

The value of μ for water at 77° Fahr. is, according to Helmholtz and Piotrowski,

$$\mu = 0{\cdot}000\,001\,91,$$

the units being the same as before. For water μ decreases rapidly with increase of temperature.

4. When a fluid flows in a very regular manner, as for instance when it flows in a capillary tube, the velocities vary gradually at any moment from one point of the fluid to a neighbouring point. The layer adjacent to the sides of the tube adheres to it and is at rest. The layers more interior than this slide on each other. But the resistance developed by these regular movements is very small. If in large pipes and open channels there were a similar regularity of movement, the neighbouring filaments would acquire, especially near the sides, very great relative velocities. Boussinesq has shown that the central filament in a semicircular canal of 1 metre radius, and inclined at a slope of only 0·0001, would have a velocity of 187 metres per second,[1] the layer next the boundary remaining at rest. But before such a difference of velocity can arise, the motion of the fluid becomes much more complicated. Volumes of fluid are detached continually from the boundaries, and, revolving, form eddies traversing the fluid in all directions, and sliding with finite relative velocities against those surrounding them. These slidings develop resistances, incomparably greater than the viscous resistance due to movements varying continuously from point to point. The movements which produce the phenomena commonly ascribed to fluid friction must be regarded as rapidly or even suddenly varying from one point to another. The internal resistances to the motion of the fluid do not depend

[1] *Journal de M. Liouville*, t. xiii., 1868; *Mémoires de l'Académie des Sciences de l'Institut de France*, t. xxiii., xxiv., 1877.

on the general velocities of translation at different points of the fluid (or what M. Boussinesq terms the mean local velocities), but rather on the intensity at each point of the eddying agitation. The problems of hydraulics are therefore much more complicated than problems in which a regular motion of the fluid is assumed, hindered by the viscosity of the fluid.

Relation of Pressure, Density, and Temperature of Liquids.

5. *Density of Water.*—Water at ordinary temperature and pressure contains 62·4 lb per cubic foot, or 1000 kilogrammes per cubic metre. The density or weight per unit of volume will be designated by G. River and spring water is not sensibly denser than pure water, being at most 1-100000th heavier. Sea-water may be taken at 64 lb per cubic foot.

6. *Compressibility of Liquids.*—The most accurate experiments show that liquids are sensibly compressed by very great pressures, and that up to a pressure of 65 atmospheres, or about 1000 lb per square inch, the compression is proportional to the pressure. The chief results of experiment are given in the following table. Let V_1 be the volume of a liquid in cubic feet under a pressure p_1 lb per square foot, and V_2 its volume under a pressure p_2. Then the cubical compression is

$$\frac{V_2 - V_1}{V_1},$$

and the ratio of the increase of pressure $p_2 - p_1$ to the cubical compression is sensibly constant. That is, $\frac{(p_2-p_1)V_1}{V_2-V_1}$ is constant. This constant is termed the elasticity of volume, and is denoted by k (Thomson). With the notation of the differential calculus,

$$k = \frac{dp}{-\frac{dV}{V}} = -V\frac{dp}{dV}.$$

Elasticity of Volume of Liquids.

	Canton.	Oerstedt.	Colladon and Sturm.	Regnault.
Water.......	45,990,000	45,900,000	42,660,000	44,090,000
Sea water...	52,900,000	...	...	...
Mercury....	705,300,000	...	626,100,000	604,500,000
Oil..........	44,090,000	...	...	...
Alcohol.....	32,060,000	...	23,100,000	...

According to the experiments of Grassi, the compressibility of water diminishes as the temperature increases, while that of ether, alcohol, and chloroform is increased.

7. *Change of Volume and Density of Water with Change of Temperature.*—Although the change of volume of water with change of temperature is so small that it may generally be neglected in ordinary hydraulic calculations, yet it should be noted that there is a change of volume which should be allowed for in very exact calculations. The values of ρ in the following short table, which gives data enough for hydraulic purposes, are taken from Professor Everett's *System of Units.*

Density of Water at Different Temperatures.

Temperature. Cent.	Temperature. Fahr.	ρ Density of Water.	G Weight of 1 c. ft. in lb.	Temperature. Cent.	Temperature. Fahr.	ρ Density of Water.	G Weight of 1 c. ft. in lb.
0	32·0	·999884	62·417	20	68·0	·998272	62·316
1	33·8	·999941	62·420	22	71·6	·997839	62·289
2	35·6	·999982	62·423	24	75·2	·997380	62·261
3	37·4	1·000004	62·424	26	78·8	·996879	62·229
4	39·2	1·000013	62·425	28	82·4	·996344	62·196
5	41·0	1·000003	62·424	30	86	·995778	62·161
6	42·8	·999983	62·423	35	95	·99469	62·093
7	44·6	·999946	62·421	40	104	·99236	61·947
8	46·4	·999899	62·418	45	113	·99038	61·823
9	48·2	·999837	62·414	50	122	·98821	61·688
10	50·0	·999760	62·409	55	131	·98583	61·540
11	51·8	·999668	62·403	60	140	·98339	61·387
12	53·6	·999562	62·397	65	149	·98075	61·222
13	55·4	·999443	62·389	70	158	·97795	61·048
14	57·2	·999312	62·381	75	167	·97499	60·863
15	59·0	·999173	62·373	80	176	·97195	60·674
16	60·8	·999015	62·363	85	185	·96880	60·477
17	62·6	·998854	62·353	90	194	·96557	60·275
18	64·4	·998667	62·341	100	212	·95866	59·844
19	66·2	·998473	62·329				

The weight per cubic foot has been calculated from the values of ρ, on the assumption that a cubic foot of water at 39·2° Fahr. is 62·425 lb. For ordinary calculations in hydraulics, the density of water (which will in future be designated by the symbol G) will be taken at 62·4 lb per cubic foot, which is its density at 53° Fahr. It may be noted also that ice at 32° Fahr. contains 57·2 lb per cubic foot. The values of ρ are the densities in grammes per cubic centimetre.

8. *Pressure Column. Free Surface Level.*—Suppose a small vertical pipe introduced into a liquid at any point P (fig. 13). Then the liquid will rise in the pipe to a level OO, such that the pressure due to the column in the pipe exactly balances the pressure on its mouth. If the fluid is in motion the mouth of the pipe must be supposed accurately parallel to the direction of motion, or the impact of the liquid at the mouth of the pipe will have an influence on the height of the column. If this condition is complied with, the height h of the column is a measure of the pressure at the point P. Let ω be the area of section of the pipe, h the height of the pressure column, p the intensity of pressure at P; then

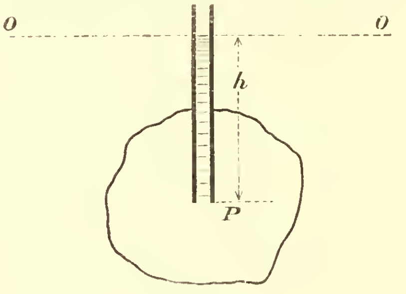


Fig. 13.

$$p\omega = Gh\omega \text{ lb},$$

$$\frac{p}{G} = h;$$

that is, h is the height due to the pressure at p. The level OO will be termed the free surface level corresponding to the pressure at P.

Relation of Pressure, Temperature, and Density of Gases.

9. *Relation of Pressure, Volume, Temperature, and Density in Compressible Fluids.*—Certain problems on the flow of air and steam are so similar to those relating to the flow of water that they are conveniently treated together. It is necessary, therefore, to state as briefly as possible the properties of compressible fluids so far as knowledge of them is requisite in the solution of these problems. Air may be taken as a type of these fluids, and the numerical data here given will relate to air.

Relation of Pressure and Volume at Constant Temperature.—At constant temperature the product of the pressure p and volume V of a given quantity of air is a constant (Boyle's law).

Let p_0 be mean atmospheric pressure (2116·8 lb per square foot), V_0 the volume of 1 lb of air at 32° Fahr. under the pressure p_0. Then

$$p_0 V_0 = 26214 \quad \ldots\ldots \quad (1).$$

If G_0 is the weight per cubic foot of air in the same conditions,

$$G_0 = \frac{1}{V_0} = \frac{2116·8}{26214} = ·08075 \quad \ldots\ldots \quad (2).$$

For any other pressure p, at which the volume of 1 lb is V and the weight per cubic foot is G, the temperature being 32° Fahr.,

$$pV = \frac{p}{G} = 26214; \quad \text{or } G = \frac{p}{26214} \quad \ldots\ldots \quad (3).$$

Change of Pressure or Volume by Change of Temperature.—Let p_0, V_0, G_0, as before be the pressure, the volume of a pound in cubic feet, and the weight of a cubic foot in pounds, at 32° Fahr. Let p, V, G be the same quantities at a temperature t (measured strictly by the air thermometer, the degrees of which differ a little from those of a mercurial thermometer). Then, by experiment,

$$pV = p_0 V_0 \frac{460·6 + t}{460·6 + 32} = p_0 V_0 \frac{\tau}{\tau_0} \quad \ldots\ldots \quad (4),$$

where τ, τ_0 are the temperatures t and 32° reckoned from the absolute zero, which is −460·6° Fahr.;

$$\frac{p}{G} = \frac{p_0}{G_0} \cdot \frac{\tau}{\tau_0} \quad \ldots\ldots \quad (4a);$$

$$G = \frac{p}{p_0} \cdot \frac{\tau_0 G_0}{\tau} \quad \ldots\ldots \quad (5).$$

If $p_0 = 2116·8$, $G_0 = ·08075$, $\tau_0 = 460·6 + 32 = 492·6$, then

$$\frac{p}{G} = 53·2\tau \quad \ldots\ldots \quad (5a).$$

II. KINEMATICS OF FLUIDS.

10. Moving fluids as commonly observed are conveniently classified thus:—

(1) *Streams* are moving masses of indefinite length, completely or incompletely bounded laterally by solid boundaries. When the solid boundaries are complete, the flow is said to take place in a pipe. When the solid boundary is incomplete and leaves the upper surface of the fluid free, it is termed a stream bed or channel or canal.

(2) A stream bounded laterally by differently moving fluid of the same kind is termed a *current*.

(3) A *jet* is a stream bounded by fluid of a different kind.

(4) An *eddy*, *vortex*, or *whirlpool* is a mass of fluid the particles of which are moving circularly or spirally.

(5) In a stream we may often regard the particles as flowing along definite paths in space. A chain of particles following each other along such a constant path may be termed a fluid filament or elementary stream.

11. *Steady and Unsteady, Uniform and Varying, Motion.*—There are two quite distinct ways of treating hydrodynamical questions. We may either fix attention on a given mass of fluid and consider its changes of position and energy under the action of the stresses to which it is subjected, or we may have regard to a given fixed portion of space and consider the volume and energy of the fluid entering and leaving that space.

If, in following a given path *ab* (fig. 14), a mass of water *a* has a constant velocity, the motion is said to be uniform. The kinetic energy of the mass *a* remains unchanged. If the velocity varies from point to point of the path, the motion is called varying motion. If at a given point *a* in space, the particles of water always arrive with the same velocity and in the same direction, during any given time, then the motion is termed steady motion. On the contrary, if at the point *a* the velocity or direction varies from moment to moment the motion is termed unsteady. Steady motion is sometimes termed permanent motion. A river which excavates its own bed is in unsteady motion so long as the slope and form of the bed is changing. It, however, tends always towards a condition in which the bed ceases to change, and it is then said to have reached a condition of permanent regime. No river probably is in absolutely permanent regime, except perhaps in rocky channels. In other cases the bed is scoured more or less during the rise of a flood, and silted again during the subsidence of the flood. But while many streams of a torrential character change the condition of their bed often and to a large extent, in others the changes are comparatively small and not easily observed.

Fig. 14.

As a stream approaches a condition which would be strictly defined as one of steady motion, its regime becomes permanent. Hence steady motion and permanent regime are sometimes used as meaning the same thing. The one, however, is a definite term applicable to the motion of the water, the other a less definite term applicable in strictness only to the condition of the stream bed.

12. *Theoretical Notions on the Motion of Water.*—The actual motion of the particles of water is in most cases very complex. To simplify hydrodynamic problems, simpler modes of motion are assumed, and the results of theory so obtained are compared experimentally with the actual motions.

Motion in Plane Layers.—The simplest kind of motion in a stream is one in which the particles initially situated in any plane cross section of the stream continue to be found in plane cross sections during the subsequent motion. Thus, if the particles in a thin plane layer *ab* (fig. 15) are found again in a thin plane layer *a'b'* after any interval of time, the motion is said to be motion in plane layers. In such motion the internal work in deforming the layer may usually be disregarded, and the resistance to the motion is confined to the circumference.

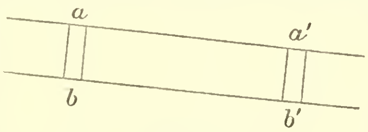


Fig. 15.

Laminar Motion.—In the case of streams having solid boundaries, it is observed that the central parts move faster than the lateral parts. To take account of these differences of velocity, the stream may be conceived to be divided into thin laminae, having cross sections somewhat similar to the solid boundary of the stream, and sliding on each other. The different laminae can then be treated as having differing velocities according to any law either observed or deduced from their mutual friction. A much closer approximation to the real motion of ordinary streams is thus obtained.

Stream Line Motion.—In the preceding hypothesis, all the particles in each lamina have the same velocity at any given cross section of the stream. If this assumption is abandoned, the cross section of the stream must be supposed divided into indefinitely small areas, each representing the section of a fluid filament. Then these filaments may have any law of variation of velocity assigned to them. If the motion is steady motion these fluid filaments (or as they are then termed *stream lines*) will have fixed positions in space.

Periodic Unsteady Motion.—In ordinary streams with rough boundaries, it is observed that at any given point the velocity varies from moment to moment in magnitude and direction, but that the average velocity for a sensible period (say for 5 or 10 minutes) varies very little either in magnitude or velocity. It has hence been conceived that the variations of direction and magnitude of the velocity are periodic, and that, if for each point of the stream the mean velocity and direction of motion were substituted for the actual more or less varying motions, the motion of the stream might be treated as steady stream line or steady laminar motion.

13. *Volume of Flow.*—Let A (fig. 16) be any ideal plane surface, of area ω, in a stream, normal to the direction of motion, and let V

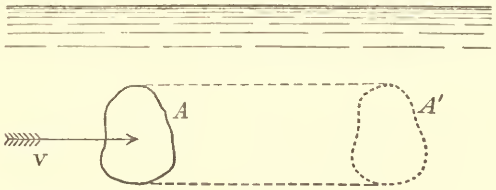


Fig. 16.

be the velocity of the fluid. Then the volume flowing through the surface A in unit time is

$$Q = \omega V \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Thus, if the motion is rectilinear, all the particles at any instant in the surface A will be found after one second in a similar surface A', at a distance V, and as each particle is followed by a continuous thread of other particles, the volume of flow is the right prism AA' having a base ω and length V.

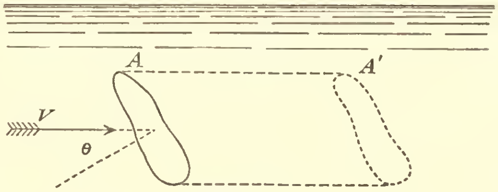


Fig. 17.

If the direction of motion makes an angle θ with the normal to the surface, the volume of flow is represented by an oblique prism AA' (fig. 17), and in that case

$$Q = \omega V \cos \theta \, .$$

If the velocity varies at different points of the surface, let the surface be divided into very small portions, for each of which the velocity may be regarded as constant. If $d\omega$ is the area and v, or $v \cos \theta$, the normal velocity for this element of the surface, the volume of flow is

$$Q = \int v d\omega, \text{ or } \int v \cos \theta \, d\omega \, ,$$

as the case may be.

14. *Principle of Continuity.*—If we consider any completely bounded fixed space in a moving liquid initially and finally filled continuously with liquid, the inflow must be equal to the outflow. Expressing the inflow with a positive and the outflow with a negative sign, and estimating the volume of flow Q for all the boundaries,

$$\Sigma Q = 0 \, .$$

In general the space will remain filled with fluid if the pressure at every point remains positive. There will be a break of continuity, if at any point the pressure becomes negative, indicating that the stress at that point is tensile. In the case of ordinary water this statement requires modification. Water contains a variable amount of air in solution, often about one-twentieth of its volume. This air is disengaged and breaks the continuity of the liquid, if the pressure falls below a point corresponding to its tension. It is for this reason that pumps will not draw water to the full height due to atmospheric pressure.

Application of the Principle of Continuity to the case of a Stream.—If A_1, A_2 are the areas of two normal cross sections of a stream and V_1, V_2 are the velocities of the stream at those sections, then, from the principle of continuity,

$$V_1A_1 = V_2A_2 ;$$
$$\frac{V_1}{V_2} = \frac{A_2}{A_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2);$$

that is, the normal velocities are inversely as the areas of the cross sections. This is true of the mean velocities, if at each section the velocity of the stream varies. In a river of varying slope the velocity varies with the slope. It is easy therefore to see that in parts of large cross section the slope is smaller than in parts of small cross section.

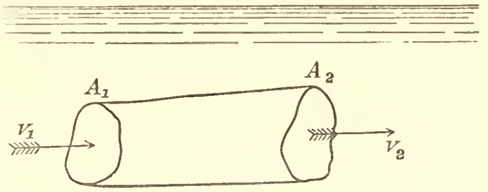


Fig. 18.

If we conceive a space in a liquid bounded by normal sections at A_1, A_2 and between A_1, A_2 by stream lines (fig. 18), then, as there is no flow across the stream lines,

$$\frac{V_1}{V_2} = \frac{A_2}{A_1},$$

as in a stream with rigid boundaries.

In the case of compressible fluids the variation of volume due to the difference of pressure at the two sections must be taken into account. If the motion is steady the weight of fluid between two cross sections of a stream must remain constant. Hence the weight flowing in must be the same as the weight flowing out. Let p_1, p_2 be the pressures, v_1, v_2 the velocities, G_1, G_2 the weight per cubic foot of fluid, at cross sections of a stream of areas A_1, A_2. The volumes of inflow and outflow are

$$A_1v_1 \text{ and } A_2v_2 ,$$

and, if the weights of these are the same,

$$G_1A_1v_1 = G_2A_2v_2 ;$$

and hence, from (5*a*) § 9, if the temperature is constant,

$$p_1A_1v_1 = p_2A_2v_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

III. PHENOMENA OF THE DISCHARGE OF LIQUIDS FROM ORIFICES AS ASCERTAINABLE BY EXPERIMENTS.

15. When a liquid issues vertically from a small orifice, it forms a jet which rises nearly to the level of the free surface of the liquid in the vessel from which it flows. The difference of level h_r (fig. 19) is so small that it may be at once suspected to be due either to air resistance on the surface of the jet or to the viscosity of the liquid or to friction against the sides of the orifice. Neglecting for the moment this small quantity, we may infer, from the elevation of the jet, that each molecule on leaving the orifice possessed the velocity required to lift it against gravity to the height h. From ordinary dynamics, the relation between the velocity and height of projection is given by the equation

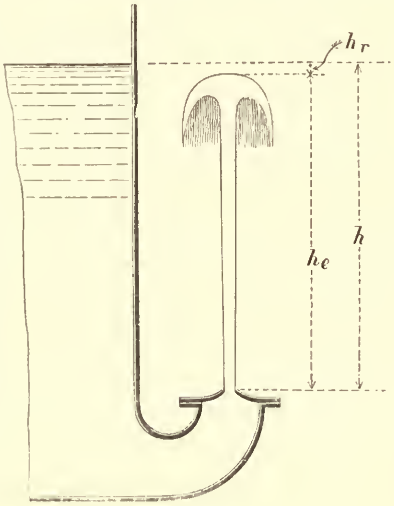


Fig. 19.

$$v = \sqrt{2gh} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

As this velocity is nearly reached in the flow from well-formed orifices, it is sometimes called the theoretical velocity of discharge. This relation was first obtained by Torricelli.

If the orifice is of a suitable conoidal form, the water issues in filaments normal to the plane of the orifice. Let ω be the area of the orifice, then the discharge per second must be, from eq. (1),

$$Q = \omega v = \omega\sqrt{2gh} \text{ nearly} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

This is often termed the theoretical discharge.

Use of the term Head in Hydraulics.—The term *head* is an old millwright's term, and meant primarily the height through which a mass of water descended in actuating a hydraulic machine. Since the water in fig. 19 descends through a height h to the orifice, we may say there are h feet of head above the orifice. Still more generally any mass of liquid h feet above a horizontal plane may be said to have h feet of elevation head relatively to that datum plane. Further, since the pressure p at the orifice which produces outflow is connected with h by the relation $\frac{p}{G} = h$, the quantity $\frac{p}{G}$ may be termed the pressure head at the orifice. Lastly, the velocity v is connected with h by the relation $\frac{v^2}{2g} = h$, so that $\frac{v^2}{2g}$ may be termed the head due to the velocity v.

16. *Coefficients of Velocity and Resistance.*—As the actual velocity of discharge differs from $\sqrt{2gh}$ by a small quantity, let the actual velocity

$$= v_a = c_v\sqrt{2gh} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3),$$

where c_v is a coefficient to be determined by experiment, called the *coefficient of velocity*. This coefficient is found to be tolerably constant for different heads with well-formed simple orifices, and it very often has the value 0·97.

The difference between the velocity of discharge and the velocity due to the head may be reckoned in another way. The total height h causing outflow consists of two parts,—one part h_e expended in producing the velocity of outflow, another h_r in overcoming the resistances due to viscosity and friction. Let

$$h_r = c_rh_e ,$$

where c_r is a coefficient determined by experiment, and called the *coefficient of resistance* of the orifice. It is tolerably constant for different heads with well-formed orifices. Then

$$v_a = \sqrt{2gh_e} = \sqrt{2g\frac{h}{1+c_r}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

The relation between c_v and c_r for any orifice is easily found:—

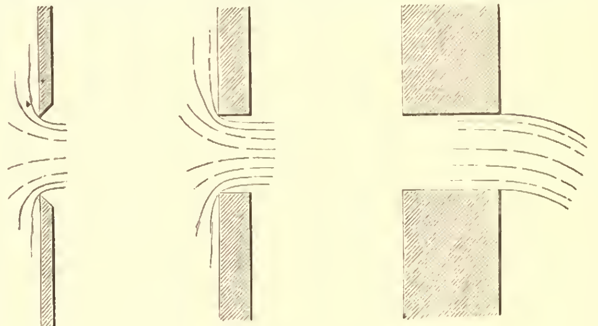
$$v_a = c_v\sqrt{2gh} = \sqrt{2g\frac{h}{1+c_r}} .$$

$$c_v = \sqrt{\frac{1}{1+c_r}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

$$c_r = \frac{1}{c_v^2} - 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5a).$$

Thus if $c_v = 0·97$, then $c_r = 0·0628$. That is, for such an orifice about 6¼ per cent. of the head is expended in overcoming frictional resistances to flow.

Coefficient of Contraction—Sharp-edged Orifices in Plane Surfaces.—When a jet issues from an aperture in a vessel, it may either spring clear from the inner edge of the orifice as at *a* or *b* (fig. 20), or it may adhere to the sides of the orifice as at *c*. The former condition will be found if the orifice is bevelled outwards as at *a*, so as to be sharp edged, and it will also occur generally for a prismatic aperture like *b*, provided the thickness of the vessel round the aperture is less than the diameter of the jet. But if the thickness is greater the condition shown at *c* will occur.



a *b* *c*

Fig. 20.

When the discharge takes place as at *a* or *b*, the section of the jet is smaller than the section of the orifice. This is due to the formation of the jet from filaments converging to the orifice in all directions inside the vessel. The inertia of the filaments opposes sudden change of direction of motion at the edge of the orifice, and the convergence continues for a distance of about half the diameter of the orifice beyond it. Let ω be the area of the orifice, and $c_c\omega$ the area of the jet at the point where convergence ceases; then c_c is a coefficient to be determined experimentally for each kind of orifice, called the *coefficient of contraction*. When the orifice is a sharp-edged orifice in a plane surface, the value of c_c is on the average 0·64, or the section of the jet is very nearly five-eighths of the area of the orifice.

Coefficient of Discharge.—In applying the general formula $Q = \omega v$ to a stream, it is assumed that the filaments have a common velocity v normal to the section ω. But if the jet contracts, it is at the contracted section of the jet that the direction of motion is normal to a transverse section of the jet. Hence the actual discharge when contraction occurs is

$$Q_a = c_v v \times c_c \omega = c_c c_v \omega \sqrt{2gh},$$

or simply, if $c = c_v\, c_c$,

$$Q_a = c\omega\sqrt{2gh},$$

where c is called the *coefficient of discharge*. Thus for a sharp-edged plane orifice $c = 0{\cdot}97 \times 0{\cdot}64 = 0{\cdot}62$.

17. *Experimental determination of c_v, c_c, and c.*—The coefficient of contraction c_c is directly determined by measuring the dimensions of the jet. For this purpose fixed screws of fine pitch (fig. 21) are convenient. These are set to touch the jet, and then the distance between them can be measured at leisure.

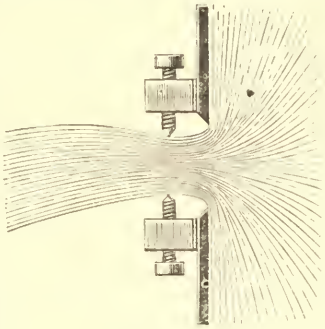


Fig. 21

The coefficient of velocity is determined directly by measuring the parabolic path of a horizontal jet.

Let OX, OY (fig. 22) be horizontal and vertical axes, the origin being at the orifice. Let h be the head, and x, y the coordinates of a point A on the parabolic path of the jet. If v_a

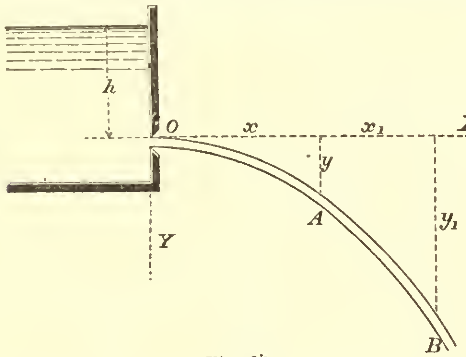


Fig. 22.

is the velocity at the orifice, and t the time in which a particle moves from O to A, then

$$x = v_a t\,;\quad y = \tfrac{1}{2}gt^2.$$

Eliminating t,

$$v_a = \sqrt{\frac{gx^2}{2y}}.$$

Then

$$c_v = \frac{v_a}{\sqrt{2gh}} = \sqrt{\frac{x^2}{4yh}}.$$

If the jet is not initially horizontal, let OB (fig. 23) be any horizontal datum line, and let the vertical distances OC, AD, BE be

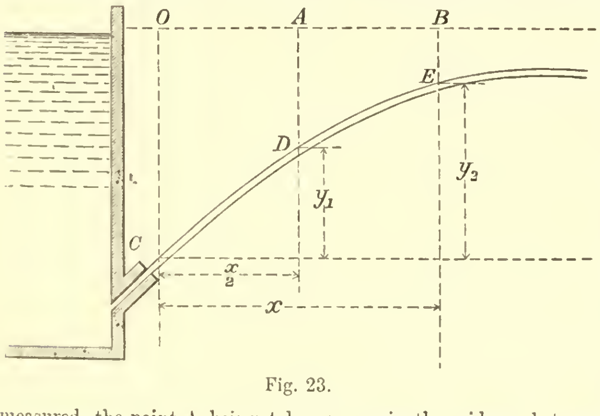


Fig. 23.

measured, the point A being taken conveniently midway between O and B. Then

$$y_1 = \mathrm{OC} - \mathrm{AD}, \text{ and } y_2 = \mathrm{OC} - \mathrm{BE}.$$

Let α be the inclination of the jet at C to the horizontal, so that $v_a \cos\alpha$ is its horizontal and $v_a \sin\alpha$ its vertical velocity at that point. If t is the time in which a particle moves from C to D, then

$$\frac{x}{2} = v_a \cos\alpha\, t,$$

$$y_1 = v_a \sin\alpha\, t - \frac{gt^2}{2}.$$

Eliminating t,

$$y_1 = \frac{x}{2}\tan\alpha - \frac{gx^2}{8v_a^2}(1 + \tan^2\alpha).$$

Similarly,

$$y_2 = x\tan\alpha - \frac{gx^2}{2v_a^2}(1 + \tan^2\alpha).$$

Hence

$$\tan\alpha = \frac{4y_1 - y_2}{x},$$

$$v_a = \sqrt{\frac{g\{x^2 + (4y_1 - y_2)^2\}}{4(2y_1 - y_2)}},$$

$$c_v = \frac{v_a}{\sqrt{2gh}} = \sqrt{\frac{x^2 + (4y_1 - y_2)^2}{8h(2y_1 - y_2)}},$$

where for h is to be put the depth of C below the free water surface.

The coefficient of discharge is determined independently, by measuring the discharge in a gauging tank for a given time. Then, if Q is the measured volume discharged in one second,

$$c = \frac{Q}{\omega\sqrt{2gh}}.$$

18. *Coefficients for Bellmouths and Bellmouthed Orifices.*—If an orifice is furnished with a mouthpiece exactly of the form of the contracted vein, then the whole of the contraction occurs within the mouthpiece, and if the area of the orifice is measured at the smaller end, c_c must be put $= 1$. It is often desirable to bellmouth the ends of pipes, to avoid the loss of head which occurs if this is not done; and such a bellmouth may also have the form of the contracted jet. Fig. 24 shows the proportions of such a bellmouth

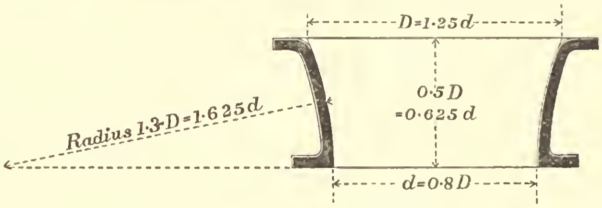


Fig. 24.

or bellmouthed orifice, which approximates to the form of the contracted jet sufficiently for any practical purpose.

For such an orifice Weisbach has found the following values of the coefficients with different heads.

Head over orifice, in feet $= h$	·66	1·64	11·48	55 77	337·93
Coefficient of velocity $= c_v$..	·959	·967	·975	·994	·994
Coefficient of resistance $= c_r$	·087	·069	·052	·012	·012

As there is no contraction after the jet issues from the orifice, $c_c = 1$, $c = c_v$; and therefore

$$Q = c_v\omega\sqrt{2gh} = \omega\sqrt{2g\frac{h}{1 + c_r}}.$$

19. *Coefficients for Sharp-edged or virtually Sharp-edged Orifices.*—The coefficient of velocity for sharp-edged orifices of different areas and under different heads is not very accurately determined. Its mean value is about 0·96.

The coefficient of contraction is also dependent on circumstances the relative influence of which is not so perfectly known as is desirable. Its mean value for well-placed orifices in a plane surface is 0·64. For conditions similar in other respects, the contraction is less (that is, the area of the stream is greater) the smaller the orifice and the less the head. If the surface surrounding the orifice is not plane, the coefficient is greater for a surface convex to the interior of the reservoir and less for a concave surface. The thickening of the edges of the orifice modifies the contraction in a slight degree, and if a border or rim is placed round part of the edge of the orifice, and projects inwards or outwards, the coefficient is very considerably altered, and the contraction is then termed incomplete. If the orifice is placed in a contracted part of the vessel so that the water approaches the orifice with considerable velocity, the coefficient is increased, and the contraction is said to be imperfect.

The coefficient of discharge has been determined for sharp-edged orifices under a great variety of conditions. Its mean value, taking the values of c_v and c_c given above, is 0·62.

For circular orifices, sharp-edged and with complete and perfect contraction, Weisbach found the following values:—

Coefficients of Discharge for Sharp-edged Circular Orifices.

Diameter of Orifice in Inches.	Coefficient of Discharge = c.	
	Head 2 ft.	Head 0·8 ft.
0·4	0·628	0·637
0·8	·621	·629
1·2	·614	·622
1·6	·607	·614

The following table, compiled by Mr Fanning (*Treatise on Water Supply Engineering*), gives values for rectangular orifices in vertical plane surfaces, the head being measured, not immediately over the orifice, where the surface is depressed, but to the still-water surface at some distance from the orifice. The values were obtained by graphic interpolation, all the most reliable experiments being plotted and curves drawn so as to average the discrepancies.

Coefficients of Discharge for Rectangular Orifices, Sharp-edged, in Vertical Plane Surfaces.

Head to Centre of Orifice.	Ratio of Height to Width.							
	4	2	1½	1	¾	½	¼	⅛
Feet.	4 ft. high. 1 ft. wide.	2 ft. high. 1 ft. wide.	1½ ft. high. 1 ft. wide.	1 ft. high. 1 ft. wide.	0·75 ft. high. 1 ft. wide.	0·50 ft. high. 1 ft. wide.	0·25 ft. high. 1 ft. wide.	0·125 ft. high. 1 ft. wide.
0·2	…	…	…	…	…	…	…	·6333
·3	…	…	…	…	…	…	·6293	·6334
·4	…	…	…	…	…	·6140	·6306	·6334
·5	…	…	…	…	·6050	·6150	·6313	·6333
·6	…	…	…	·5984	·6063	·6156	·6317	·6332
·7	…	…	…	·5994	·6074	·6162	·6319	·6328
·8	…	…	·6130	·6000	·6082	·6165	·6322	·6326
·9	…	…	·6134	·6006	·6086	·6168	·6323	·6324
1·0	…	…	·6135	·6010	·6090	·6172	·6320	·6320
1·25	…	·6188	·6140	·6018	·6095	·6173	·6317	·6312
1·50	…	·6187	·6144	·6026	·6100	·6172	·6313	·6303
1·75	…	·6186	·6145	·6033	·6103	·6168	·6307	·6296
2	…	·6183	·6144	·6036	·6104	·6166	·6302	·6291
2·25	…	·6180	·6143	·6039	·6103	·6163	·6293	·6286
2·50	·6290	·6176	·6139	·6043	·6102	·6157	·6282	·6278
2·75	·6280	·6173	·6136	·6046	·6101	·6155	·6274	·6273
3	·6273	·6170	·6132	·6048	·6100	·6153	·6267	·6267
3·5	·6250	·6160	·6123	·6050	·6094	·6146	·6254	·6254
4	·6245	·6150	·6110	·6047	·6085	·6136	·6236	·6236
4·5	·6226	·6138	·6100	·6044	·6074	·6125	·6222	·6222
5	·6208	·6124	·6088	·6038	·6063	·6114	·6202	·6202
6	·6158	·6094	·6063	·6020	·6044	·6087	·6154	·6154
7	·6124	·6064	·6038	·6011	·6032	·6058	·6110	·6114
8	·6090	·6036	·6022	·6010	·6022	·6033	·6073	·6087
9	·6060	·6020	·6014	·6010	·6015	·6020	·6045	·6070
10	·6035	·6015	·6010	·6010	·6010	·6010	·6030	·6060
15	·6040	·6018	·6010	·6011	·6012	·6013	·6033	·6066
20	·6045	·6024	·6012	·6012	·6014	·6018	·6036	·6074
25	·6048	·6028	·6014	·6012	·6016	·6022	·6040	·6083
30	·6054	·6034	·6017	·6013	·6018	·6027	·6044	·6092
35	·6060	·6939	·6021	·6014	·6022	·6032	·6049	·6103
40	·6066	·6045	·6025	·6015	·6026	·6037	·6055	·6114
45	·6054	·6052	·6029	·6016	·6030	·6043	·6062	·6125
50	·6086	·6060	·6034	·6018	·6035	·6050	·6070	·6140

20. *Orifices with Edges of Sensible Thickness.*—When the edges of the orifice are not bevelled outwards, but have a sensible thickness, the coefficient of discharge is somewhat altered. The following table gives values of the coefficient of discharge for the arrangements of the orifice shown in vertical section at P, Q, R (fig. 25). The plan of all the orifices is shown at S. The planks forming the orifice and sluice were each 2 inches thick, and the orifices were all 24 inches wide. The heads were measured immediately over the orifice. The formula above becomes, in this case,

$$Q = cb(H-h)\sqrt{2g\frac{H+h}{2}}.$$

Table of Coefficients of Discharge for Rectangular Vertical Orifices in Fig. 25.

Head h above upper edge of Orifice in ft.	Height of Orifice, $H-h$, in feet.											
	1·31			0·66			0·16			0·10		
	P	Q	R	P	Q	R	P	Q	R	P	Q	R
0·328	0·598	0·644	0·648	0·634	0·665	0·668	0·691	0·664	0·666	0·710	0·694	0·696
·656	0·609	0·653	0·657	0·640	0·672	0·675	0·685	0·687	0·688	0·696	0·704	0·706
·787	0·612	0·655	0·659	0·641	0·674	0·677	0·684	0·690	0·692	0·694	0·706	0·708
·984	0·616	0·656	0·660	0·641	0·675	0·678	0·683	0·693	0·695	0·692	0·709	0·711
1·968	0·618	0·649	0·653	0·640	0·676	0·679	0·678	0·695	0·697	0·688	0·710	0·712
3·28	0·608	0·632	0·634	0·638	0·674	0·676	0·673	0·694	0·695	0·680	0·704	0·705
4·27	0·602	0·624	0·626	0·637	0·673	0·675	0·672	0·693	0·694	0·678	0·701	0·702
4·92	0·598	0·620	0·622	0·637	0·673	0·674	0·672	0·692	0·693	0·676	0·699	0·699
5·58	0·596	0·618	0·620	0·637	0·672	0·673	0·672	0·692	0·693	0·676	0·698	0·698
6·56	0·595	0·615	0·617	0·636	0·671	0·672	0·671	0·691	0·692	0·675	0·696	0·696
9·84	0·592	0·611	0·612	0·634	0·669	0·670	0·668	0·689	0·690	0·672	0·693	0·693

21. *Partially Suppressed Contraction.*—Since the contraction of the jet is due to the convergence towards the orifice of the issuing streams, it will be diminished if for any portion of the edge of the orifice the convergence is prevented. Thus, if an internal rim or border is applied to part of the edge of the orifice (fig. 26), the convergence for so much of the edge is suppressed. For such cases Bidone found the following empirical formulæ applicable:—

For rectangular orifices,

$$c_c = 0·62\left(1 + 0·152\frac{n}{p}\right);$$

and for circular orifices,

$$c_c = 0·62\left(1 + 0·128\frac{n}{p}\right);$$

where n is the length of the edge of the orifice over which the border extends, and p is the whole length of edge or perimeter of the orifice.

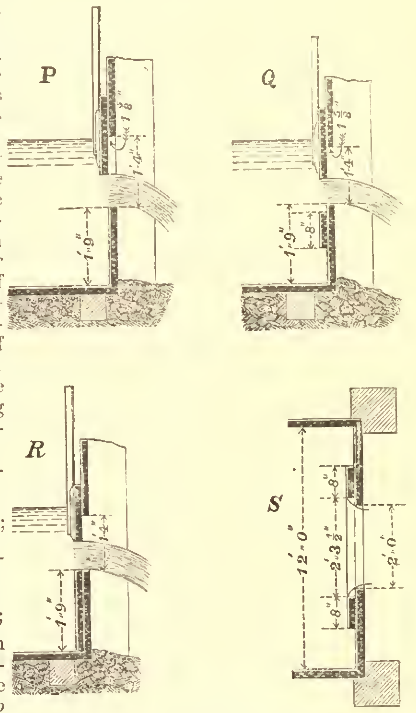


Fig. 25.

The following are the values of c_c, when the border extends over ¼, ½, or ¾ of the whole perimeter:—

$\frac{n}{p}$	c_c Rectangular Orifices.	c_c Circular Orifices.
0·25	0·643	·640
0·50	0·667	·660
0·75	0·691	·680

For larger values of $\frac{n}{p}$ the formulæ are not applicable. Bornemann has shown, however, that these formulæ for suppressed contraction are not reliable.

22. *Imperfect Contraction.*—If the sides of the vessel approach near to the edge of the orifice, they interfere with the convergence of the streams to which the contraction is due, and the contraction is then modified. It is generally stated that the influence of the sides begins to be felt if their distance from the edge of the orifice is less than 2·7 times the corresponding width of the orifice. The coefficients of contraction for this case are imperfectly known.

23. *Orifices Furnished with Channels of Discharge.*—These external borders to an orifice also modify the contraction.

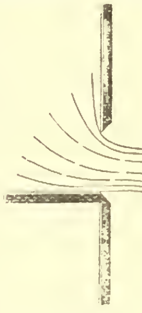


Fig. 26.

The following coefficients of discharge were obtained with openings 8 inches wide, and small in proportion to the channel of approach (fig. 27, A, B, C).

$h_2 - h_1$ in feet.		h_1 in feet.								
		·0656	·164	·328	·656	1·640	3·28	4·92	6·56	9·84
A	0·656	·480	·511	·542	·574	·599	·601	·601	·601	·601
B	0·656	·480	·510	·538	·566	·592	·600	·602	·602	·601
C	0·656	·527	·553	·574	·592	·607	·610	·610	·609	·608
A	0·164	·488	·577	·624	·631	·625	·624	·619	·613	·606
B	0·164	·487	·571	·606	·617	·626	·628	·627	·623	·618
C	0·164	·585	·614	·633	·645	·652	·651	·650	·650	·649

24. *Inversion of the Jet.*—When a jet issues from a horizontal orifice, or is of small size compared with the head, it presents no marked peculiarity of form. But if the orifice is in a vertical surface, and if its dimensions are not small compared with the head, it undergoes a series of singular changes of form after leaving the orifice. These were first investigated by Bidone; subsequently Magnus measured jets from different orifices; and lately Lord Rayleigh (*Proc. Roy. Soc.*, xxix. 71) has investigated them anew.

Fig. 28 shows some remarkable forms, the upper row giving the shape of the orifices, and the others sections of the jet. The jet first contracts as described above, in consequence of the convergence

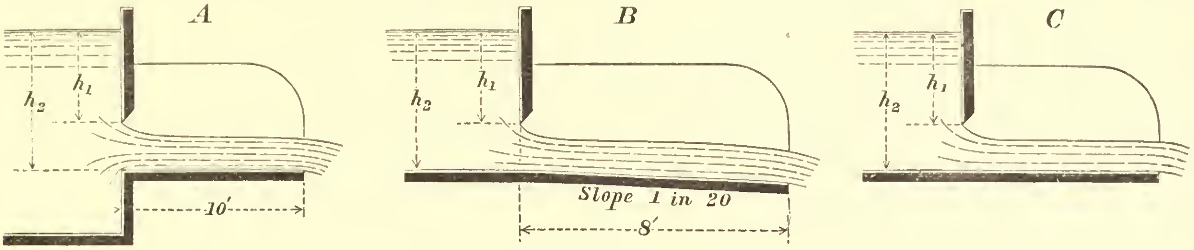


Fig. 27.

of the fluid streams within the vessel, retaining, however, a form similar to that of the orifice. Afterwards it expands into sheets in planes perpendicular to the sides of the orifice. Thus the jet from a triangular orifice expands into three sheets, in planes bisecting at right angles the three sides of the triangle. Generally a jet from an orifice, in the form of a regular polygon of n sides, forms n sheets in planes perpendicular to the sides of the polygon.

Bidone explains this by reference to the simpler case of meeting streams. If two equal streams having the same axis, but moving in opposite directions, meet, they spread out into a thin disk normal to the common axis of the streams. If the directions of two streams intersect obliquely they spread into a symmetrical sheet perpendicular to the plane of the streams. Now those portions of a jet which proceed from different portions of an orifice are conceived to behave in some degree like independent meeting streams.

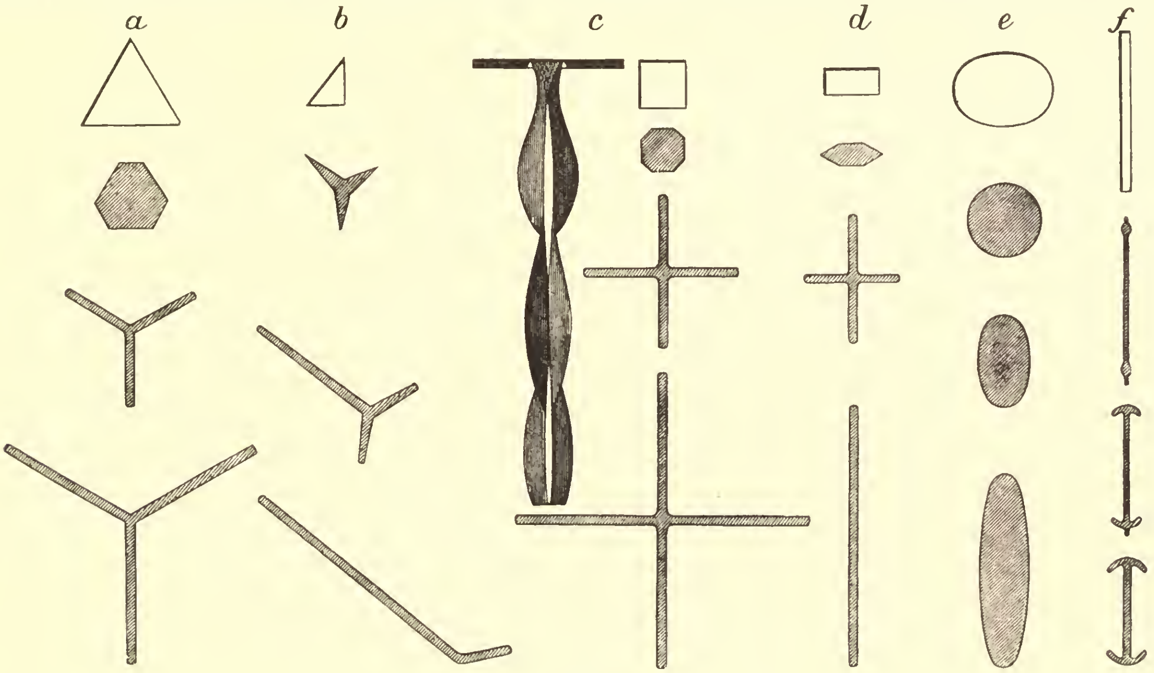


Fig. 28.

Let a_1, a_2 (fig. 29) be two points in an orifice at depths h_1, h_2 from the free surface. The filaments issuing at a_1, a_2 will have the different velocities $\sqrt{2gh_1}$ and $\sqrt{2gh_2}$. Consequently they will tend to describe parabolic paths a_1cb_1 and a_2cb_2 of different horizontal range, and intersecting in the point c. But since two filaments cannot simultaneously flow through the same point, they must exercise mutual pressure, and will be deflected out of the paths they tend to describe. It is this mutual pressure which causes the expansion of the jet into sheets.

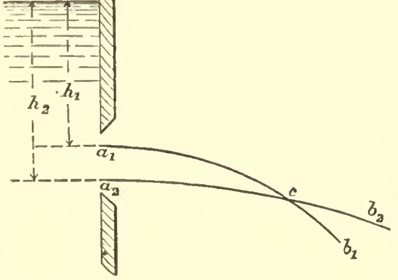


Fig. 29.

Lord Rayleigh has pointed out that, when the orifices are small and the head is not great, the expansion of the sheets in directions perpendicular to the direction of flow reaches a limit. Sections taken at greater distance from the orifice show a contraction of the sheets until a compact form is reached similar to that at the first contraction. This is shown in the elevation of the jet c. Beyond this point, if the jet retains its coherence, sheets are thrown out again, but in directions bisecting the angles between the previous sheets. Lord Rayleigh accepts an explanation of this contraction first suggested by Buff, namely, that it is due to surface tension or capillarity. The fluid is enclosed in an envelope of constant tension, and the recurrent form of the jet is due to vibrations of the fluid column, about a circular figure of equilibrium, superposed on the general progressive motion. Since the phase of vibration depends on the time elapsed, it is always the same at the same point in space, and thus the motion is steady and the boundary of the jet is a fixed surface.

In so far as the vibrations may be considered isochronous, the distance between consecutive corresponding points of the recurrent figure, or, as it may be termed, the wave length of the figure, is directly proportional to the velocity of the jet, that is, to the square root of the head of water. For low heads the measurements confirm this law. For higher heads there is an increase of the wave lengths in a higher ratio than the velocity of the jet. This points to a departure from isochronous vibration, the nature of which is investigated in Lord Rayleigh's paper.

IV. THEORY OF THE STEADY MOTION OF FLUIDS.

25. The general equation of the steady motion of a fluid given under Hydrodynamics furnishes immediately three results as to the distribution of pressure in a stream which may here be assumed.

(*a.*) If the motion is rectilinear and uniform, the variation of pressure is the same as in a fluid at rest. In a stream flowing in an open channel, for instance, when the effect of eddies produced by the roughness of the sides is neglected, the pressure at each point is simply the hydrostatic pressure due to the depth below the free surface.

(*b.*) If the velocity of the fluid is very small, the distribution of pressure is approximately the same as in a fluid at rest.

(*c.*) If the fluid molecules take precisely the accelerations which they would have if independent and submitted only to the external forces, the pressure is uniform. Thus in a jet falling freely in the air the pressure throughout any cross section is uniform and equal to the atmospheric pressure.

(*d.*) In any bounded plane section traversed normally by streams which are rectilinear for a certain distance on either side of the section, the distribution of pressure is the same as in a fluid at rest.

Distribution of Energy in Incompressible Fluids.

26. *Application of the Principle of the Conservation of Energy to Cases of Stream Line Motion.*—The external and internal work done on a mass is equal to the change of kinetic energy produced. In many hydraulic questions this principle is difficult to apply, because from the complicated nature of the motion produced it is difficult to estimate the total kinetic energy generated, and because in some cases the internal work done in overcoming frictional or viscous resistances cannot be ascertained; but in the case of stream line motion it furnishes a simple and important result known as Bernouilli's theorem.

Let AB (fig. 30) be any one elementary stream, in a steadily moving fluid mass. Then, from the steadiness of the motion, AB is a fixed

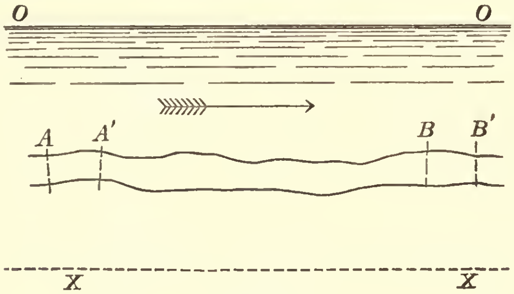


Fig. 30.

path in space through which a stream of fluid is constantly flowing. Let OO be the free surface and XX any horizontal datum line. Let ω be the area of a normal cross section, v the velocity, p the intensity of pressure, and z the elevation above XX, of the elementary stream AB at A, and ω_1, p_1, v_1, z_1 the same quantities at B. Suppose that in a short time t the mass of fluid initially occupying AB comes to A'B'. Then AA', BB' are equal to vt, v_1t, and the volumes of fluid AA', BB' are the equal inflow and outflow $= Qt = \omega vt = \omega_1 v_1 t$, in the given time. If we suppose the filament AB surrounded by other filaments moving with not very different velocities, the frictional or viscous resistance on its surface will be small enough to be neglected, and if the fluid is incompressible no internal work is done in change of volume. Then the work done by external forces will be equal to the kinetic energy produced in the time considered.

The normal pressures on the surface of the mass (excluding the ends A, B) are at each point normal to the direction of motion, and do no work. Hence the only external forces to be reckoned are gravity and the pressures on the ends of the stream.

The work of gravity when AB falls to A'B' is the same as that of transferring AA' to BB'; that is, $GQt\,(z-z_1)$. The work of the pressures on the ends, reckoning that at B negative, because it is opposite to the direction of motion, is $(p\omega \times vt) - (p_1\omega_1 \times v_1 t) = Qt\,(p-p_1)$. The change of kinetic energy in the time t is the difference of the kinetic energy originally possessed by AA' and that finally acquired by BB', for in the intermediate part A'B there is no change of kinetic energy, in consequence of the steadiness of the motion. But the mass of AA' and BB' is $\frac{G}{g}Qt$, and the change of kinetic energy is therefore $\frac{G}{g}Qt\left(\frac{v_1^2}{2}-\frac{v^2}{2}\right)$. Equating this to the work done on the mass AB,

$$GQt(z-z_1)+Qt(p-p_1)=\frac{G}{g}Qt\left(\frac{v_1^2}{2}-\frac{v^2}{2}\right).$$

Dividing by GQt and rearranging the terms,

$$\frac{v^2}{2g}+\frac{p}{G}+z=\frac{v_1^2}{2g}+\frac{p_1}{G}+z_1 \quad . \quad . \quad . \quad . \quad . \quad (1);$$

or, as A and B are any two points,

$$\frac{v^2}{2g}+\frac{p}{G}+z=\text{constant}=H \quad . \quad . \quad . \quad . \quad (2).$$

Now $\frac{v^2}{2g}$ is the head due to the velocity v, $\frac{p}{G}$ is the head equivalent to the pressure, and z is the elevation above the datum (see § 15). Hence the terms on the left are the total head due to velocity, pressure, and elevation at a given cross section of the filament. z is easily seen to be the work in foot-pounds which would be done by 1 lb of fluid falling to the datum line, and similarly $\frac{p}{G}$ and $\frac{v^2}{2g}$ are the quantities of work which would be done by 1 lb of fluid due to the pressure p and velocity v. The expression on the left of the equation is, therefore, the total energy of the stream at the section considered, per lb of fluid, estimated with reference to the datum line XX. Hence we see that in stream line motion, under the restrictions named above, the total energy per lb of fluid is uniformly distributed along the stream line. If the free surface of the fluid OO is taken as the datum, and $-h$, $-h_1$ are the depths of A and B measured down from the free surface, the equation takes the form

$$\frac{v^2}{2g}+\frac{p}{G}-h=\frac{v_1^2}{2g}+\frac{p_1}{G}-h_1 \quad . \quad . \quad . \quad . \quad . \quad (3);$$

or generally

$$\frac{v^2}{2g}+\frac{p}{G}-h=\text{constant} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3a).$$

27. *Second Form of the Theorem of Bernoulli.*—Suppose at the two sections A, B (fig. 31) of an elementary stream small vertical pipes are introduced, which may be termed pressure columns

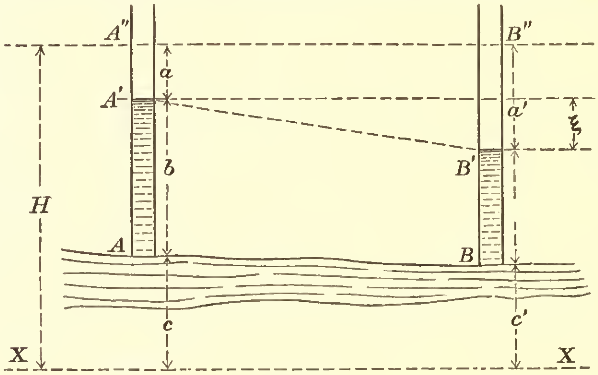


Fig. 31.

(§ 8), having their lower ends accurately parallel to the direction of flow. In such tubes the water will rise to heights corresponding to the pressures at A and B. Hence

$$b=\frac{p}{G}, \quad \text{and } b'=\frac{p_1}{G}$$

Consequently the tops of the pressure columns A' and B' will be at total heights $b+c=\frac{p}{G}+z$ and $b'+c'=\frac{p_1}{G}+z_1$ above the datum line XX. The difference of level of the pressure column tops, or the fall of free surface level between A and B, is therefore

$$\xi=\frac{p-p_1}{G}+(z-z_1);$$

and this by equation (1), § 26, is

$$=\frac{v_1^2-v^2}{2g}.$$

That is, the fall of free surface level between two sections is equal to the difference of the heights due to the velocities at the sections. The line A'B' is sometimes called the line of hydraulic gradient, though this term is also used in cases where friction needs to be taken into account. It is the line the height of which above datum is the sum of the elevation and pressure head at that point, and it falls below a horizontal line A″B″ drawn at H feet above XX by the quantities $a=\frac{v^2}{2g}$ and $b=\frac{v_1^2}{2g}$, when friction is absent.

28. *Illustrations of the Theorem of Bernoulli.*—In a lecture to the mechanical section of the British Association in 1875, the late Mr W. Froude gave some experimental illustrations of the principle of Bernoulli. Mr Froude remarked that it was a common but erroneous impression that a fluid exercises in a contracting pipe A (fig. 32) an excess of pressure against the entire converging surface which it meets, and that, conversely, as it enters an enlargement B, a relief of pressure is experienced by the entire diverging surface of the pipe. Further it is commonly assumed that when passing through a contraction C, there is in the narrow neck an excess of pressure due to the squeezing together of the liquid at that point. These impressions are in no respect correct; the pressure is smaller as the section of the pipe is smaller and conversely.

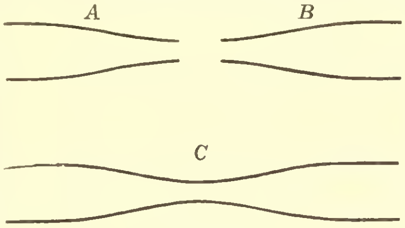


Fig. 32

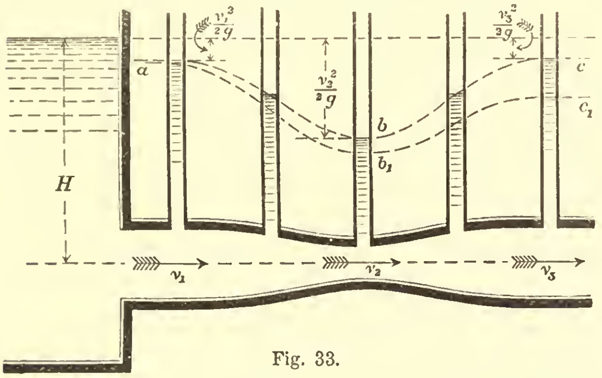


Fig. 33.

Fig. 33 shows a pipe so formed that a contraction is followed by an enlargement, and fig. 34 one in which an enlargement is followed by a contraction. The vertical pressure columns show the decrease of pressure at the contraction and increase of pressure at the enlargement.

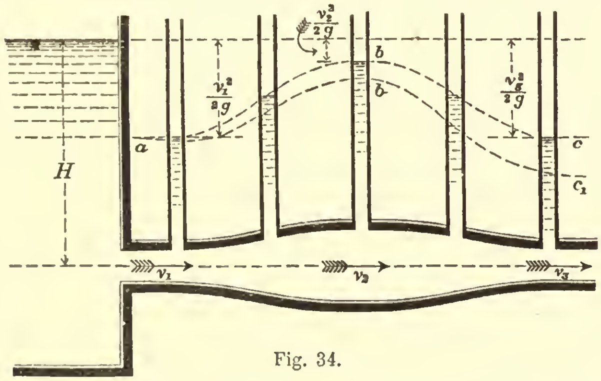


Fig. 34.

The line *abc* in both figures shows the variation of free surface level, supposing the pipe frictionless. In actual pipes, however, work is expended in friction against the pipe; the total head diminishes in proceeding along the pipe, and the free surface level is a line such as ab_1c_1, falling below *abc*.

Mr Froude further points out that, if a pipe contracts and enlarges again to the same size, the resultant pressure on the converging part exactly balances the resultant pressure on the diverging part so that there is no tendency to move the pipe bodily when water flows through it. Thus the conical part AB (fig. 35) presents the same projected surface as HI, and the pressures parallel to the axis of the pipe, normal to these projected surfaces, balance each other.

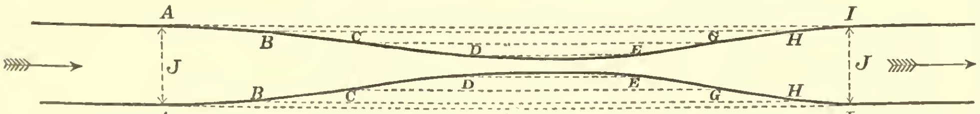


Fig. 35.

Similarly the pressures on BC, CD balance those on GH, EG. In the same way, in any combination of enlargements and contractions, a balance of pressures, due to the flow of liquid parallel to the axis of the pipe, will be found, provided the sectional area and direction of the ends are the same.

The following experiment is interesting. Two cisterns provided with converging pipes were placed so that the jet from one was exactly opposite the entrance to the other. The cisterns being filled very nearly to the same level, the jet from the left hand cistern A entered the right hand cistern B (fig. 36), shooting across the free

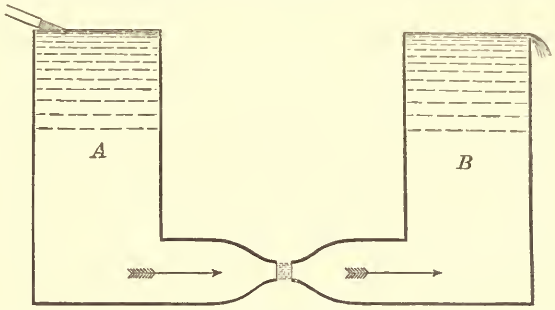


Fig. 36.

space between them without any waste, except that due to indirectness of aim and want of exact correspondence in the form of the orifices. In the actual experiment there was 18 inches of head in the right and $20\frac{1}{2}$ inches of head in the left hand cistern, so that about $2\frac{1}{2}$ inches were wasted in friction. It will be seen that in the open space between the orifices there was no pressure, except the atmospheric pressure acting uniformly throughout the system.

29. *Pressure, Velocity, and Energy in Different Stream Lines.*—The equation of Bernouilli gives the variation of pressure and velocity from point to point along a stream line, and shows that the total energy of the flow across any two sections is the same. Two other directions may be defined, one normal to the stream line and in the plane containing its radius of curvature at any point, the other normal to the stream line and the radius of curvature. For the problems most practically useful it will be sufficient to consider the stream lines as parallel to a vertical or horizontal plane. If the motion is in a vertical plane, the action of gravity must be

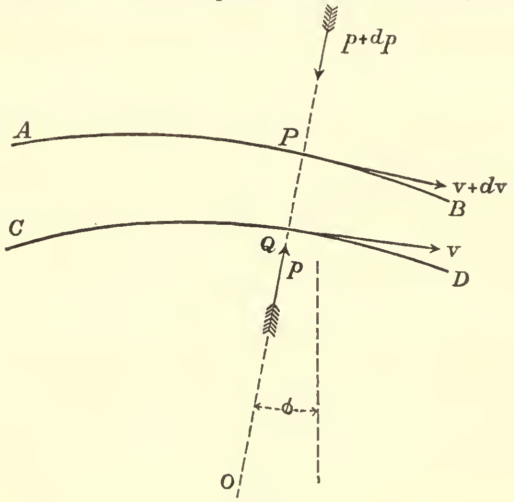


Fig. 37.

taken into the reckoning; if the motion is in a horizontal plane, the terms expressing variation of elevation of the filament will disappear.[1]

Let AB, CD (fig. 37) be two consecutive stream lines, at present assumed to be in a vertical plane, and PQ a normal to these lines making an angle ϕ with the vertical. Let P, Q be two particles moving along these lines at a distance $PQ=ds$, and let z be the height of Q above the horizontal plane with reference to which the energy is measured, v its velocity, and p it

[1] The following theorem is taken from a paper by Professor Cotterill, "On the Distribution of Energy in a Mass of Fluid in Steady Motion," *Phil. Mag.*, February 1876.

pressure. Then, if H is the total energy at Q per unit of weight of fluid,

$$\mathrm{H} = z + \frac{p}{\mathrm{G}} + \frac{v^2}{2g}.$$

Differentiating, we get

$$d\mathrm{H} = dz + \frac{dp}{\mathrm{G}} + \frac{vdv}{g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

for the increment of energy between Q and P. But

$$dz = \mathrm{PQ} \cos \phi = ds \cos \phi ;$$

$$\therefore d\mathrm{H} = \frac{dp}{\mathrm{G}} + \frac{vdv}{g} + ds \cos \phi \quad . \quad . \quad . \quad . \quad . \quad . \quad (1a),$$

where the last term disappears if the motion is in a horizontal plane.

Now imagine a small cylinder of section ω described round PQ as an axis. This will be in equilibrium under the action of its centrifugal force, its weight and the pressure on its ends. But its volume is ωds and its weight $\mathrm{G}\omega ds$. Hence, taking the components of the forces parallel to PQ—

$$\omega dp = \frac{\mathrm{G}}{g} \frac{v^2}{\rho} \omega ds - \mathrm{G}\omega \cos \phi \, ds.$$

where ρ is the radius of curvature of the stream line at Q. Consequently, introducing these values in (1),

$$d\mathrm{H} = \frac{v^2}{g\rho} ds + \frac{vdv}{g} = \frac{v}{g} \left\{ \frac{v}{\rho} + \frac{dv}{ds} \right\} ds \quad . \quad . \quad . \quad (2).$$

Now it is already known that if, through any particle A, lines be drawn through B and C two particles near to A, such that AB and AC are at right angles at the instant considered, then the mean angular velocity of these lines is the same in whatever direction they are drawn, and is equal to the angular velocity with which a small cylindrical element described round A would rotate if supposed suddenly solidified. This mean angular velocity may be conveniently called the molecular rotation, and will be denoted by $\circlearrowleft$. In the present case $\frac{v}{\rho}$ is the angular velocity of the tangent at Q, and $\frac{dv}{ds}$ is the angular velocity, reckoned in the same direction, of a line perpendicular to the tangent through P and Q. The sum of these is, therefore, twice the molecular rotation, and

$$d\mathrm{H} = 2\frac{v}{g} \circlearrowleft ds \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Now vds is constant, being the flow in an elementary stream of breadth unity, and thickness ds. Therefore the difference of energy between two consecutive elementary streams is proportional to the molecular rotation at any point of either.

Currents.

30. *Rectilinear Current.*—Suppose the motion is in parallel straight stream lines (fig. 38) in a vertical plane. Then ρ is infinite, and from eq. (2), § 29,

$$d\mathrm{H} = \frac{vdv}{g}.$$

Comparing this with (1) we see that

$$dz + \frac{dp}{\mathrm{G}} = 0 ;$$

$$\therefore z + \frac{p}{\mathrm{G}} = \text{constant} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4);$$

or the pressure varies hydrostatically as in a fluid at rest. For two stream lines in a horizontal plane, z is constant, and therefore p is constant.

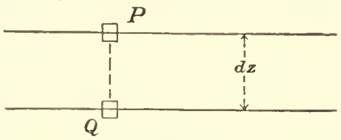


Fig. 38.

Radiating Current.—Suppose water flowing radially between horizontal parallel planes, at a distance apart $= \delta$. Conceive two cylindrical sections of the current at radii r_1 and r_2, where the velocities are v_1 and v_2, and the pressures p_1 and p_2. Since the flow across each cylindrical section of the current is the same,

$$\mathrm{Q} = 2\pi r_1 \delta v_1 = 2\pi r_2 \delta v_2$$

$$r_1 v_1 = r_2 v_2$$

$$\frac{r_1}{r_2} = \frac{v_2}{v_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

The velocity would be infinite at radius 0, if the current could be conceived to extend to the axis. Now, if the motion is steady,

$$\mathrm{H} = \frac{p_1}{\mathrm{G}} + \frac{v_1^2}{2g} = \frac{p_2}{\mathrm{G}} + \frac{v_2^2}{2g},$$

$$= \frac{p_2}{\mathrm{G}} + \frac{r_1^2}{r_2^2} \frac{v_1^2}{2g};$$

$$\frac{p_2 - p_1}{\mathrm{G}} = \frac{v_1^2}{2g} \left(1 - \frac{r_1^2}{r_2^2}\right) \quad . \quad . \quad . \quad . \quad (6);$$

$$\frac{p_2}{\mathrm{G}} = \mathrm{H} - \frac{r_1^2}{r_2^2} \frac{v_1^2}{2g} \quad . \quad . \quad . \quad . \quad (6a).$$

Hence the pressure increases from the interior outwards, in a way indicated by the pressure columns in fig. 39, the curve through the free surfaces of the pressure columns being, in a radial section, the

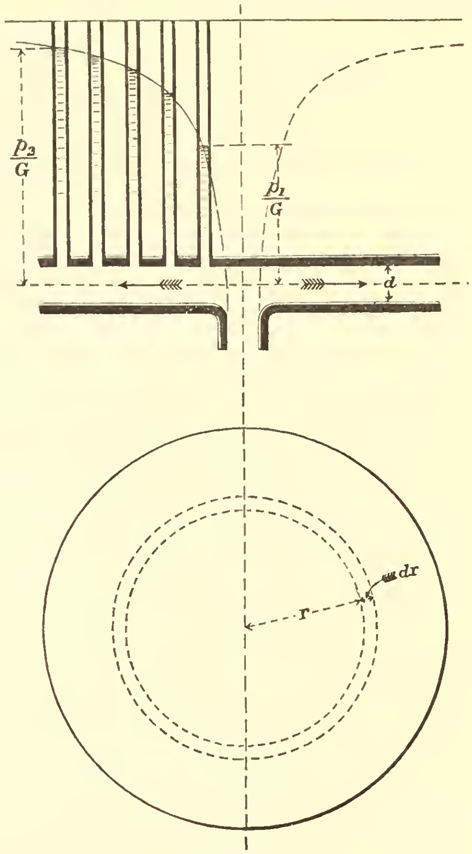


Fig. 39.

quasi-hyperbola of the form $xy^2 = c^3$. This curve is asymptotic to a horizontal line, H feet above the line from which the pressures are measured, and to the axis of the current.

Free Circular Vortex.—A free circular vortex is a revolving mass of water, in which the stream lines are concentric circles, and in which the total head for each stream line is the same. Hence, if by any slow radial motion portions of the water strayed from one stream line to another, they would take freely the velocities proper to their new positions under the action of the existing fluid pressures only.

For such a current, the motion being horizontal, we have for all the circular elementary streams

$$\mathrm{H} = \frac{p}{\mathrm{G}} + \frac{v^2}{2g} = \text{constant};$$

$$\therefore d\mathrm{H} = \frac{dp}{\mathrm{G}} + \frac{vdv}{g} = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

Consider two stream lines at radii r and $r + dr$ (fig. 39). Then in (2), § 29, $\rho = r$ and $ds = dr$,

$$\frac{v^2}{gr} dr + \frac{vdv}{g} = 0,$$

$$\frac{dv}{v} = -\frac{dr}{r},$$

$$v \propto \frac{1}{r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8),$$

precisely as in a radiating current; and hence the distribution of pressure is the same, and formulæ 6, $6a$ are applicable to this case.

Free Spiral Vortex.—As in a radiating and circular current the equations of motion are the same, they will also apply to a vortex in which the motion is compounded of these motions in any proportions, provided the radial component of the motion varies inversely as the radius as in a radial current, and the tangential component varies inversely as the radius as in a free vortex. Then the whole velocity at any point will be inversely proportional to the radius of the point, and the fluid will describe stream lines having a constant inclination to the radius drawn to the axis of the current. That is, the stream lines will be logarithmic spirals. When water is delivered from the circumference of a centrifugal pump or turbine into a chamber, it forms a free vortex of this kind. The water flows spirally outwards, its velocity diminishing and its pressure increasing according to the law stated above, and the head along each spiral stream line is constant.

31. *Forced Vortex.*—If the law of motion in a rotating current is different from that in a free vortex, some force must be applied to cause the variation of velocity. The simplest case is that of a rotating current in which all the particles have equal angular velocity, as for instance when they are driven round by radiating paddles revolving uniformly. Then in equation (2), § 29, considering two circular stream lines of radii r and $r+dr$ (fig. 40), we have $\rho=r$, $ds=dr$. If the angular velocity is α, then $v=\alpha r$ and $dv=\alpha dr$. Hence

$$dH=\frac{\alpha^2 r}{g}dr+\frac{\alpha^2 r dr}{g}=\frac{2\alpha^2 r}{g}dr \; .$$

Comparing this with (1), § 29, and putting $dz=0$, because the motion is horizontal,

$$\frac{dp}{G}+\frac{\alpha^2 r dr}{g}=\frac{2\alpha^2 r}{g}dr \; ,$$

$$\frac{dp}{G}=\frac{\alpha^2 r}{g}dr \; ,$$

$$\frac{p}{G}=\frac{\alpha^2 r^2}{2g}+\text{constant} \quad . \quad . \quad . \quad . \quad . \quad (9).$$

Let p_1, r_1, v_1 be the pressure, radius, and velocity of one cylindrical section, p_2, r_2, v_2 those of another; then

$$\frac{p_1}{G}-\frac{\alpha^2 r_1^2}{2g}=\frac{p_2}{G}-\frac{\alpha^2 r_2^2}{2g} \; ;$$

$$\frac{p_2-p_1}{G}=\frac{\alpha^2}{2g}(r_2^2-r_1^2)=\frac{v_2^2-v_1^2}{2g} \quad . \quad . \quad . \quad . \quad (10).$$

That is, the pressure increases from within outwards in a curve which in radial sections is a parabola, and surfaces of equal pressure are paraboloids of revolution (fig. 40).

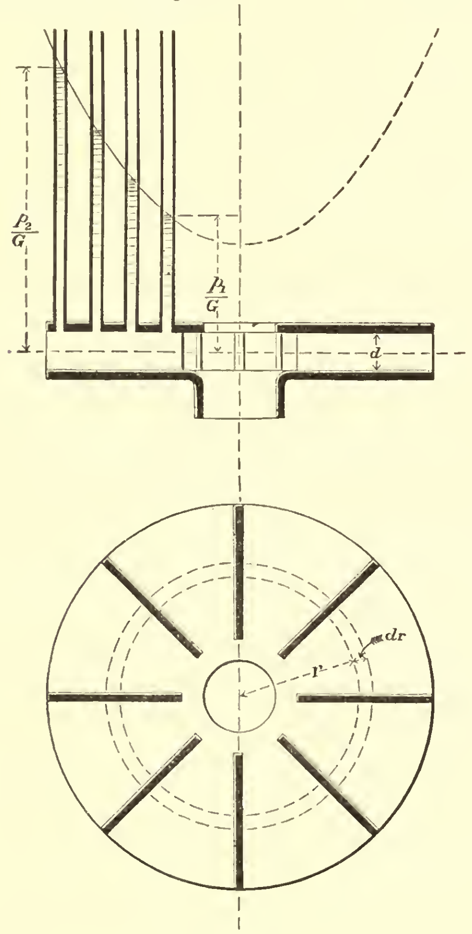


Fig. 40.

Dissipation of Head in Shock.

32. *Relation of Pressure and Velocity in a Stream in Steady Motion when the Changes of Section of the Stream are Abrupt.*—When a stream changes section abruptly, rotating eddies are formed which dissipate energy. The energy absorbed in producing rotation is at once abstracted from that effective in causing the flow, and sooner or later it is wasted by frictional resistances due to the rapid relative motion of the eddying parts of the fluid. In such cases the work thus expended internally in the fluid is too important to be neglected, and the energy thus lost is commonly termed energy lost in shock. Suppose fig. 41 to represent a stream having such an abrupt change of section. Let AB, CD be normal sections at points where ordinary stream line motion has not been disturbed and where it has been re-established. Let ω, p, v be the area of section, pressure, and velocity at AB, and ω_1, p_1, v_1 corresponding quantities at CD. Then if no work were expended internally, and assuming the stream horizontal, we should have

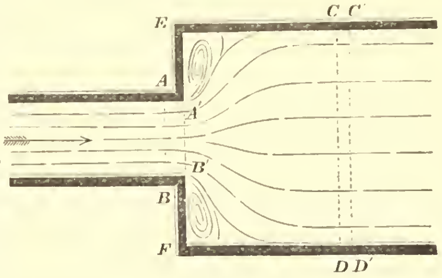


Fig. 41.

$$\frac{p}{G}+\frac{v^2}{2g}=\frac{p_1}{G}+\frac{v_1^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

But if work is expended in producing irregular eddying motion, the head at the section CD will be diminished.

Suppose the mass ABCD comes in a short time t to A′B′C′D′. The resultant force parallel to the axis of the stream is

$$p\omega+p_0(\omega_1-\omega)-p_1\omega_1,$$

where p_0 is put for the unknown pressure on the annular space between AB and EF. The impulse of that force is

$$\{p\omega+p_0(\omega_1-\omega)-p_1\omega_1\}t.$$

The horizontal change of momentum in the same time is the difference of the momenta of CDC′D′ and ABA′B′, because the amount of momentum between A′B′ and CD remains unchanged if the motion is steady. The volume of ABA′B′ or CDC′D′, being the inflow and outflow in the time t, is $Qt=\omega vt=\omega_1 v_1 t$, and the momentum of these masses is $\frac{G}{g}Qvt$ and $\frac{G}{g}Qv_1 t$. The change of momentum is therefore $\frac{G}{g}Qt(v_1-v)$. Equating this to the impulse,

$$\{p\omega+p_0(\omega_1-\omega)-p_1\omega_1\}t=\frac{G}{g}Qt(v_1-v) \; .$$

Assume that $p_0=p$, the pressure at AB extending unchanged through the portions of fluid in contact with AE, BF which lie out of the path of the stream. Then (since $Q=\omega_1 v_1$)

$$(p-p_1)=\frac{G}{g}v_1(v_1-v) \; ;$$

$$\frac{p}{G}-\frac{p_1}{G}=\frac{v_1(v_1-v)}{g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2) \; ;$$

$$\frac{p}{G}+\frac{v^2}{2g}=\frac{p_1}{G}+\frac{v_1^2}{2g}+\frac{(v-v_1)^2}{2g} \quad . \quad . \quad . \quad (3).$$

This differs from the expression (1), § 26, obtained for cases where no sensible internal work is done, by the last term on the right. That is, $\frac{(v-v_1)^2}{2g}$ has to be added to the total head at CD, which is $\frac{p_1}{G}+\frac{v_1^2}{2g}$, to make it equal to the total head at AB, or $\frac{(v-v_1)^2}{2g}$ is the head lost in shock at the abrupt change of section. But $v-v_1$ is the relative velocity of the two parts of the stream. Hence, when an abrupt change of section occurs, the head due to the relative velocity is lost in shock, or $\frac{(v-v_1)^2}{2g}$ foot-pounds of energy is wasted for each pound of fluid. Experiment verifies this result, so that the assumption that $p_0=p$ appears to be admissible.

If there is no shock,

$$\frac{p_1}{G}=\frac{p}{G}+\frac{v^2-v_1^2}{2g} \; .$$

If there is shock,

$$\frac{p_1}{G}=\frac{p}{G}-\frac{v_1(v_1-v)}{g} \; .$$

Hence the pressure head at CD in the second case is less than in the former by the quantity

$$\frac{(v-v_1)^2}{2g} \; ,$$

or, putting $\omega_1 v_1=\omega v$, by the quantity

$$\frac{v^2}{2g}\left(1-\frac{\omega}{\omega_1}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

V. THEORY OF THE DISCHARGE FROM ORIFICES AND MOUTHPIECES.

33. *Minimum Coefficient of Contraction. Re-entrant Mouthpiece of Borda.*—In one special case the coefficient of contraction can be determined theoretically, and, as it is the case where the convergence of the streams approaching the orifice takes place through the greatest possible angle, the coefficient thus determined is the minimum coefficient.

Let fig. 42 represent a vessel with vertical sides, OO being the free water surface, at which the pressure is p_a. Suppose the liquid issues by a horizontal mouthpiece, which is re-entrant and of the greatest length which permits the jet to spring clear from the inner end of the orifice, without adhering to its sides. With such an orifice the velocity near the points CD is negligible, and the pressure at those points may be taken equal to the hydrostatic pressure due to the depth from the free surface. Let Ω be the area of the mouthpiece AB, ω that of the contracted jet *aa*. Suppose that in a short time t, the mass OO*aa* comes to the position O′O′ *a′a′*; the impulse of the horizontal external forces acting on the mass during that time is equal to the horizontal change of momentum.

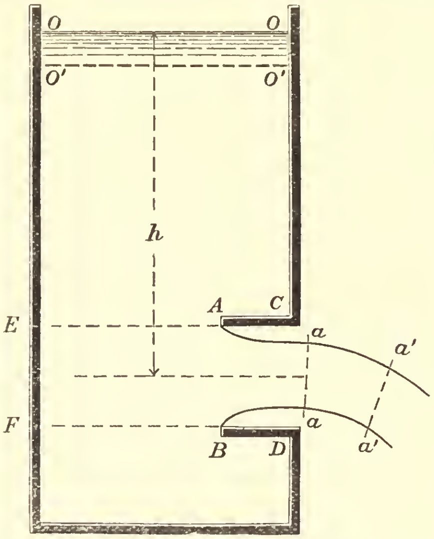


Fig. 42.

The pressure on the side OC of the mass will be balanced by the pressure on the opposite side OE, and so for all other portions of the vertical surfaces of the mass, excepting the portion EF opposite the mouthpiece and the surface *Aaa*B of the jet. On EF the pressure is simply the hydrostatic pressure due to the depth, that is, $(p_a + Gh)\Omega$. On the surface and section *Aaa*B of the jet, the horizontal resultant of the pressure is equal to the atmospheric pressure p_a acting on the vertical projection AB of the jet; that is, the resultant pressure is $-p_a\Omega$. Hence the resultant horizontal force for the whole mass OO*aa* is $(p_a + Gh)\Omega - p_a\Omega = Gh\Omega$. Its impulse in the time t is $Gh\Omega t$. Since the motion is steady there is no change of momentum between O′O′ and *aa*. The change of horizontal momentum is, therefore, the difference of the horizontal momentum lost in the space OOO′O′ and gained in the space *aaa′a′*. In the former space there is no horizontal momentum.

The volume of the space *aaa′a′* is ωvt; the mass of liquid in that space is $\frac{G}{g}\omega vt$; its momentum is $\frac{G}{g}\omega v^2 t$. Equating impulse to momentum gained,

$$Gh\Omega t = \frac{G}{g}\omega v^2 t\ ;$$

$$\frac{\omega}{\Omega} = \frac{gh}{v^2}\ .$$

But
$$v^2 = 2gh, \text{ and } \frac{\omega}{\Omega} = c_c\ ;$$

$$\therefore\ \frac{\omega}{\Omega} = \frac{1}{2} = c_c\ ;$$

a result confirmed by experiment with mouthpieces of this kind. A similar theoretical investigation is not possible for orifices in plane surfaces, because the velocity along the sides of the vessel in the neighbourhood of the orifice is not so small that it can be neglected. The resultant horizontal pressure is therefore greater than $Gh\Omega$, and the contraction is less. The experimental values of the coefficient of discharge for a re-entrant mouthpiece are 0·5149 (Borda), 0·5547 (Bidone), 0·5324 (Weisbach), values which differ little from the theoretical value, 0·5, given above.

34. *Velocity of Filaments issuing in a Jet.*—A jet is composed of fluid filaments or elementary streams, which start into motion at some point in the interior of the vessel from which the fluid is discharged, and gradually acquire the velocity of the jet. Let M*m*, fig. 43, be such a filament, the point M being taken where the velocity is insensibly small, and m at the most contracted section of the jet, where the filaments have become parallel and exercise uniform mutual pressure. Take the free surface AB for datum line, and let

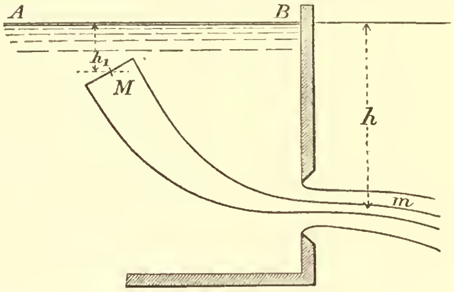


Fig. 43.

p_1, v_1, h_1, be the pressure, velocity, and depth below datum at M; p, v, h, the corresponding quantities at m. Then § 26, eq. (3),

$$\frac{v_1^2}{2g} + \frac{p_1}{G} - h_1 = \frac{v^2}{2g} + \frac{p}{G} - h\ . \quad . \quad . \quad . \quad . \quad (1).$$

But at M, since the velocity is insensible, the pressure is the hydrostatic pressure due to the depth; that is, $v_1 = 0$, $p_1 = p_a + Gh_1$. At m, $p = p_a$, the atmospheric pressure round the jet. Hence, inserting these values,

$$0 + \frac{p_a}{G} + h_1 - h_1 = \frac{v^2}{2g} + \frac{p_a}{G} - h\ ;$$

$$\frac{v^2}{2g} = h\ . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2);$$

or
$$v = \sqrt{2gh} = 8{\cdot}025\sqrt{h} \quad . \quad . \quad (2a).$$

That is, neglecting the viscosity of the fluid, the velocity of filaments at the contracted section of the jet is simply the velocity due to the difference of level of the free surface in the reservoir and the orifice. If the orifice is small in dimensions compared with h, the filaments will all have nearly the same velocity, and if h is measured to the centre of the orifice, the equation above gives the mean velocity of the jet.

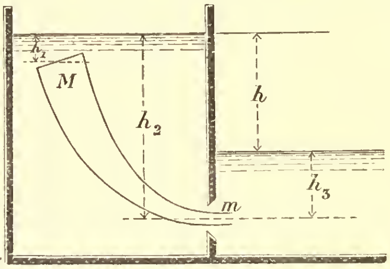


Fig. 44.

Case of a Submerged Orifice.—Let the orifice discharge below the level of the tail water. Then using the notation shown in fig. 44, we have at M, $v_1 = 0$, $p_1 = Gh_1 + p_a$; at m, $p = Gh_3 + p_a$. Inserting these values in (3), § 26,

$$0 + h_1 + \frac{p_a}{G} - h_1 = \frac{v^2}{2g} + h_3 - h_2 + \frac{p_a}{G}\ ;$$

$$\frac{v^2}{2g} = h_2 - h_3 = h \quad . \quad . \quad . \quad . \quad . \quad (3),$$

where h is the difference of level of the head and tail water, and may be termed the *effective head* producing flow.

Case where the Pressures are different on the Free Surface and at the Orifice.—Let the fluid flow from a vessel in which the pressure is p_0 into a vessel in which the pressure is p, fig. 45. The pressure p_0 will produce the same effect as a layer of fluid of thickness $\frac{p_0}{G}$ added to the head water; and the pressure p will produce the same effect as a layer of thickness $\frac{p}{G}$ added to the tail water. Hence the effective difference of level, or effective head producing flow, will be

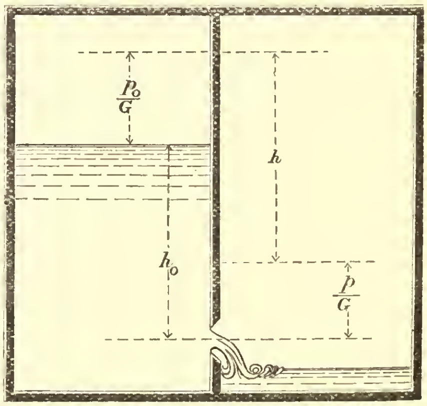


Fig. 45.

$$h = h_0 + \frac{p_0}{G} - \frac{p}{G}\ ;$$

and the velocity of discharge will be

$$v = \sqrt{2g\left\{h_0 + \frac{p_0 - p}{G}\right\}} \quad . \quad . \quad . \quad . \quad . \quad (4).$$

We may express this result by saying that differences of pressure at the free surface and at the orifice are to be reckoned as part of the effective head.

Hence in all cases thus far treated the velocity of the jet is the velocity due to the effective head, and the discharge, allowing for contraction of the jet, is

$$Q = c\omega v = c\omega\sqrt{2gh} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5),$$

where ω is the area of the orifice, $c\omega$ the area of the contracted section of the jet, and h the effective head measured to the centre of the orifice. If h and ω are taken in feet, Q is in cubic feet per second.

It is obvious, however, that this formula assumes that all the filaments have sensibly the same velocity. That will be true for horizontal orifices, and very approximately true in other cases, if the dimensions of the orifice are not large compared with the head h. In large orifices in say a vertical surface, the value of h is different for different filaments, and then the velocity of different filaments is not sensibly the same.

Simple Orifices—Head Constant.

35. *Large Rectangular Jets from Orifices in Vertical Plane Surfaces.*—Let an orifice in a vertical plane surface be so formed that it produces a jet having a rectangular contracted section with vertical and horizontal sides. Let b (fig. 46) be the breadth of the jet, h_1 and h_2 the depths below the free surface of its upper and lower surfaces. Consider a lamina of the jet between the depths h and $h+dh$.

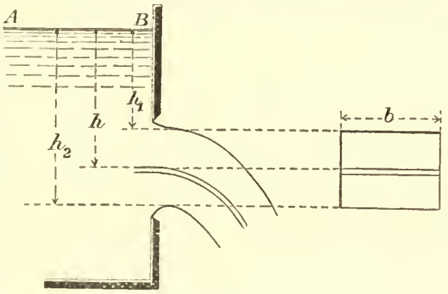


Fig. 46.

Its normal section is bdh, and the velocity of discharge $\sqrt{2gh}$. The discharge per second in this lamina is therefore $b\sqrt{2gh}\,dh$, and that of the whole jet is therefore

$$Q = \int_{h_1}^{h_2} b\sqrt{2gh}\,dh$$

$$= \tfrac{2}{3}\,b\sqrt{2g}\left\{h_2^{\frac{3}{2}} - h_1^{\frac{3}{2}}\right\} \quad . \quad . \quad . \quad . \quad . \quad (6),$$

where the first factor on the right is a coefficient depending on the form of the orifice.

Now an orifice producing a rectangular jet must itself be very approximately rectangular. Let B be the breadth, H_1, H_2, the depths to the upper and lower edges of the orifice. Put

$$\frac{b(h_2^{\frac{3}{2}} - h_1^{\frac{3}{2}})}{B(H_2^{\frac{3}{2}} - H_1^{\frac{3}{2}})} = c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

Then the discharge, in terms of the dimensions of the orifice, instead of those of the jet, is

$$Q = \tfrac{2}{3}cB\sqrt{2g}(H_2^{\frac{3}{2}} - H_1^{\frac{3}{2}}) \quad . \quad . \quad . \quad . \quad . \quad (8),$$

the formula commonly given for the discharge of rectangular orifices. The coefficient c is not, however, simply the coefficient of contraction, the value of which is

$$\frac{b(h_2 - h_1)}{B(H_2 - H_1)},$$

and not that given in (7). It cannot be assumed, therefore, that c in equation (8) is constant, and in fact it is found to vary for different values of $\frac{B}{H_2}$ and $\frac{B}{H_1}$, and must be ascertained experimentally.

Relation between the Expressions (5) and (8).—For a rectangular orifice the area of the orifice is $\omega = B(H_2 - H_1)$, and the depth measured to its centre is $\frac{1}{2}(H_2 + H_1)$. Putting these values in (5),

$$Q_1 = cB(H_2 - H_1)\sqrt{g(H_2 + H_1)}.$$

From (8) the discharge is

$$Q_2 = \tfrac{2}{3}cB\sqrt{2g}(H_2^{\frac{3}{2}} - H_1^{\frac{3}{2}}).$$

Hence, for the same value of c in the two cases,

$$\frac{Q_2}{Q_1} = \frac{2}{3}\,\frac{H_2^{\frac{3}{2}} - H_1^{\frac{3}{2}}}{(H_2 - H_1)\sqrt{\frac{1}{2}(H_2 + H_1)}},$$

$$= 0{\cdot}9427\,\frac{1 - \frac{H_1}{H_2}\sqrt{\frac{H_1}{H_2}}}{1 - \frac{H_1}{H_2}\sqrt{\left(1 + \frac{H_1}{H_2}\right)}} \quad . \quad . \quad . \quad (9).$$

If H_1 varies from 0 to ∞, $\frac{H_1}{H_2}$ varies from 0 to 1. The following table gives values of the two estimates of the discharge for different values of $\frac{H_1}{H_2}$:—

$\frac{H_1}{H_2}$.	$\frac{Q_2}{Q_1}$.	$\frac{H_1}{H_2}$.	$\frac{Q_2}{Q_1}$.
0·0	·943	0·8	·999
0·2	·979	0·9	·999
0·5	·995	1·0	1·000
0·7	·998		

Hence it is obvious that, except for very small values of $\frac{H_1}{H_2}$, the simpler equation (5) gives values sensibly identical with those of (8). When $\frac{H_1}{H_2} < 0{\cdot}5$ it is better to use equation (8) with values of c determined experimentally for the particular proportions of orifice which are in question.

36. *Large Jets having a Circular Section from Orifices in a Vertical Plane Surface.*—Let fig. 47 represent the section of the jet,

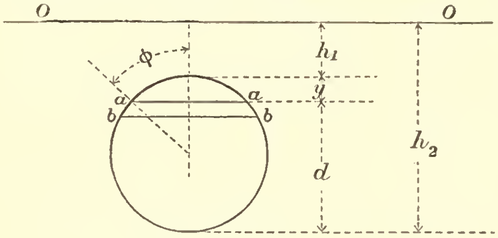


Fig. 47.

OO being the free surface level in the reservoir. The discharge through the horizontal strip $aabb$, of breadth $aa = b$, between the $h_1 + y$ and depths $h_1 + y + dy$, is

$$dQ = b\sqrt{\{2g(h_1 + y)\}}dy\,.$$

The whole discharge of the jet is

$$Q = \int_0^d b\sqrt{\{2g(h_1 + y)\}}dy\,.$$

But $b = d\sin\phi$; $y = \frac{1}{2}d(1 - \cos\phi)$; $dy = \frac{1}{2}d\sin\phi\,d\phi$. Let

$$\epsilon = \frac{d}{2h_1 + d},$$

then

$$Q = \frac{d^2}{2}\sqrt{\left\{2g\left(h_1 + \frac{d}{2}\right)\right\}}\int_0^\pi \sin^2\phi\sqrt{1 - \epsilon\cos\phi}\,d\phi\,.$$

From eq. (5), putting $\omega = \frac{\pi}{4}d^2$, $h = h_1 + \frac{d}{2}$, $c = 1$ when d is the diameter of the jet and not that of the orifice,

$$Q_1 = \frac{\pi}{4}d^2\sqrt{\left\{2g\left(h_1 + \frac{d}{2}\right)\right\}},$$

$$\frac{Q}{Q_1} = \frac{2}{\pi}\int_0^\pi \sin^2\phi\sqrt{\{1 - \epsilon\cos\phi\}}d\phi\,.$$

For $\quad h_1 = \infty$, $\epsilon = 0$ and $\frac{Q}{Q_1} = 1$;

and for $\quad h_1 = 0$, $\epsilon = 1$ and $\frac{Q}{Q_1} = 0{\cdot}96$.

So that in this case also the difference between the simple formula (5) and the formula above, in which the variation of head at different parts of the orifice is taken into account, is very small.

Notches and Weirs.

37. *Notches, Weirs, and Bycwashes.*—A notch is an orifice extending up to the free surface level in the reservoir from which the discharge takes place. A weir is a structure over which the water flows, the discharge being in the same conditions as for a notch. The formula of discharge for an orifice of this kind is ordinarily deduced by putting $H_1 = 0$ in the formula for the corresponding orifice, ob-

tained as in the preceding section. Thus for a rectangular notch, put $H_1=0$ in (8). Then

$$Q=\tfrac{2}{3}\,c\,B\sqrt{2g}\;H^{\frac{3}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11),$$

where H is put for the depth to the crest of the weir or the bottom of the notch. Fig. 48 shows the mode in which the discharge occurs in the case of a rectangular notch or weir with a level crest. As the free surface level falls very sensibly near the notch, the head H should be measured at some distance back from the notch, at a point where the velocity of the water is very small.

Since the area of the notch opening is BH, the above formula is of the form

$$Q=c\times BH\times k\sqrt{2gH}\,,$$

where k is a factor depending on the form of the notch and expressing the ratio of the mean velocity of discharge to the velocity due to the depth H.

38. *Francis's Formula for Rectangular Notches.*—The jet discharged through a rectangular notch has a section smaller than BH, (*a*) because of the fall of the water surface from the point where H is measured towards the weir, (*b*) in consequence of the crest contraction, (*c*) in consequence of the end contractions. It may be pointed out that while the diminution of the section of the jet due to the surface fall and to the crest contraction is proportional to the length of the weir, the end contractions have nearly the same effect whether the weir is wide or narrow.

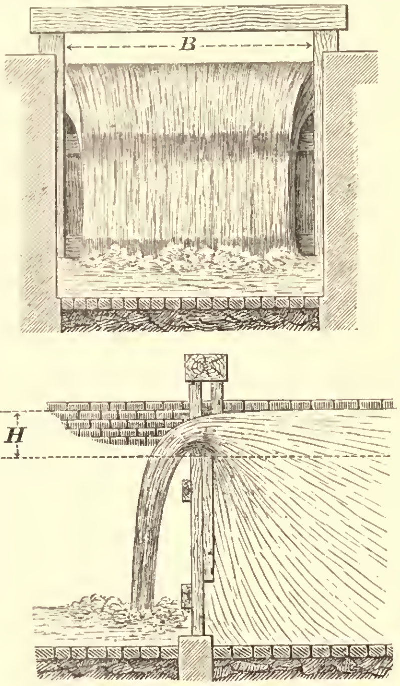


Fig. 48.

Mr Francis's experiments showed that a perfect end contraction, when the heads varied from 3 to 24 inches, and the length of the weir was not less than three times the head, diminished the effective length of the weir by an amount approximately equal to one-tenth of the head. Hence, if l is the length of the notch or weir, and H the head measured behind the weir where the water is nearly still, then the width of the jet passing through the notch would be $l-0{\cdot}2H$, allowing for two end contractions. In a weir divided by posts there may be more than two end contractions. Hence, generally, the width of the jet is $l-0{\cdot}1nH$, where n is the number of end contractions of the stream. The contractions due to the fall of surface and to the crest contraction are proportional to the width of the jet. Hence, if cH is the thickness of the stream over the weir, measured at the contracted section, the section of the jet will be $c(l-0{\cdot}1nH)H$ and (§ 37) the mean velocity will be $\tfrac{2}{3}\sqrt{2gH}$. Consequently the discharge will be given by an equation of the form

$$Q=\tfrac{2}{3}c(l-0{\cdot}1nH)H\sqrt{2gH}$$

$$=5{\cdot}35c(l-0{\cdot}1nH)H^{\frac{3}{2}}\,.$$

This is Francis's formula, in which the coefficient of discharge c is much more nearly constant for different values of l and h than in the ordinary formula. Francis found for c the mean value 0·622, the weir being sharp-edged.

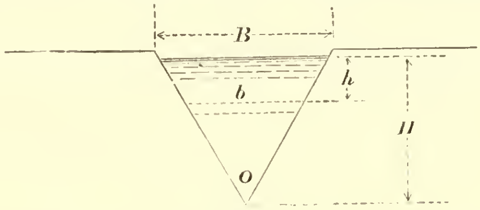


Fig. 49.

39. *Triangular Notch* (fig. 49).—Consider a lamina issuing between the depths h and $h+dh$. Its area, neglecting contraction, will be bdh, and the velocity at that depth is $\sqrt{2gh}$. Hence the discharge for this lamina is

$$b\sqrt{2gh}\,dh\,.$$

But

$$\frac{B}{b}=\frac{H}{H-h}\,;$$

$$b=B\frac{H-h}{H}\,.$$

Hence discharge of lamina

$$=B\,\frac{H-h}{H}\sqrt{2gh}\,dh\,;$$

and total discharge of notch

$$=Q=B\sqrt{2g}\int_0^H\frac{H-h}{H}h^{\frac{1}{2}}\,dh$$

$$=\tfrac{4}{15}B\sqrt{2g}\,H^{\frac{5}{2}}\,,$$

or, introducing a coefficient to allow for contraction,

$$Q=\tfrac{4}{15}cB\sqrt{2g}\,H^{\frac{5}{2}}\,.$$

When a notch is used to gauge a stream of varying flow, the ratio $\frac{B}{H}$ varies if the notch is rectangular, but is constant if the notch is triangular. This led Professor James Thomson to suspect that the coefficient of discharge, c, would be much more constant with different values of H in a triangular than in a rectangular notch, and this has been experimentally shown to be the case. Hence a triangular notch is more suitable for accurate gaugings than a rectangular notch. For a sharp-edged triangular notch Professor J. Thomson found $c=0{\cdot}617$. It will be seen, as in § 37, that since $\tfrac{1}{2}BH$ is the area of section of the stream through the notch, the formula is again of the form

$$Q=c\times\tfrac{1}{2}BH\times k\sqrt{2gH}\,,$$

where $k=\tfrac{8}{15}$ is the ratio of the mean velocity in the notch to the velocity at the depth H. It may easily be shown that for all notches the discharge can be expressed in this form.

40. *Weir with a Broad Sloping Crest.*—Suppose a weir formed with a broad crest so sloped that the streams flowing over it have a movement sensibly rectilinear and uniform (fig. 50). Let the inner edge be

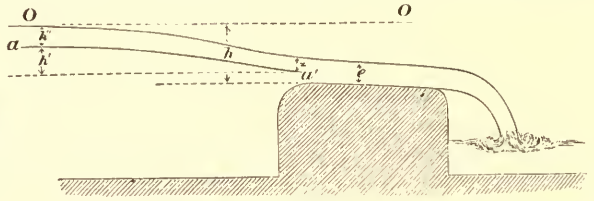


Fig. 50.

so rounded as to prevent a crest contraction. Consider a filament aa', the point a being so far back from the weir that the velocity of approach is negligible. Let OO be the surface level in the reservoir, and let a be at a height h'' below OO, and h' above a'. Let h be the distance from OO to the weir crest and e the thickness of the stream upon it. Neglecting atmospheric pressure, which has no influence, the pressure at a is Gh''; at a' it is Gz. If v be the velocity at a',

$$\frac{v^2}{2g}=h'+h''-z=h-e\,;$$

$$Q=be\sqrt{2g(h-e)}\,.$$

Theory does not furnish a value for e, but $Q=0$ for $e=0$ and for $e=h$. Q has therefore a maximum for a value of e between 0 and h, obtained by equating $\frac{dQ}{de}$ to zero. This gives $e=\tfrac{2}{3}h$, and, inserting this value,

$$Q=0{\cdot}385\,bh\sqrt{2gh}\,,$$

as a maximum value of the discharge with the conditions assigned. Experiment shows that the actual discharge is very approximately equal to this maximum, and the formula is more legitimately applicable to the discharge over broad-crested weirs and to cases such as the discharge with free upper surface through large masonry sluice openings than the ordinary weir formula for sharp-edged weirs. It should be remembered, however, that the friction on the sides and crest of the weir has been neglected, and that this tends to reduce a little the discharge. The formula is equivalent to the ordinary weir formula with $c=0{\cdot}577$.

Coefficients for the Discharge over Weirs, derived from the Experiments of Mr Blackwell. When more than one experiment was made with the same head, and the results were pretty uniform, the resulting coefficients are marked with an (*). The effect of the converging wing-boards is very strongly marked.

Heads in inches measured from still Water in Reservoir.	Sharp Edge.		Planks 2 inches thick, square on Crest				Crests 3 feet wide.					
	3 feet long.	10 feet long.	3 feet long.	6 feet long.	10 feet long.	10 feet long, wing boards making an angle of 60°.	3 feet long, level.	3 feet long, fall 1 in 18.	3 feet long, fall 1 in 12.	6 feet long, level.	10 feet long, level.	10 feet long, fall 1 in 18.
1	·677	·809	·467	·459	·435[1]	·754	·452	·545	·467	...	·381	·467
2	·675	·803	·509*	·561	·585*	·675	·482	·546	·533	...	·479*	·495*
3	·630	·642*	·563*	·597*	·569*	...	·441	·537	·539	·492*	...	...
4	·617	·656	·549	·575	·602*	·656	·419	·431	·455	·497*	...	·515
5	·602	·650*	·588	·601*	·609*	·671	·479	·516	...	...	·518	...
6	·593	...	·593*	·608*	·576*	...	·501*	...	·531	·507	·513	·543
7	...	...	·617*	·608*	·576*	...	·488	·513	·527	·497	...	...
8	...	·581	·606*	·590*	·548*	...	·470	·491	...	...	·468	·507
9	...	·530	·600	·569*	·558*	...	·476	·492*	·498	·480*	·486	...
10	...	...	·614*	·539	·534*	...	...	...	...	·465*	·455	...
12	...	...	...	·525	·534*	...	...	...	...	·467*	...	...
14	...	...	...	·549*	...	...	...	...	...	...	...	...

[1] The discharge per second varied from ·461 to ·665 cubic feet in two experiments. The coefficient ·435 is derived from the mean value.

Special Cases of Discharge from Orifices.

41. *Cases in which the Velocity of Approach needs to be taken into Account. Rectangular Orifices and Notches.*—In finding the velocity at the orifice in the preceding investigations, it has been assumed that the head h has been measured from the free surface of still water above the orifice. In many cases which occur in practice the channel of approach to an orifice or notch is not so large, relatively to the stream through the orifice or notch, that the velocity in it can be disregarded.

Let h_1, h_2 (fig. 51) be the heads measured from the free surface to the top and bottom edges of a rectangular orifice, at a point in the

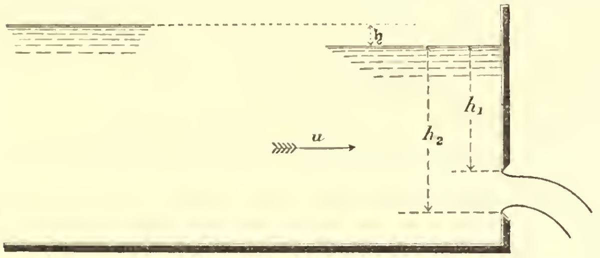


Fig. 51.

channel of approach where the velocity is u. It is obvious that a fall of the free surface,

$$\mathfrak{h} = \frac{u^2}{2g}$$

has been somewhere expended in producing the velocity u, and hence the true heads measured in still water would have been $h_1 + \mathfrak{h}$ and $h_2 + \mathfrak{h}$. Consequently the discharge, allowing for the velocity of approach, is

$$Q = \tfrac{2}{3} cb \sqrt{2g} \left\{ (h_2 + \mathfrak{h})^{\frac{3}{2}} - (h_1 + \mathfrak{h})^{\frac{3}{2}} \right\} \quad . \quad . \quad . \quad . \quad (1).$$

And for a rectangular notch for which $h_1 = 0$, the discharge is

$$Q = \tfrac{2}{3} cb \sqrt{2g} \left\{ (h_2 + \mathfrak{h})^{\frac{3}{2}} - \mathfrak{h}^{\frac{3}{2}} \right\} \quad . \quad . \quad . \quad . \quad . \quad (2).$$

In cases where u can be directly determined, these formulæ give the discharge quite simply. When, however, u is only known as a function of the section of the stream in the channel of approach, they become complicated. Let Ω be the sectional area of the channel where h_1 and h_2 are measured. Then $u = \dfrac{Q}{\Omega}$ and $\mathfrak{h} = \dfrac{Q^2}{2g\Omega^2}$.

This value introduced in the equations above would render them excessively cumbrous. In cases therefore where Ω only is known, it is best to proceed by approximation. Calculate an approximate value Q′ of Q by the equation

$$Q' = \tfrac{2}{3} cb \sqrt{2g} \left\{ h_2^{\frac{3}{2}} - h_1^{\frac{3}{2}} \right\} .$$

Then $\mathfrak{h} = \dfrac{Q'^2}{2g\Omega^2}$ nearly. This value of $\mathfrak{h}$ introduced in the equations above will give a second and much more approximate value of Q.

42. *Partially Submerged Rectangular Orifices and Notches.*—When the tail water is above the lower but below the upper edge of the orifice, the flow in the two parts of the orifice, into which it is divided by the surface of the tail water, takes place under different conditions. A filament M_1m_1 (fig. 52) in the upper part of the orifice issues with a head h' which may have any value between h_1 and h. But a filament M_2m_2 issuing in the lower part of the orifice has a velocity due to $h'' - h'''$, or h, simply. In the upper part

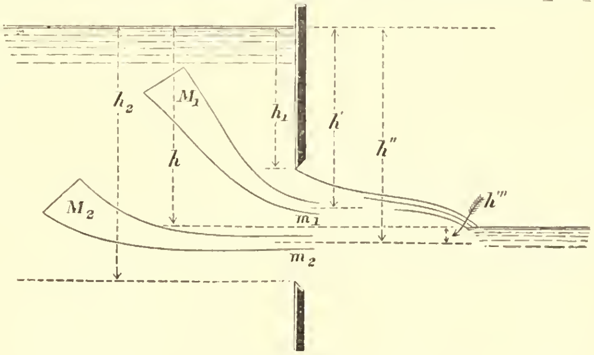


Fig. 52.

of the orifice the head is variable, in the lower constant. If Q_1, Q_2 are the discharges from the upper and lower parts of the orifice, b the width of the orifice, then

$$\left. \begin{aligned} Q_1 &= \tfrac{2}{3} cb \sqrt{2g} \left\{ h^{\frac{3}{2}} - h_1^{\frac{3}{2}} \right\} \\ Q_2 &= cb(h_2 - h)\sqrt{2gh} \end{aligned} \right\} \quad . \quad . \quad . \quad . \quad . \quad (3).$$

In the case of a rectangular notch or weir, $h_1 = 0$. Inserting this value, and adding the two portions of the discharge together, we get for a drowned weir

$$Q = cb\sqrt{2gh}\left(h_2 - \frac{h}{3} \right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (4),$$

where h is the difference of level of the head and tail water, and h_2 is the head from the free surface above the weir to the weir crest. If velocity of approach is taken into account, let $\mathfrak{h}$ be the head due to that velocity; then, adding $\mathfrak{h}$ to each of the heads in the equations (3), and reducing, we get for a weir

$$Q = cb\sqrt{2g}\left[(h_2 + \mathfrak{h})(h + \mathfrak{h})^{\frac{1}{2}} - \tfrac{1}{3}(h + \mathfrak{h})^{\frac{3}{2}} - \tfrac{2}{3}\mathfrak{h}^{\frac{3}{2}} \right] \quad . \quad . \quad (5);$$

an equation which may be useful in estimating flood discharges.

Bridge Piers and other Obstructions in Streams.—When the piers of a bridge are erected in a stream they create an obstruction to the flow of the stream, which causes a difference of surface-level above

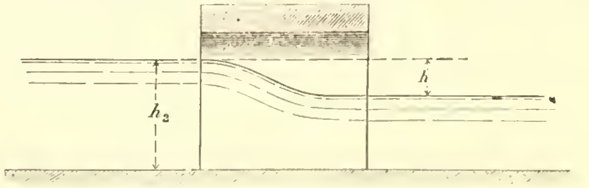


Fig. 53.

and below the pier (fig. 53). If it is necessary to estimate this difference of level, the flow between the piers may be treated as if it occurred over a drowned weir. But the value of c in this case is imperfectly known.

43. *Separating Weirs.*—Many towns derive their water supply from streams in high moorland districts, in which the flow is extremely variable. The water is collected in large storage reservoirs, from which an uniform supply can be sent to the town. In such cases it is desirable to separate the coloured water which comes down the streams in high floods from the purer water of ordinary flow. The latter is sent into the reservoirs; the former is allowed to flow away down the original stream channel, or is stored in separate reservoirs and used as compensation water. To accomplish the separation of the flood and ordinary water, advantage is taken of the different horizontal range of the parabolic path of the water falling over a weir, as the depth on the weir and, consequently, the velocity change. Fig. 54 shows one of these separating weirs in the form in which they were first introduced on the Manchester Waterworks; fig 55 a more modern weir of the same kind designed by Mr Binnie for the Bradford Waterworks. When the quantity of water coming

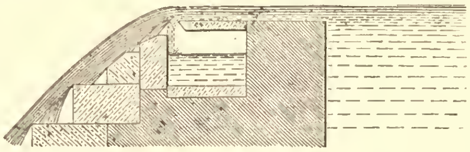
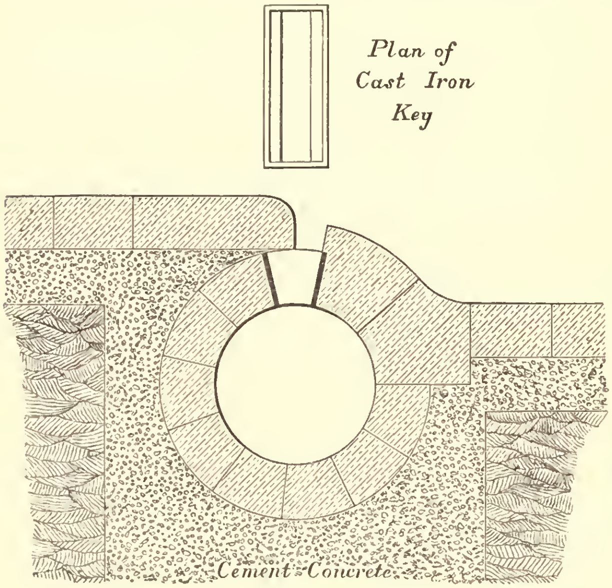


Fig. 54.



Fig, 55.

down the stream is not excessive, it drops over the weir into a transverse channel leading to the reservoirs. In flood, the water springs over the mouth of this channel and is led into a waste channel.

It may be assumed, probably with accuracy enough for practical purposes, that the particles describe the parabolas due to the mean velocity of the water passing over the weir, that is, to a velocity

$$\tfrac{2}{3}\sqrt{2gh}\,,$$

where h is the head above the crest of the weir.

Let $eb = x$ be the width of the orifice and $ac = y$ the difference of level of its edges (fig. 56). Then, if a particle passes from a to b in t seconds,

$$x = \tfrac{1}{2}gt^2\,,$$
$$y = \tfrac{2}{3}\sqrt{2gh}\,t\,;$$
$$\therefore \quad x = \tfrac{9}{16}\frac{y^2}{h}\,,$$

which gives the width x for any given difference of level y and head h, which the jet will just pass over the orifice. Set off ad vertically and equal to $\frac{1}{2}g$ on any scale; af horizontally and equal to $\frac{2}{3}\sqrt{gh}$. Divide af, fe into an equal number of equal parts. Join a with the divisions on ef. The intersections of these lines with verticals from the divisions on af give the parabolic path of the jet.

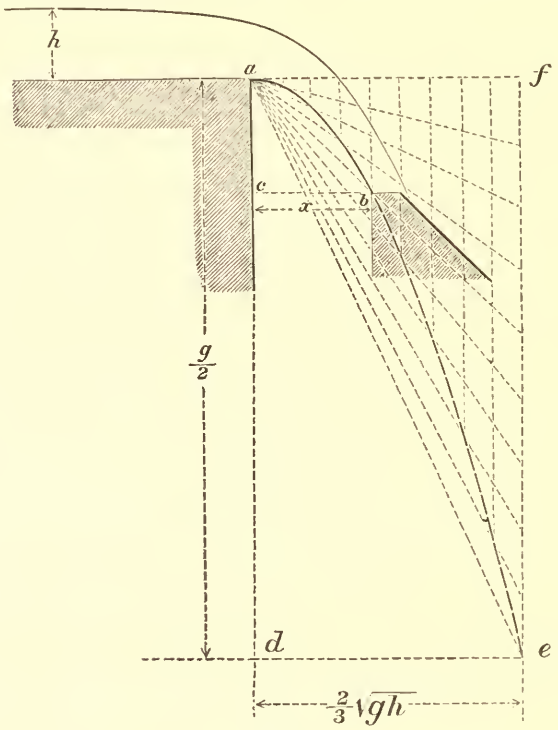


Fig. 56.

Mouthpieces—Head Constant.

44. *Cylindrical Mouthpieces.*—When water issues from a short cylindrical pipe or mouthpiece of a length at least equal to $1\frac{1}{2}$ times its smallest transverse dimension, the stream, after contraction within the mouthpiece, expands to fill it and issues full bore, or without contraction, at the point of discharge. The discharge is found to be about one-third greater than that from a simple orifice of the same size. On the other hand, the energy of the fluid per unit of weight is less than that of the stream from a simple orifice with the same head, because part of the energy is wasted in eddies produced at the point where the stream expands to fill the mouthpiece, the action being something like that which occurs at an abrupt change of section.

Let fig. 57 represent a vessel discharging through a cylindrical mouthpiece at the depth h from the free surface, and let the axis of the jet XX be taken as the datum with reference to which the head is estimated. Let Ω be the area of the mouthpiece, ω the area of the stream at the contracted section EF. Let v, p be the velocity and pressure at EF, and v_1, p_1 the same quantities at GH. If the discharge is into the air, p_1 is equal to the atmospheric pressure p_a.

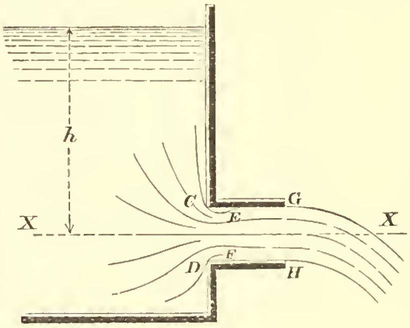


Fig. 57.

The total head of any filament which goes to form the jet, taken at a point where its velocity is sensibly zero, is $h + \frac{p_a}{G}$; at EF the total head is $\frac{v^2}{2g} + \frac{p}{G}$; at GH it is $\frac{v_1^2}{2g} + \frac{p_1}{G}$.

Between EF and GH there is a loss of head due to abrupt change of velocity, which from eq. (3), § 32, may have the value

$$\frac{(v - v_1)^2}{2g}\,.$$

Adding this head lost to the head at GH, before equating it to the heads at EF and at the point where the filaments start into motion,—

$$h + \frac{p_a}{G} = \frac{v^2}{2g} + \frac{p}{G} = \frac{v_1^2}{2g} + \frac{p_1}{G} + \frac{(v - v_1)^2}{2g}\,.$$

But $\omega v = \Omega v_1$, and $\omega = c_c\Omega$, if c_c is the coefficient of contraction within the mouthpiece. Hence

$$v = \frac{\Omega}{\omega}v_1 = \frac{v_1}{c_c}\,.$$

Supposing the discharge into the air, so that $p_1 = p_a$,

$$h + \frac{p_a}{G} = \frac{v_1^2}{2g} + \frac{p_a}{G} + \frac{v_1^2}{2g}\left(\frac{1}{c_c} - 1\right)^2 ;$$

$$\frac{v_1^2}{2g}\left\{1 + \left(\frac{1}{c_c} - 1\right)^2\right\} = h ;$$

$$\therefore \quad v_1 = \frac{1}{\sqrt{1 + \left(\frac{1}{c_c} - 1\right)^2}} \sqrt{2gh} \quad . \quad . \quad . \quad . \quad (1);$$

where the first term on the right is evidently the coefficient of velocity for the cylindrical mouthpiece in terms of the coefficient of contraction at EF. Let $c_c = 0{\cdot}64$, the value for simple orifices, then the coefficient of velocity is

$$c_v = \frac{1}{\sqrt{1 + \left(\frac{1}{c_c} - 1\right)^2}} = 0{\cdot}87 \quad . \quad . \quad . \quad . \quad (2).$$

The actual value of c_v found by experiment is 0·82, which does not differ more from the theoretical value than might be expected if the friction of the mouthpiece is allowed for. Hence, for mouthpieces of this kind, and for the section at GH,

$$c_v = 0{\cdot}82 \quad c_c = 1{\cdot}00 \quad c = 0{\cdot}82,$$

$$Q = 0{\cdot}82\,\Omega\sqrt{2gh}$$

It is easy to see from the equations that the pressure p at EF is less than atmospheric pressure. Eliminating v_1, we get

$$\frac{p_a - p}{G} = \tfrac{3}{4}h \text{ nearly} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3);$$

or

$$p = p_a - \tfrac{3}{4}Gh \text{ lb per sq. ft.}$$

If a pipe connected with a reservoir on a lower level is introduced into the mouthpiece at the part where the contraction is formed (fig. 58), the water will rise in this pipe to a height

$$KL = \frac{p_a - p}{G} = \tfrac{3}{4}h \text{ nearly.}$$

If the distance X is less than this, the water from the lower reservoir will be forced continuously into the jet by the atmospheric pressure, and discharged with it. This is the crudest form of a kind of pump known as the jet pump.

45. *Convergent Mouthpieces.*—With convergent mouthpieces there is a contraction within the mouthpiece causing a loss of head, and a diminution of the velocity of discharge, as with cylindrical mouthpieces. There is also a second contraction of the stream outside the mouthpiece. Hence the discharge is given by an equation of the form

$$Q = c_v c_c \Omega \sqrt{2gh} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4),$$

where Ω is the area of the external end of the mouthpiece, and $c_c\Omega$ the section of the contracted jet beyond the mouthpiece.

Convergent Mouthpieces (Castel's Experiments).—Smallest diameter of orifice = 0·05085 feet. Length of mouthpiece = 2·6 diameters.

Angle of Convergence.	Coefficient of Contraction, c_c	Coefficient of Velocity, c_v	Coefficient of Discharge, c
0° 0′	·999	·830	·829
1° 36′	1·000	·866	·866
3° 10′	1·001	·894	·895
4° 10′	1·002	·910	·912
5° 26′	1·004	·920	·924
7° 52′	·998	·931	·929
8° 58′	·992	·942	·934
10° 20′	·987	·950	·938
12° 4′	·986	·955	·942
13° 24′	·983	·962	·946
14° 28′	·979	·966	·941
16° 36′	·969	·971	·938
19° 28′	·953	·970	·924
21° 0′	·945	·971	·918
23° 0′	·937	·974	·913
29° 58′	·919	·975	·896
40° 20′	·887	·980	·869
48° 50′	·861	·984	·847

The maximum coefficient of discharge is that for a mouthpiece with a convergence of 13° 24′.

The values of c_v and c_c must here be determined by experiment. The above table gives values sufficient for practical purposes. Since the contraction beyond the mouthpiece increases with the convergence, or, what is the same thing, c_c diminishes, and on the other hand the loss of energy diminishes, so that c_v increases with the convergence, there is an angle for which the product $c_c\, c_v$, and consequently the discharge, is a maximum.

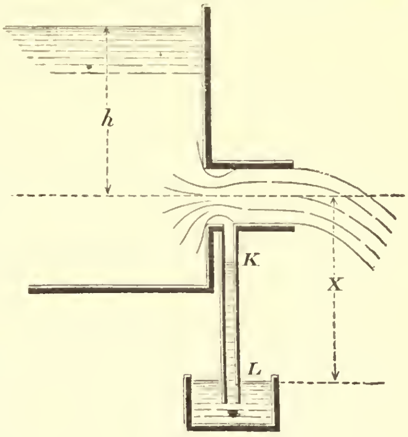


Fig. 58.

46. *Divergent Conoidal Mouthpiece.*—Suppose a mouthpiece so designed that there is no abrupt change in the section or velocity of the stream passing through it. It may have a form at the inner end approximately the same as that of a simple contracted vein, and may then enlarge gradually, as shown in fig. 59. Suppose that at EF it becomes cylindrical, so that the jet may be taken to be of the diameter EF. Let ω, v, p be the section, velocity, and pressure at CD, and Ω, v_1, p_1 the same quantities at EF, p_a being as usual the atmospheric pressure, or pressure on the free surface AB. Then, since there is no loss of energy, except the small frictional resistance of the surface of the mouthpiece,

$$h + \frac{p_a}{G} = \frac{v^2}{2g} + \frac{p}{G} = \frac{v_1^2}{2g} + \frac{p_1}{G}.$$

If the jet discharges into the air, $p_1 = p_a$; and

$$\frac{v_1^2}{2g} = h ;$$

$$v_1 = \sqrt{2gh} ;$$

or, if a coefficient is introduced to allow for friction,

$$v_1 = c_v\sqrt{2gh} ;$$

where c_v is about 0·97 if the mouthpiece is smooth and well-formed.

$$Q = \Omega v_1 = c_v \Omega \sqrt{2gh}.$$

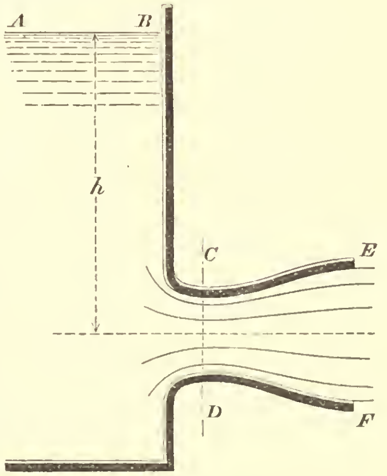


Fig. 59.

Hence the discharge depends on the area of the stream at EF, and not at all on that at CD, and the latter may be made as small as we please without affecting the amount of water discharged.

There is, however, a limit to this. As the velocity at CD is greater than at EF the pressure is less, and therefore less than atmospheric pressure, if the discharge is into the air. If CD is so contracted that $p = 0$, the continuity of flow is impossible. In fact the stream disengages itself from the mouthpiece for some value of p greater than 0 (fig. 60).

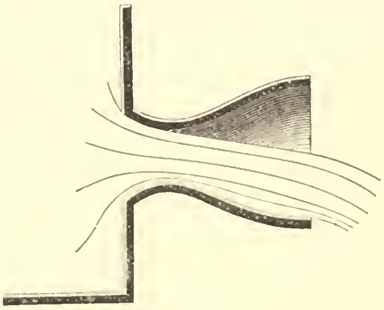


Fig. 60.

From the equations,

$$\frac{p}{G} = \frac{p_a}{G} - \left(\frac{v^2 - v_1^2}{2g}\right).$$

Let $\frac{\Omega}{\omega} = m$. Then

$$v = v_1 m ;$$

$$\frac{p}{G} = \frac{p_a}{G} - \frac{v_1^2}{2g}(m^2 - 1)$$

$$= \frac{p_a}{G} - (m^2 - 1)h ;$$

whence we find that $\frac{p}{G}$ will become zero or negative if

$$\frac{\Omega}{\omega} \geqq \sqrt{\frac{h+\frac{p_a}{G}}{h}} = \sqrt{1+\frac{p_a}{Gh}}\,;$$

or, putting $\frac{p_a}{G}=34$ feet, if

$$\frac{\Omega}{\omega} \geqq \sqrt{\frac{h+34}{h}}\,.$$

In practice there will be an interruption of the full bore flow with a less ratio of $\frac{\Omega}{\omega}$, because of the disengagement of air from the water. But, supposing this does not occur, the maximum discharge of a mouthpiece of this kind is

$$Q=\omega\sqrt{2g\left(h+\frac{p_a}{G}\right)}\,;$$

that is, the discharge is the same as for a well-bellmouthed mouthpiece of area ω, and without the expanding part, discharging into a vacuum.

47. *Jet Pump.*—A divergent mouthpiece may be arranged to act as a pump, as shown in fig. 61. The water which supplies the energy

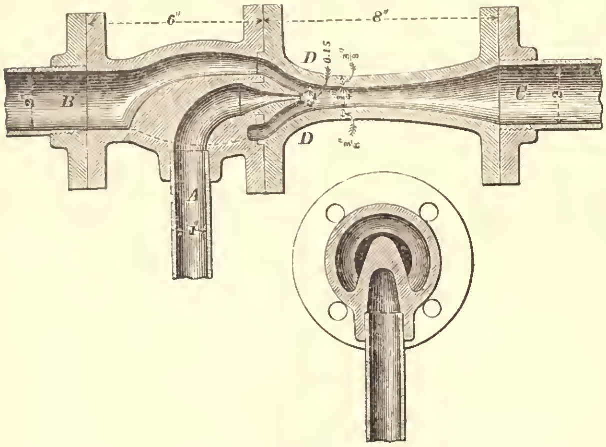


Fig. 61

required for pumping enters at A. The water to be pumped enters at B. The streams combine at DD where the velocity is greatest and the pressure least. Beyond DD the stream enlarges in section, and its pressure increases, till it is sufficient to balance the head due to the height of the lift, and the water flows away by the discharge pipe C.

Fig. 62 shows the whole arrangement in a diagrammatic way. A is the reservoir which supplies the water that effects the pump-

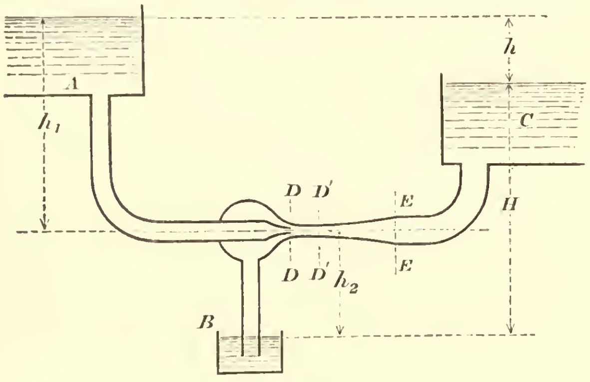


Fig. 62.

ing; B is the reservoir of water to be pumped; C is the reservoir into which the water is pumped.

Discharge with Varying Head.

48. *Flow from a Vessel when the Effective Head varies with the Time.*—Various useful problems arise relating to the time of emptying and filling vessels, reservoirs, lock chambers, &c., where the flow is dependent on a head which increases or diminishes during the operation. The simplest of these problems is the case of filling or emptying a vessel of constant horizontal section.

Time of Emptying or Filling a Vertical-sided Lock Chamber.—Suppose the lock chamber, which has a water surface of Ω square feet, is emptied through a sluice in the tail gates, of area ω, placed below the tail-water level. Then the effective head producing flow through the sluice is the difference of level in the chamber and tail bay. Let H (fig. 63) be the initial difference of level, h the difference

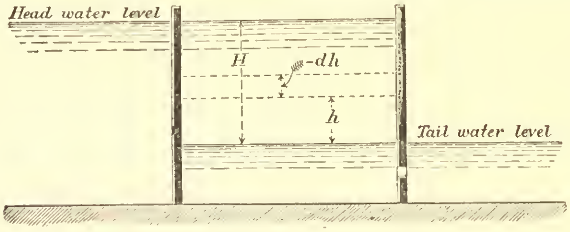


Fig. 63.

of level after t seconds. Let $-dh$ be the fall of level in the chamber during an interval dt. Then in the time dt the volume in the chamber is altered by the amount $-\Omega dh$, and the outflow from the sluice in the same time is $c\omega\sqrt{2gh}\,dt$. Hence the differential equation connecting h and t is

$$c\omega\sqrt{2gh}\,dt+\Omega h=0.$$

For the time t, during which the initial head H diminishes to any other value h,

$$-\frac{\Omega}{c\omega\sqrt{2g}}\int_H^h\frac{dh}{\sqrt{h}}=\int_0^t dt.$$

$$\therefore\ t=\frac{\Omega}{c\omega\sqrt{2g}}\,2\left(\sqrt{H}-\sqrt{h}\right)$$

$$=\frac{\Omega}{c\omega}\left\{\sqrt{\frac{2H}{g}}-\sqrt{\frac{2h}{g}}\right\}.$$

For the whole time of emptying, during which h diminishes from H to 0,

$$T=\frac{\Omega}{c\omega}\sqrt{\frac{2H}{g}}\,.$$

Comparing this with the equation for flow under a constant head, it will be seen that the time is double that required for the discharge of an equal volume under a constant head.

The time of filling the lock through a sluice in the head gates is exactly the same, if the sluice is below the tail-water level. But if the sluice is above the tail-water level, then the head is constant till the level of the sluice is reached, and afterwards it diminishes with the time.

Practical Use of Orifices in Gauging Water.

49. If the water to be measured is passed through a known orifice under an arrangement by which the constancy of the head is ensured, the amount which passes in a given time can be ascertained by the formulæ already given. It will obviously be best to make the orifices of the forms for which the coefficients are most accurately determined; hence sharp-edged orifices or notches are most commonly used.

Water Inch.—For measuring small quantities of water circular sharp-edged orifices have been used. The discharge from a circular orifice one French inch in diameter, with a head of one line above the top edge, was termed by the older hydraulic writers a water-inch. A common estimate of its value was 14 pints per minute, or 677 English cubic feet in 24 hours. An experiment by Bossut gave 634 cubic feet in 24 hours (see Navier's edition of *Belidor's Arch. Hydr.*, p. 212).

Weisbach points out that measurements of this kind would be made more accurately with a greater head over the orifice, and he proposes that the head should be equal to the diameter of the orifice. Several equal orifices may be used for larger discharges.

50. *Pin Ferrules or Measuring Cocks.*—To give a tolerably definite supply of water to houses, without the expense of a meter, a ferrule with an orifice of a definite size, or a cock, is introduced in the service-pipe. If the head in the water main is constant, then a definite quantity of water would be delivered in a given time. The arrangement is not a very satisfactory one, and acts chiefly as a check on extravagant use of water. It is interesting here chiefly as an example of regulation of discharge by means of an orifice. Fig. 64 shows a cock of this kind used at Zurich. It consists of three cocks, the middle one having the orifice of the predetermined size in a small circular plate, protected by wire gauze from stoppage by impurities in the water. The cock on the right hand can be used by the consumer for emptying the pipes. The one on the left and the measuring cock are connected by a key which can be locked by a padlock, which is under the control of the water company.

51. *Measurement of the Flow in Streams.*—To determine the quantity of water flowing off the ground in small streams, which is available for water supply or for obtaining water power, small temporary weirs are often used. These may be formed of planks supported by piles and puddled to prevent leakage. The measurement of the head may be made by a thin-edged scale at a short distance behind the weir, where the water surface has not begun to slope down to the weir and where the velocity of approach is not high. The measurements are conveniently made from a short pile driven into the bed of the river, accurately level with the crest of the weir (fig. 65). Then if at any moment the head is h, the discharge is, for a rectangular notch of breadth b,

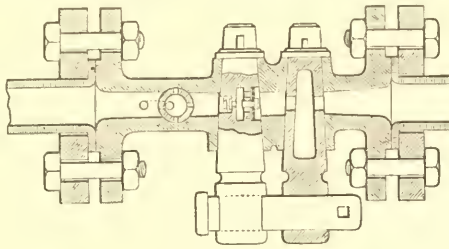


Fig. 64.

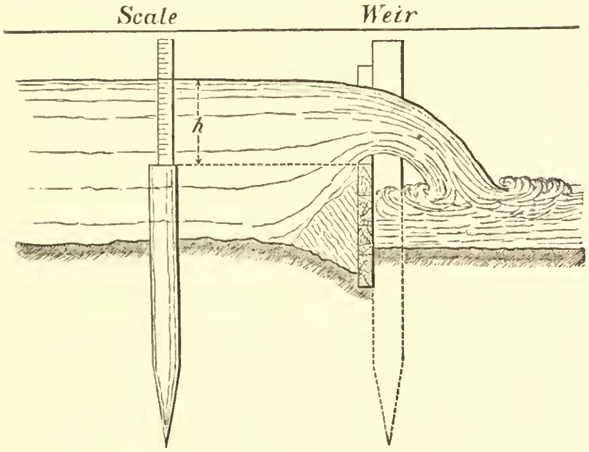


Fig. 65.

$$Q = \tfrac{2}{3} c b h \sqrt{2gh}$$

where $c = 0\cdot62$; or, better, the formula in § 38 may be used.

Gauging weirs are most commonly in the form of rectangular notches; and care should be taken that the crest is accurately horizontal, and that the weir is normal to the direction of flow of the stream. If the planks are thick, they should be bevelled (fig. 66), and then the edge may be protected by a metal plate about $\frac{1}{16}$th inch thick to secure the requisite accuracy of form and sharpness of edge. In permanent gauging weirs a cast steel plate is sometimes used to form the edge of the weir crest. The weir should be large enough to discharge the maximum volume flowing in the stream, and at the same time it is desirable that the minimum head should not be too small (say half a foot) to decrease the effects of errors of measurement. The section of the jet over the weir should not exceed one-fifth the section of the stream behind the weir, or the velocity of approach will need to be taken into account. A triangular notch is very suitable for measurements of this kind.

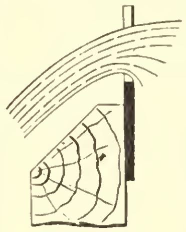


Fig. 66.

If the flow is variable, the head h must be recorded at equidistant intervals of time, say twice daily, and then for each 12 hour period the discharge must be calculated for the mean of the heads at the beginning and end of the time. As this involves a good deal of troublesome calculation, Mr Sang has proposed to use a scale so graduated as to read off the discharge in cubic feet per second. The lengths of the principal graduations of such a scale are easily calculated by putting $Q = 1, 2, 3 \ldots$ in the ordinary formulæ for notches; the intermediate graduations may be taken accurately enough by subdividing equally the distances between the principal graduations.

The accurate measurement of the discharge of a stream by means of a weir is, however, in practice, rather more difficult than might be inferred from the simplicity of the principle of the operation. Apart from the difficulty of selecting a suitable coefficient of discharge, which need not be serious if the form of the weir and the nature of its crest are properly attended to, other difficulties of measurement arise. The length of the weir should be very accurately determined, and if the weir is rectangular its deviations from exactness of level should be tested. Then the agitation of the water, the ripple on its surface, and the adhesion of the water to the scale on which the head is measured, are liable to introduce errors. Upon a weir 10 feet long, with 1 foot depth of water flowing over an error of 1-1000th of a foot in measuring the head, or an error of 1-100th of a foot in measuring the length of the weir, would cause an error in computing the discharge of 2 cubic feet per minute.

52. *Hook Gauge.*—For the determination of the surface level of water, the most accurate instrument is the hook gauge used first by Mr U. Boyden of Boston, in 1840. It consists of a fixed frame with scale and vernier. In the instrument in fig. 67 the vernier is fixed to the frame, and the scale slides vertically. The scale carries at its lower end a hook with a fine point, and the scale can be raised or lowered by a fine pitched screw. If the hook is depressed below the water surface and then raised by the screw, the moment of its reaching the water surface will be very distinctly marked, by the reflexion from a small capillary elevation of the water surface over the point of the hook. In ordinary light, differences of level of the water of ·001 of a foot are easily detected by the hook gauge. If such a gauge is used to determine the heads at a weir, the hook should first be set accurately level with the weir crest, and a reading taken. Then the difference of the reading at the water surface and that for the weir crest will be the head at the weir.

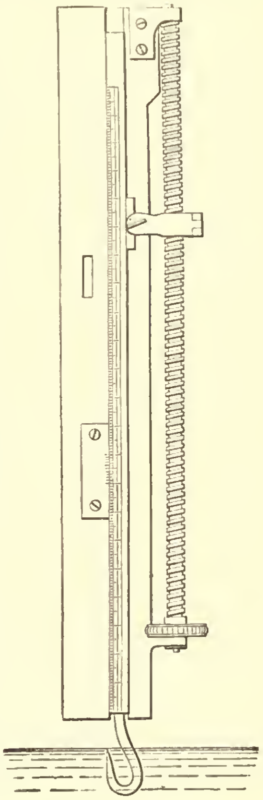


Fig. 67.

53. *Modules used in Irrigation.*—In distributing water for irrigation, the charge for the water may be simply assessed on the area of the land irrigated for each consumer, a method followed in India; or a regulated quantity of water may be given to each consumer, and the charge may be made proportional to the quantity of water supplied, a method employed for a long time in Italy and other parts of Europe. To deliver a regulated quantity of water from the irrigation channel, arrangements termed modules are used. These are constructions intended to maintain a constant or approximately constant head above an orifice of fixed size, or to regulate the size of the orifice so as to give a constant discharge, notwithstanding the variation of level in the irrigating channel.

54. *Italian Module.*—The Italian modules are masonry constructions, consisting of a regulating chamber, to which water is admitted by an adjustable sluice from the canal. At the other end of the chamber is an orifice in a thin flagstone of fixed size. By means of the adjustable sluice a tolerably constant head above the fixed orifice is maintained, and therefore there is a nearly constant discharge of ascertainable amount through the orifice, into the channel leading to the fields which are to be irrigated.

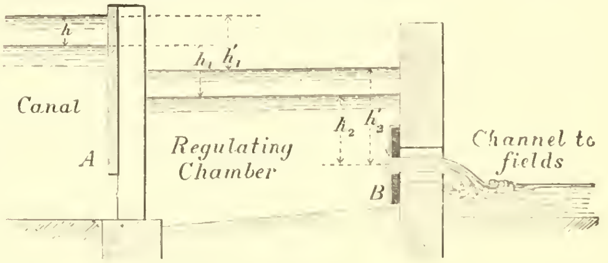


Fig. 68.

In fig. 68 A is the adjustable sluice by which water is admitted to the regulating chamber, B is the fixed orifice through which the water is discharged. The sluice A is adjusted from time to time by the canal officers, so as to bring the level of the water in the regulating chamber to a fixed level marked on the wall of the chamber. When adjusted it is locked. Let ω_1 be the area of the orifice through the sluice at A, and ω_2 that of the fixed orifice at B; let h_1 be the difference of level between the surface of the water in the canal and regulating chamber; h_2 the head above the centre of the discharging orifice, when the sluice has been adjusted and the flow has become steady; Q the normal discharge in cubic feet per second. Then, since the flow through the orifices at A and B is the same,

$$Q = c_1\omega_1\sqrt{2gh_1} = c_2\omega_2\sqrt{2gh_2}\,,$$

where c_1 and c_2 are the coefficients of discharge suitable for the two orifices. Hence

$$\frac{c_1\omega_1}{c_2\omega_2} = \sqrt{\left(\frac{h_2}{h_1}\right)}\,.$$

Suppose now that in the interval between the visits of the canal officer the level of the canal rises h feet, causing the heads relatively to the orifices A and B to become h'_1 and h'_2. Since the areas of the orifices are unchanged

$$\sqrt{\frac{h'_2}{h'_1}} = \frac{c_1\omega_1}{c_2\omega_2}\,,$$

and therefore

$$\frac{h'_1}{h'_2} = \frac{h_1}{h_2}\,;$$

or the ratio of the effective heads above the orifices A and B is unaffected by the change of level of the canal. Also

$$h'_1 + h'_2 = h_1 + h_2 + h\,.$$

Eliminating h'_1, we get

$$h'_2 = \frac{(h_1+h_2+h)h_2}{h_1+h_2}\,;$$

and the discharge in the altered conditions is

$$Q' = c_2\omega_2\sqrt{2gh'_2}$$

$$= c_2\omega_2\sqrt{\left\{2g\frac{(h_1+h_2+h)h_2}{h_1+h_2}\right\}}\,.$$

That is,

$$\frac{Q'}{Q} = \sqrt{\frac{h_1+h_2+h}{h_1+h_2}}\,.$$

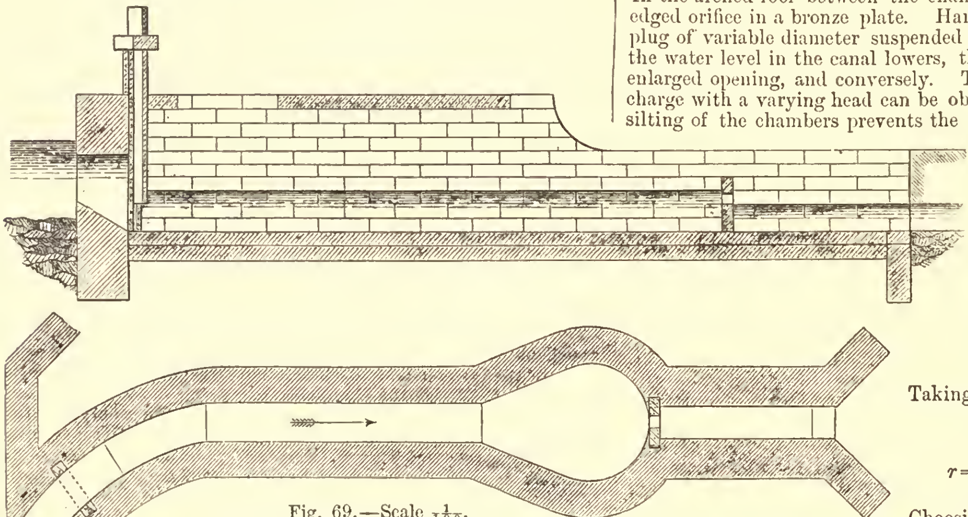


Fig. 69.—Scale $\frac{1}{100}$.

If the orifice at B opened directly into the canal without any intermediate regulating chamber, the discharge would increase for a given change of level in the canal in exactly the same ratio. Consequently the Italian module in no way moderates the fluctuations of discharge, except so far as it affords means of easy adjustment from time to time. It has further the advantage that the cultivator, by observing the level of the water in the chamber, can always see whether or not he is receiving the proper quantity of water.

On each canal the orifices are of the same height, and intended to work with the same normal head, the width of the orifices being varied to suit the demand for water. The unit of discharge varies on different canals, being fixed in each case by legal arrangements. Thus on the Canal Lodi the unit of discharge or one module of water is the discharge through an orifice 1·12 feet high, 0·12416 feet wide, with a head of 0·32 feet above the top edge of the orifice, or ·88 feet above the centre. This corresponds to a discharge of about 0·6165 cubic feet per second. Two modules would be the discharge of a similar orifice of twice the width. The following table gives some examples of different units of discharge.

	Height of Orifice.	Width of Orifice.	Head above top edge of Orifice.	Discharge per sec. in c. feet.
Canal Lodi	1·12	0·12416	0·32	0·6165
Canal of Cremona	1·31816	0·131	0·131	0·7225
Sardinian Module	0·6562	0·6562	0·6562	2·046
Oncia Magistrale of Milan	0·655	0·3426	0·3294	0·866

In the most elaborate Italian modules the regulating chamber is arched over, and its dimensions are very exactly prescribed. Thus in the modules of the Naviglio Grande of Milan, shown in fig. 69, the measuring orifice is cut in a thin stone slab, and so placed that the discharge is into the air with free contraction on all sides. The adjusting sluice is placed with its sill flush with the bottom of the canal, and is provided with a rack and lever and locking arrangement. The covered regulating chamber is about 20 feet long, with a breadth 1·64 feet greater than that of the discharging orifice. At precisely the normal level of the water in the regulating chamber, there is a ceiling of planks intended to still the agitation of the water. A block of stone serves to indicate the normal level of the water in the chamber. The water is discharged into an open channel 0·655 feet wider than the orifice, splaying out till it is 1·637 feet wider than the orifice, and about 18 feet in length. This apparatus was invented in the 16th century, and is still used. The greatest objection to it is the loss of level between the canal and discharging channel. Arrangements precisely similar to an Italian module are in use in England, for discharging compensation water into streams from impounding reservoirs. The fullest account of Italian modules is to be found in Colonel Baird Smith's *Italian Irrigation*.

55. *Spanish Module.*—On the canal of Isabella II., which supplies water to Madrid, a module much more perfect in principle than the Italian module is employed. Part of the water is supplied for irrigation, and as it is very valuable its strict measurement is essential. The module (fig. 71) consists of two chambers one above the other, the upper chamber being in free communication with the irrigation canal, and the lower chamber discharging by a culvert to the fields. In the arched roof between the chambers there is a circular sharp edged orifice in a bronze plate. Hanging in this there is a bronze plug of variable diameter suspended from a hollow brass float. If the water level in the canal lowers, the plug descends and gives an enlarged opening, and conversely. Thus a perfectly constant discharge with a varying head can be obtained, provided no clogging or silting of the chambers prevents the free discharge of the water or the rise and fall of the float. The theory of the module is very simple. Let R (fig. 70) be the radius of the fixed opening, r the diameter of the plug at a distance h from the plane of flotation of the float, and Q the required discharge of the module. Then

$$Q = c\pi(R^2 - r^2)\sqrt{2gh}\,.$$

Taking $c = 0·63$,

$$Q = 15·88(R^2 - r^2)\sqrt{h}\,;$$

$$r = \sqrt{\left\{R^2 - \frac{Q}{15·88\sqrt{h}}\right\}}\,.$$

Choosing a value for R, successive values of r can be found for different values of h, and from these the

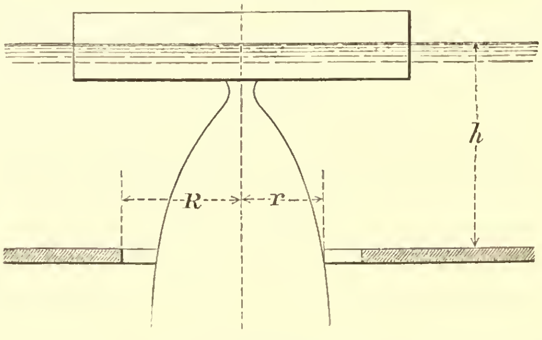


Fig. 70.

curve of the plug can be drawn. The module shown in fig. 71 will discharge 1 cubic metre per second. The fixed opening is 0·2 metre diameter, and the greatest head above the fixed orifice is 1 metre. The use of this module involves a great sacrifice of level between the canal and the fields. The module is described in Lieutenant Scott Moncrieff's *Irrigation in Southern Europe.*

56. *Reservoir Gauging Basins.*—In obtaining the power to store the water of streams in reservoirs, it is usual to concede to riparian owners below the reservoirs a right to a regulated supply through-

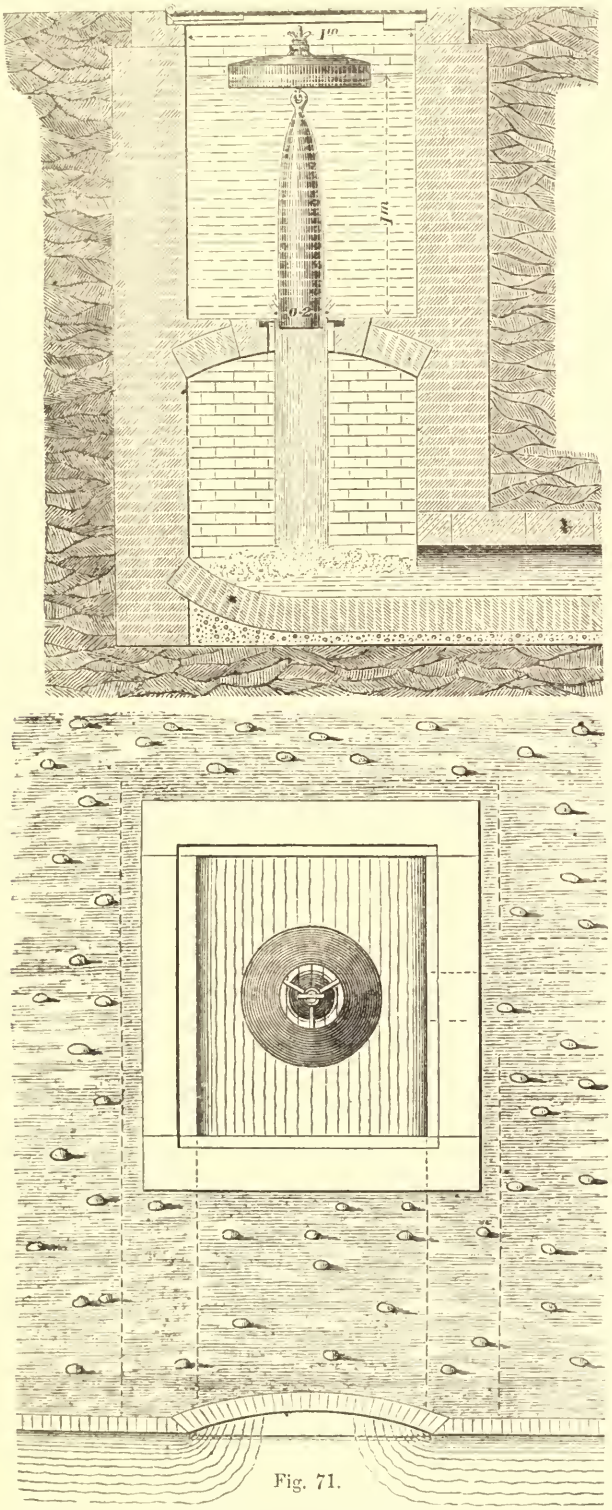


Fig. 71.

out the year. This compensation water requires to be measured in such a way that the millowners and others interested in the matter can assure themselves that they are receiving a proper quantity, and they are generally allowed a certain amount of control as to the times during which the daily supply is discharged into the stream.

Figs. 72 and 73 show an arrangement designed for the Manchester Water Works. The water enters from the reservoir a chamber A, the object of which is to still the irregular motion of the water. The admission is regulated by sluices at *b, b, b*. The water is discharged by orifices or notches at *a, a*, over which a tolerably constant head is maintained by adjusting the sluices at *b, b, b*. At any time the millowners can see whether the discharge is given and whether the proper head is maintained over the orifices. To test at any time the discharge of the orifices, a gauging basin B is

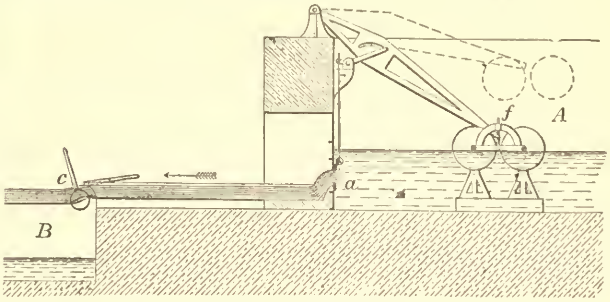


Fig. 72.—Scale $\frac{1}{120}$.

provided. The water ordinarily flows over this, without entering it, on a floor of cast-iron plates. If the discharge is to be tested, the water is turned for a definite time into the gauging basin, by suddenly opening and closing a sluice at *c*. The volume of flow can be ascertained from the depth in the gauging chamber. A mechanical arrangement was designed for securing an absolutely constant head over the orifices at *a, a*. The orifices were formed

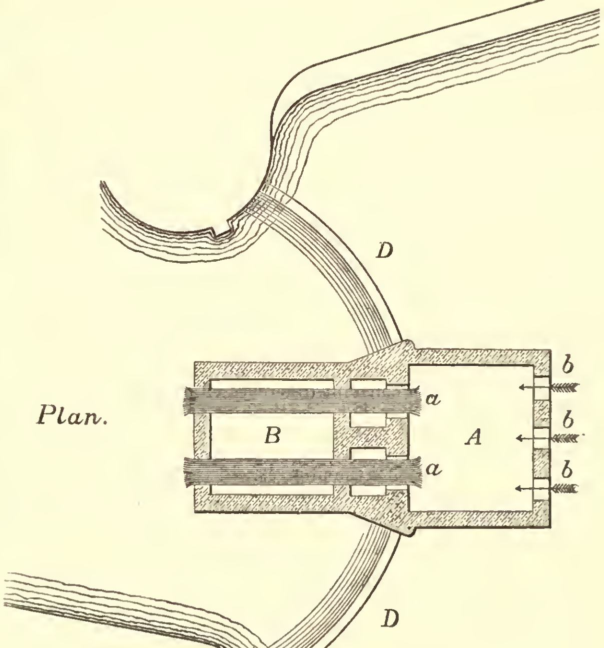


Fig. 73.—Scale $\frac{1}{500}$.

in a cast-iron plate capable of sliding up and down, without sensible leakage, on the face of the wall of the chamber. The orifice plate was attached by a link to a lever, one end of which rested on the wall and the other on floats *f* in the chamber A. The floats rose and fell with the changes of level in the chamber, and raised and lowered the orifice plate at the same time. This mechanical arrangement was not finally adopted, careful watching of the sluices at b, b, b, being sufficient to secure a regular discharge. The arrangement is then equivalent to an Italian module, but on a large scale.

57. *Professor Fleeming Jenkin's Constant Flow Valve.*—In the modules thus far described constant discharge is obtained by varying the area of the orifice through which the water flows. Professor F. Jenkin has contrived a valve in which a constant pressure head is obtained, so that the orifice need not be varied (*Roy. Scot. Society of Arts*, 1876). Fig. 74 shows a valve of this kind suitable for a

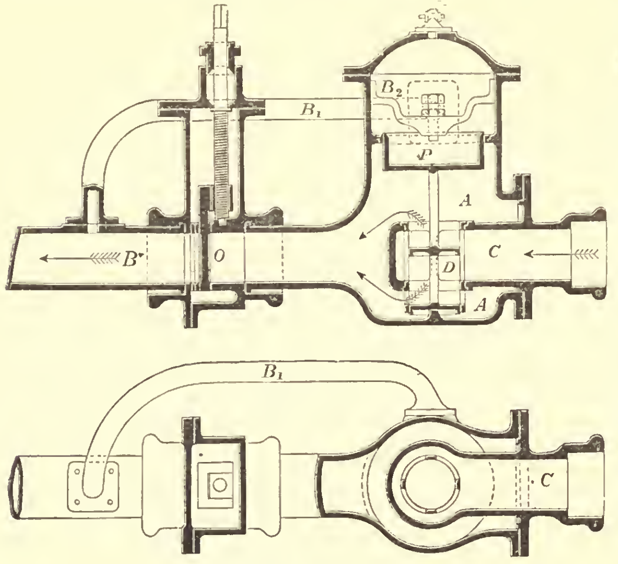


Fig. 74.—Scale $\frac{1}{24}$.

6 inch water main. The water arriving by the main C passes through an equilibrium valve D into the chamber A, and thence through a sluice O, which can be set for any required area of opening, into the discharging main B. The object of the arrangement is to secure a constant difference of pressure between the chambers A and B, so that a constant discharge flows through the stop valve O. The equilibrium valve D is rigidly connected with a plunger P loosely fitted in a diaphragm, separating A from a chamber B_2 connected by a pipe B_1 with the discharging main B. Any increase of the difference of pressure in A and B will drive the plunger up and close the equilibrium valve, and conversely a decrease of the difference of pressure will cause the descent of the plunger and open the equilibrium valve wider. Thus a constant difference of pressure is obtained in the chambers A and B. Let ω be the area of the plunger in square feet, p the difference of pressure in the chambers A and B in pounds per square foot, w the weight of the plunger and valve. Then if at any moment $p\omega$ exceeds w the plunger will rise, and if it is less than w the plunger will descend. Apart from friction, and assuming the valve D to be strictly an equilibrium valve, since ω and w are constant, p must be constant also, and equal to $\frac{w}{\omega}$. By making w small and ω large, the difference of pressure required to ensure the working of the apparatus may be made very small. Valves working with a difference of pressure of $\frac{1}{2}$ inch of water have been constructed.

58. *Appold's Module.*—This acts on the same general principle as the Spanish module, but it secures only an approximately constant discharge. On the other hand it involves no great sacrifice of level, and is not very likely to be affected by silting. It was contrived originally as an air regulator, but it has also been tried with success as a water module. It consists simply of a horizontal pipe with an

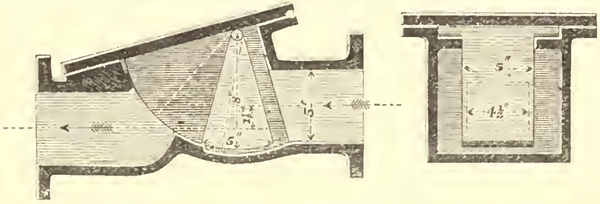


Fig. 75.—Scale $\frac{1}{17}$.

enlarged chamber, in which hangs a heavy wedge-shaped pendulum. The pressure of the water on the upstream side of this pendulum keeps it in a position inclined to the vertical, and partially closing the orifice of discharge as shown by the dotted lines in fig. 75. Any increase of pressure will cause a greater inclination of the pendulum and decrease the orifice of discharge, and *vice versa*.

VI. STEADY FLOW OF COMPRESSIBLE FLUIDS.

59. *External Work during the Expansion of Air.*—If air expands without doing any external work, its temperature remains constant. This result was first experimentally demonstrated by Joule. It leads to the conclusion that, however air changes its state, the internal work done is proportional to the change of temperature. When, in expanding, air does work against an external resistance, either heat must be supplied or the temperature falls.

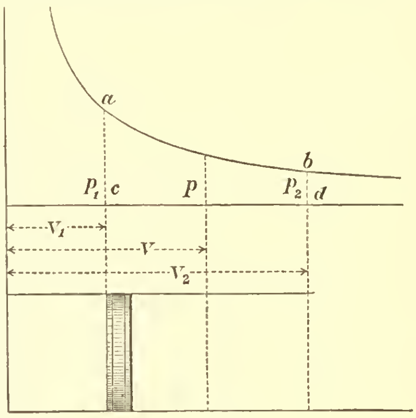


Fig. 76.

To fix the conditions, suppose one pound of air confined behind a piston of one square foot area (fig. 76). Let the initial pressure be p_1 and the volume of the air v_1, and suppose this to expand to the pressure p_2 and volume v_2. If p and v are the corresponding pressure and volume at any intermediate point in the expansion, the work done on the piston during the expansion from v to $v+dv$ is pdv, and the whole work during the expansion from v_1 to v_2, represented by the area *abcd*, is

$$\int_{v_1}^{v_2} pdv.$$

Amongst possible cases two may be selected.

Case 1.—So much heat is supplied to the air during expansion that the temperature remains constant. Hyperbolic expansion. Then

$$pv = p_1 v_1 .$$

Work done during expansion per pound of air

$$= \int_{v_1}^{v_2} pdv = p_1 v_1 \int_{v_1}^{v_2} \frac{dv}{v}$$

$$= p_1 v_1 \log_\epsilon \frac{v_2}{v_1} = p_1 v_1 \log_\epsilon \frac{p_1}{p_2} \quad . \quad . \quad . \quad (1).$$

Since the weight per cubic foot is the reciprocal of the volume per pound, this may be written

$$\frac{p_1}{G_1} \log_\epsilon \frac{G_1}{G_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1a).$$

Then the expansion curve ab is a common hyperbola.

Case 2.—No heat is supplied to the air during expansion. Then the air loses an amount of heat equivalent to the external work done and the temperature falls. Adiabatic expansion.

In this case it can be shown that

$$pv^\gamma = p_1 v_1{}^\gamma ,$$

where γ is the ratio of the specific heats of air at constant pressure and volume. Its value for air is 1·408, and for dry steam 1·135.

Work done during expansion per pound of air

$$= \int_{v_1}^{v_2} pdv = p_1 v_1{}^\gamma \int_{v_1}^{v_2} \frac{dv}{v^\gamma}$$

$$= -\frac{p_1 v_1{}^\gamma}{\gamma - 1} \left\{ \frac{1}{v_2{}^{\gamma-1}} - \frac{1}{v_1{}^{\gamma-1}} \right\}$$

$$= \frac{p_1 v_1{}^\gamma}{\gamma - 1} \left\{ \frac{1}{v_1{}^{\gamma-1}} - \frac{1}{v_2{}^{\gamma-1}} \right\}$$

$$= \frac{p_1 v_1}{\gamma - 1} \left\{ 1 - \left(\frac{v_1}{v_2} \right)^{\gamma-1} \right\} \quad . \quad (2).$$

The value of $p_1 v_1$ for any given temperature can be found from the data already given.

As before, substituting the weights G_1, G_2 per cubic foot for the volumes per pound, we get for the work of expansion

$$\frac{p_1}{G_1} \cdot \frac{1}{\gamma - 1} \cdot \left\{ 1 - \left(\frac{G_2}{G_1} \right)^{\gamma-1} \right\} \quad . \quad . \quad . \quad (2a),$$

$$= p_1 v_1 \frac{1}{\gamma - 1} \left\{ 1 - \left(\frac{p_2}{p_1} \right)^{\frac{\gamma-1}{\gamma}} \right\} . \quad . \quad . \quad . \quad . \quad (2b).$$

60. *Modification of the Theorem of Bernoulli for the Case of a Compressible Fluid.*—In the application of the principle of work to a filament of compressible fluid, the internal work done by the expansion of the fluid, or absorbed in its compression, must be taken into

account. Suppose, as before, that AB (fig. 77) comes to A'B' in a short time t. Let p_1, ω_1, v_1, G_1 be the pressure, sectional area of stream, velocity, and weight of a cubic foot at A, and p_2, ω_2, v_2, G_2 the same quantities at B. Then, from the steadiness of motion, the weight of fluid passing A in any given time must be equal to the weight passing B:

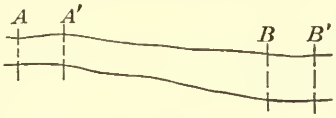


Fig. 77.

$$G_1\omega_1 v_1 t = G_2\omega_2 v_2 t.$$

Let z_1, z_2 be the heights of the sections A and B above any given datum. Then the work of gravity on the mass AB in t seconds is

$$G_1\omega_1 v_1 t(z_1 - z_2) = W(z_1 - z_2)t,$$

where W is the weight of gas passing A or B per second. As in the case of an incompressible fluid, the work of the pressures on the ends of the mass AB is

$$p_1\omega_1 v_1 t - p_2\omega_2 v_2 t,$$
$$= \left(\frac{p_1}{G_1} - \frac{p_2}{G_2}\right) Wt.$$

The work done by expansion of Wt pounds of fluid between A and B is $Wt\int_{v_1}^{v_2} p\,dv$. The change of kinetic energy as before is $\frac{W}{2g}(v_2^2 - v_1^2)t$. Hence, equating work to change of kinetic energy,

$$W(z_1 - z_2)t + \left(\frac{p_1}{G_1} - \frac{p_2}{G_2}\right) Wt + Wt\int_{v_1}^{v_2} p\,dv = \frac{W}{2g}(v_2^2 - v_1^2)t\ ;$$

$$\therefore\ z_1 + \frac{p_1}{G_1} + \frac{v_1^2}{2g} = z_2 + \frac{p_2}{G_2} + \frac{v_2^2}{2g} - \int_{v_1}^{v_2} p\,dv\ . \quad . \quad . \quad (1).$$

Now the work of expansion per pound of fluid has already been given. If the temperature is constant, we get (eq. $1a$, § 59)

$$z_1 + \frac{p_1}{G_1} + \frac{v_1^2}{2g} = z_2 + \frac{p_2}{G_2} + \frac{v_2^2}{2g} - \frac{p_1}{G_1}\log_\epsilon \frac{G_1}{G_2}.$$

But at constant temperature $\frac{p_1}{G_1} = \frac{p_2}{G_2}$;

$$\therefore\ z_1 + \frac{v_1^2}{2g} = z_2 + \frac{v_2^2}{2g} - \frac{p_1}{G_1}\log_\epsilon \frac{p_1}{p_2}, \quad . \quad . \quad . \quad . \quad (2);$$

or, neglecting the difference of level,

$$\frac{v_2^2 - v_1^2}{2g} = \frac{p_1}{G_1}\log_\epsilon \frac{p_1}{p_2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2a).$$

Similarly, if the expansion is adiabatic (eq. $2a$, § 59),

$$z_1 + \frac{p_1}{G_1} + \frac{v_1^2}{2g} = z_2 + \frac{p_2}{G_2} + \frac{v_2^2}{2g} - \frac{p_1}{G_1}\frac{1}{\gamma - 1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\}. \quad (3);$$

or neglecting the difference of level

$$\frac{v_2^2 - v_1^2}{2g} = \frac{p_1}{G_1}\left[1 + \frac{1}{\gamma - 1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\}\right] - \frac{p_2}{G_2}. \quad . \quad (3a).$$

It will be seen hereafter that there is a limit in the ratio $\frac{p_1}{p_2}$ beyond which these expressions cease to be true.

61. *Discharge of Air from an Orifice.*—The form of the equation of work for a steady stream of compressible fluid is

$$z_1 + \frac{p_1}{G_1} + \frac{v_1^2}{2g} = z_2 + \frac{p_2}{G_2} + \frac{v_2^2}{2g} - \frac{p_1}{G_1}\frac{1}{\gamma - 1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\},$$

the expansion being adiabatic, because in the flow of the streams of air through an orifice no sensible amount of heat can be communicated from outside.

Suppose the air flows from a vessel, where the pressure is p_1 and the velocity sensibly zero, through an orifice, into a space where the pressure is p_2. Let v_2 be the velocity of the jet at a point where the convergence of the streams has ceased, so that the pressure in the jet is also p_2. As air is light, the work of gravity will be small compared with that of the pressures and expansion, so that z_1, z_2 may be neglected. Putting these values in the equation above—

$$\frac{p_1}{G_1} = \frac{p_2}{G_2} + \frac{v_2^2}{2g} - \frac{p_1}{G_1}\frac{1}{\gamma - 1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\};$$

$$\frac{v_2^2}{2g} = \frac{p_1}{G_1} - \frac{p_2}{G_2} + \frac{p_1}{G_1}\frac{1}{\gamma - 1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\}$$

$$= \frac{p_1}{G_1}\left\{\frac{\gamma}{\gamma - 1} - \frac{1}{\gamma - 1}\left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\} - \frac{p_2}{G_2}.$$

But $$\frac{p_1}{G_1^\gamma} = \frac{p_2}{G_2^\gamma} \quad \therefore \quad \frac{p_2}{G_2} = \frac{p_1}{G_1}\left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}.$$

$$\frac{v_2^2}{2g} = \frac{p_1}{G_1}\frac{\gamma}{\gamma - 1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\}. \quad . \quad . \quad . \quad . \quad (1);$$

or $$\frac{v_2^2}{2g} = \frac{\gamma}{\gamma - 1}\left\{\frac{p_1}{G_1} - \frac{p_2}{G_2}\right\};$$

an equation commonly ascribed to Weisbach (*Civilingenieur*, 1856), though it appears to have been given earlier by St Venant and Wantzel.

It has already (§ 9, eq. $4a$) been seen that

$$\frac{p_1}{G_1} = \frac{p_0}{G_0}\frac{\tau_1}{\tau_0},$$

where for air $p_0 = 2116{\cdot}8$, $G_0 = {\cdot}08075$ and $\tau_0 = 492{\cdot}6$.

$$\frac{v_2^2}{2g} = \frac{p_0}{G_0}\frac{\tau_1}{\tau_0}\frac{\gamma}{\gamma - 1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\}, \quad . \quad . \quad . \quad (2);$$

or, inserting numerical values,

$$\frac{v_2^2}{2g} = 183{\cdot}6\tau_1\left\{1 - \left(\frac{p_2}{p_1}\right)^{0{\cdot}29}\right\}, \quad . \quad . \quad . \quad . \quad (2a);$$

which gives the velocity of discharge v_2 in terms of the pressure and absolute temperature, p_1, τ_1, in the vessel from which the air flows, and the pressure p_2 in the vessel into which it flows.

Proceeding now as for liquids, and putting ω for the area of the orifice and c for the coefficient of discharge, the volume of air discharged per second at the pressure p_2 and temperature τ_2 is

$$Q_2 = c\omega v_2 = c\omega\sqrt{2g\frac{\gamma}{\gamma - 1}\frac{p_1}{G_1}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\}}$$

$$= 108{\cdot}7c\omega\sqrt{\left[\tau_1\left\{1 - \left(\frac{p_2}{p_1}\right)^{0{\cdot}29}\right\}\right]} \quad . \quad . \quad . \quad (3).$$

If the volume discharged is measured at the pressure p_1 and absolute temperature τ_1 in the vessel from which the air flows, let Q_1 be that volume; then

$$p_1 Q_1^\gamma = p_2 Q_2^\gamma\ ;$$

$$Q_1 = \left(\frac{p_2}{p_1}\right)^{\frac{1}{\gamma}} Q_2\ ;$$

$$Q_1 = c\omega\sqrt{\left[2g\frac{\gamma}{\gamma - 1}\frac{p_1}{G_1}\left\{\left(\frac{p_2}{p_1}\right)^{\frac{2}{\gamma}} - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma+1}{\gamma}}\right\}\right]}.$$

Let $$\left(\frac{p_2}{p_1}\right)^{\frac{2}{\gamma}} - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma+1}{\gamma}} = \left(\frac{p_2}{p_1}\right)^{1{\cdot}41} - \left(\frac{p_2}{p_1}\right)^{1{\cdot}7} = \psi\ ; \text{ then}$$

$$Q_1 = c\omega\sqrt{\left[2g\frac{\gamma}{\gamma - 1}\frac{p_1}{G_1}\psi\right]}$$

$$= 108{\cdot}7c\omega\sqrt{\tau_1\psi}\ . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

The weight of air at pressure p_1 and temperature τ_1 is

$$G_1 = \frac{p_1}{53{\cdot}2\tau_1} \text{ pounds per cubic foot.}$$

Hence the weight of air discharged is

$$W = G_1 Q_1 = c\omega\sqrt{\left[2g\frac{\gamma}{\gamma - 1}p_1 G_1\psi\right]}$$

$$= 2{\cdot}043c\omega p_1\sqrt{\frac{\psi}{\tau_1}}. \quad . \quad . \quad . \quad . \quad . \quad (5).$$

Weisbach has found the following values of the coefficient of discharge c:—

	$c=$
Conoidal mouthpieces of the form of the contracted vein with effective pressures of ·23 to 1·1 atmosphere..................	0·97 to 0·99
Circular sharp-edged orifices	0·563 ,, 0·788
Short cylindrical mouthpieces	0·81 ,, 0·84
The same rounded at the inner end	0·92 ,, 0·93
Conical converging mouthpieces............	0·90 ,, 0·99

62. *Limit to the Application of the above Formulæ.*—In the formulæ above it is assumed that the fluid issuing from the orifice expands from the pressure p_1 to the pressure p_2, while passing from the vessel to the section of the jet considered in estimating the area ω. Hence p_2 is strictly the pressure in the jet at the plane of the external orifice in the case of mouthpieces, or at the plane of the contracted section in the case of simple orifices. Till recently it was tacitly assumed that this pressure p_2 was identical with the general pressure external to the orifice. Mr R. D. Napier first discovered that, when the ratio $\frac{p_2}{p_1}$ exceeded a value which does not greatly differ from 0·5, this was no longer true. In that case the expansion of the fluid down to the external pressure is not completed at the time it reaches the plane of the contracted section, and the pressure there is greater than the general external pressure; or, what amounts to the same thing, the section of the jet where the expansion is completed is a section which is greater than the area $c_c\omega$ of the contracted section of the jet, and may be greater than the area ω of the orifice. Mr Napier made experiments with steam which showed that, so long as $\frac{p_2}{p_1} > 0{\cdot}5$, the formulæ above

were trustworthy, when p_2 was taken to be the general external pressure, but that, if $\frac{p_2}{p_1} < 0{\cdot}5$, then the pressure at the contracted section was independent of the external pressure and equal to $0{\cdot}5p_1$. Hence in such cases the constant value 0·5 should be substituted in the formulæ for the ratio of the internal and external pressures $\frac{p_2}{p_1}$.

It is easily deduced from Weisbach's theory that, if the pressure external to an orifice is gradually diminished, the weight of air discharged per second increases to a maximum for a value of the ratio

$$\frac{p_2}{p_1} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$
$$= 0{\cdot}527 \text{ for air}$$
$$= 0{\cdot}58 \text{ for dry steam.}$$

For a further decrease of external pressure the discharge diminishes, —a result no doubt improbable. The new view of Weisbach's formula is that from the point where the maximum is reached, or not greatly differing from it, the pressure at the contracted section ceases to diminish.

Fliegner has shown (*Civilingenieur*, xx., 1874) that for air flowing from well-rounded mouthpieces there is no discontinuity of the law of flow, as Napier's hypothesis implies, but the curve of flow bends so sharply that Napier's rule may be taken to be a good approximation to the true law. The limiting value of the ratio $\frac{p_2}{p_1}$, for which Weisbach's formula, as originally understood, ceases to apply, is for air 0·5767; and this is the number to be substituted for $\frac{p_2}{p_1}$ in the formulæ when $\frac{p_2}{p_1}$ falls below that value. For later researches on the flow of air, reference may be made to Zeuner's paper (*Civilingenieur*, 1871), and Fliegner's papers (*ibid.*, 1877, 1878).

VII. FRICTION OF LIQUIDS.

63. When a stream of fluid flows over a solid surface, or conversely when a solid moves in still fluid, a resistance to the motion is generated, commonly termed fluid friction. It is due to the viscosity of the fluid, but generally the laws of fluid friction are very different from those of simple viscous resistance. It would appear that at all speeds, except the slowest, rotating eddies are formed by the roughness of the solid surface, or by abrupt changes of velocity distributed throughout the fluid; and the energy expended in producing these eddying motions is gradually lost in overcoming the viscosity of the fluid in regions more or less distant from that where they are first produced.

The laws of fluid friction are generally stated thus:—

1. The frictional resistance is independent of the pressure between the fluid and the solid against which it flows. This may be verified by a simple direct experiment. Coulomb, for instance, oscillated a disk under water, first with atmospheric pressure acting on the water surface, afterwards with the atmospheric pressure removed. No difference in the rate of decrease of the oscillations was observed. The chief proof that the friction is independent of the pressure is that no difference of resistance has been observed in water mains and in other cases, where water flows over solid surfaces under widely different pressures.

2. The frictional resistance of large surfaces is proportional to the area of the surface.

3. At low velocities of not more than 1 inch per second for water, the frictional resistance increases directly as the relative velocity of the fluid and the surface against which it flows. At velocities of ½ foot per second and greater velocities, the frictional resistance is more nearly proportional to the square of the relative velocity.

In many treatises on hydraulics it is stated that the frictional resistance is independent of the nature of the solid surface. The explanation of this was supposed to be that a film of fluid remained attached to the solid surface, the resistance being generated between this fluid layer and layers more distant from the surface. At extremely low velocities the solid surface does not seem to have much influence on the friction. In Coulomb's experiments a metal surface covered with tallow, and oscillated in water, had exactly the same resistance as a clean metal surface, and when sand was scattered over the tallow the resistance was only very slightly increased. The earlier calculations of the resistance of water at higher velocities in iron and wood pipes and earthen channels seemed to give a similar result. These, however, were erroneous, and it is now well understood that differences of roughness of the solid surface very greatly influence the friction, at such velocities as are common in engineering practice. Darcy's experiments, for instance, showed that in old and incrusted water mains the resistance was twice or sometimes thrice as great as in new and clean mains.

64. *Ordinary Expressions for Fluid Friction at Velocities not Extremely Small.*—Let f be the frictional resistance estimated in pounds per square foot of surface at a velocity of one foot per second; ω the area of the surface in square feet; and v its velocity in feet per second relatively to the water in which it is immersed. Then, in accordance with the laws stated above, the total resistance of the surface is

$$R = f\omega v^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

where f is a quantity approximately constant for any given surface. If

$$\xi = \frac{2gf}{G},$$

$$R = \xi G \omega \frac{v^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

where ξ is, like f, nearly constant for a given surface, and is termed the coefficient of friction.

The following are average values of the coefficient of friction for water, obtained from experiments on large plane surfaces moved in an indefinitely large mass of water.

	Coefficient of Friction, ξ	Frictional Resistance in lb per sq. ft. f
New well-painted iron plate	·00489	·00473
Painted and planed plank (Beaufoy).....	·00350	·00339
Surface of iron ships (Rankine)	·00362	·00351
Varnished surface (Froude)	·00258	·00250
Fine sand surface ,, ...	·00418	·00405
Coarser sand surface ,, ...	·00503	·00488

The distance through which the frictional resistance is overcome is v feet per second. The work expended in fluid friction is therefore given by the equation—

$$\left.\begin{aligned}\text{Work expended} &= f\omega v^3 \text{ foot-pounds per second} \\ &= \xi G \omega \frac{v^3}{2g} \quad ,, \quad ,,\end{aligned}\right\} \quad . \quad . \quad . \quad (3).$$

The coefficient of friction and the friction per square foot of surface can be indirectly obtained from observations of the discharge of pipes and canals. In obtaining them, however, some assumptions as to the motion of the water must be made, and it will be better therefore to discuss these values in connexion with the cases to which they are related.

Many attempts have been made to express the coefficient of friction in a form applicable to low as well as high velocities. The older hydraulic writers considered the resistance termed fluid friction to be made up of two parts,—a part due directly to the distortion of the mass of water and proportional to the velocity of the water relatively to the solid surface, and another part due to kinetic energy imparted to the water striking the roughnesses of the solid surface and proportional to the square of the velocity. Hence they proposed to take

$$\xi = \alpha + \frac{\beta}{v},$$

in which expression the second term is of greatest importance at very low velocities, and of comparatively little importance at velocities over about ½ foot per second. Values of ξ expressed in this and similar forms will be given in connexion with pipes and canals.

All these expressions must at present be regarded as merely empirical expressions serving practical purposes. The frictional resistance will be seen to vary through wider limits than these expressions allow, and to depend on circumstances of which they do not take account.

65. *Coulomb's Experiments.*—The first direct experiments on fluid friction were made by Coulomb, who employed a circular disk suspended by a thin brass wire and oscillated in its own plane. His experiments were chiefly made at very low velocities. When the disk is rotated to any given angle, it oscillates under the action of its inertia and the torsion of the wire. The oscillations diminish gradually in consequence of the work done in overcoming the friction of the disk. The diminution furnishes a means of determining the friction.

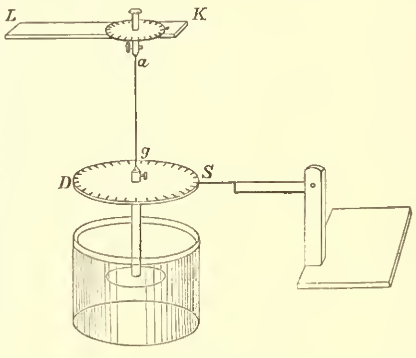


Fig. 78.

Fig. 78 shows Coulomb's apparatus. LK supports the wire and disk; ag is the brass wire, the torsion of which causes the oscillations; DS is a graduated disk serving to measure the angles through which the apparatus oscillates. To this the friction disk is rigidly attached hanging in a vessel of water. The friction disks were from 4·7 to 7·7 inches diameter, and they generally made one oscillation in from 20 to 30 seconds, through angles varying from 360° to 6°. When the velocity of the circumference of the disk was less than 6 inches per second, the resistance was sensibly proportional to the velocity.

Beaufoy's Experiments.—Towards the end of the last century Colonel Beaufoy made an immense mass of experiments on the resistance of bodies moved through water (*Nautical and Hydraulic Experiments*, London, 1834). Of these the only ones directly bearing on surface friction were some made in 1796 and 1798. Smooth painted planks were drawn through water and the resistance measured. For two planks differing in area by 46 square feet, at a velocity of 10 feet per second, the difference of resistance, measured on the difference of area, was 0·339 lb per square foot. Also the resistance varied as the 1·949th power of the velocity.

66. *Mr Froude's Experiments.*—The most important direct experiments on fluid friction at ordinary velocities are those made by Mr Froude at Torquay. The method adopted in these experiments was to tow a board in a still water canal, the velocity and the resistance being registered by very ingenious recording arrangements. The general arrangement of the apparatus is shown in fig. 79. AA is the board the resistance of which is to be determined. B is a cutwater giving a fine entrance to the plane surfaces of the board. CC is a bar to which the board AA is attached, and which is suspended by a parallel motion from a carriage running on rails above the still water canal. G is a link by which the resistance of the board is transmitted to a spiral spring H. A bar I rigidly connects the other end of the spring to the carriage. The dotted lines K, L indicate the position of a couple of levers by which the extension of the spring is caused to move a pen M, which records the extensions on a greatly increased scale, by a line drawn on the paper cylinder N. This cylinder revolves at a speed proportionate to that of the carriage, its motion being obtained from the axle of the carriage wheels. A second pen O, receiving jerks at every second and a quarter from a clock P, records time on the paper cylinder. The scale for the line of resistance is ascertained by stretching the spiral spring by known weights. The boards used for the experiment were $\frac{3}{16}$ inch thick, 19 inches deep, and from 1 to 50 feet in length, cutwater included. A lead keel counteracted the buoyancy of the board. The boards were covered with various substances, such as paint, varnish, Hay's composition, tinfoil, &c., so as to try the effect of different degrees

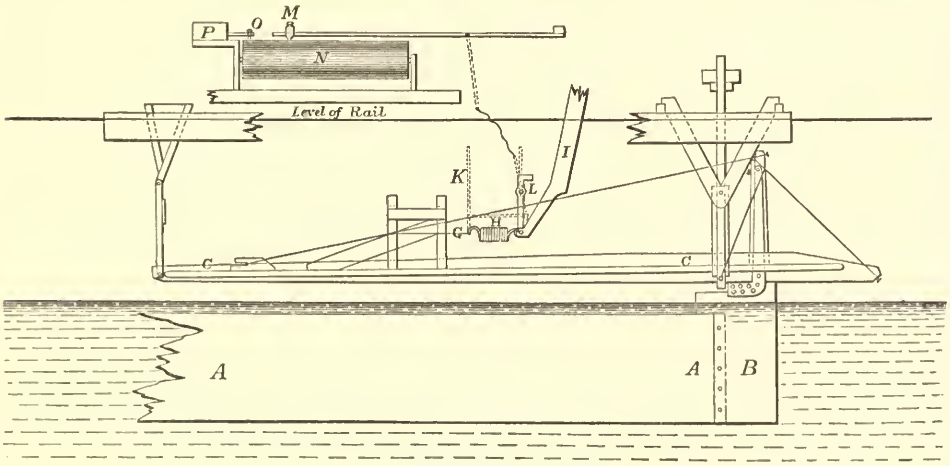


Fig. 79.

of roughness of surface. The results obtained by Mr Froude may be summarized as follows :—

(1) The friction per square foot of surface varies very greatly for different surfaces, being generally greater as the sensible roughness of the surface is greater. Thus, when the surface of the board was covered as mentioned below, the resistance for boards 50 feet long, at 10 feet per second, was—

Tinfoil or varnish	0·25 lb per sq. ft.
Calico	0·47 ,, ,,
Fine sand	0·405 ,, ,,
Coarser sand....................................	0·488 ,, ,,

(2) The power of the velocity to which the friction is proportional varies for different surfaces. Thus, with short boards 2 feet long,

For tinfoil the resistance varied as $v^{2\cdot16}$

For other surfaces ,, ,, $v^{2\cdot00}$

With boards 50 feet long,

For varnish or tinfoil the resistance varied as $v^{1\cdot83}$

For sand ,, ,, ,, $v^{2\cdot00}$

(3) The average resistance per square foot of surface was much greater for short than for long boards; or, what is the same thing, the resistance per square foot at the forward part of the board was greater than the friction per square foot of portions more sternward. Thus,

		Mean Resistance in lb per sq. ft.
Varnished surface...............	2 ft. long	0·41
	50 ,,	0·25
Fine sand surface	2 ,,	0·81
	50 ,,	0·405

This remarkable result is explained thus by Mr Froude :—"The portion of surface that goes first in the line of motion, in experiencing resistance from the water, must in turn communicate motion to the water, in the direction in which it is itself travelling. Consequently the portion of surface which succeeds the first will be rubbing, not against stationary water, but against water partially moving in its own direction, and cannot therefore experience so much resistance from it."

67. The following table gives a general statement of Mr Froude's results. In all the experiments in this table, the boards had a fine cutwater and a fine stern end or run, so that the resistance was entirely due to the surface. The table gives the resistances per square foot in pounds, at the standard speed of 600 feet per minute, and the power of the speed to which the friction is proportional, so that the resistance at other speeds is easily calculated.

	Length of Surface, or distance from Cutwater, in feet.											
	2 feet.			8 feet.			20 feet.			50 feet.		
	A	B	C	A	B	C	A	B	C	A	B	C
Varnish...............	2·00	·41	·390	1·85	·325	·264	1·85	·278	·240	1·83	·250	·226
Paraffin...............	...	·38	·370	1·94	·314	·260	1·93	·271	·237	...	...	...
Tinfoil	2·16	·30	·295	1·99	·278	·263	1·90	·262	·244	1·83	·246	·232
Calico	1·93	·87	·725	1·92	·626	·504	1·89	·531	·447	1·87	·474	·423
Fine sand	2·00	·81	·690	2·00	·583	·450	2·00	·480	·384	2·06	·405	·337
Medium sand	2·00	·90	·730	2·00	·625	·488	2·00	·534	·465	2·00	·488	·456
Coarse sand.........	2·00	1·10	·880	2·00	·714	·520	2·00	·588	·490	...	...	...

Columns A give the power of the speed to which the resistance is approximately proportional.

Columns B give the mean resistance per square foot of the whole surface of a board of the lengths stated in the table.

Columns C give the resistance in pounds of a square foot of surface at the distance sternward from the cutwater stated in the heading.

Although these experiments do not directly deal with surfaces of greater length than 50 feet, they indicate what would be the resistances of longer surfaces. For at 50 feet the decrease of resistance for an increase of length is so small that it will make no very great difference in the estimate of the friction whether we suppose it to continue to diminish at the same rate or not to diminish at all. For a varnished surface the friction at 10 feet per second diminishes from 0·41 to 0·32 lb per square foot when the length is increased from 2 to 8 feet, but it only diminishes from 0·278 to 0·250 lb per square foot for an increase from 20 feet to 50 feet.

If the decrease of friction sternwards is due to the generation of a current accompanying the moving plane, there is not at first sight any reason why the decrease should not be greater than that shown by the experiments. The current accompanying the board might be assumed to gain in volume and velocity sternwards, till the velocity was nearly the same as that of the moving plane and the friction per square foot nearly zero. That this does not happen appears to be due to the mixing up of the current with the still water surrounding it. Part of the water in contact with the board at any point, and receiving energy of motion from it, passes afterwards to distant regions of still water, and portions of still water are fed in towards the board to take its place. In the forward part of the board more kinetic energy is given to the current than is diffused into surrounding space, and the current gains in velocity. At a greater distance back there is an approximate balance between the energy communicated to the water and that diffused. The velocity of the current accompanying the board becomes constant or nearly constant, and the friction per square foot is therefore nearly constant also.

VIII. STEADY FLOW OF WATER IN PIPES OF UNIFORM SECTION.

68. The ordinary theory of the flow of water in pipes, on which all practical formulæ are based, assumes that the variation of velocity at different points of any cross section may be neglected. The water is considered as moving in plane layers, which are driven through the pipe against the frictional resistance, by the difference of pressure at or elevation of the ends of the pipe. If the motion is steady the velocity at each cross section remains the same from moment to moment, and if the cross sectional area is constant the velocity at all sections must be the same. Hence the motion is uniform. The most important resistance to the motion of the water is the surface friction of the pipe, and it is convenient to estimate this independently of some smaller resistances which will be accounted for presently.

In any portion of a uniform pipe, excluding for the present the ends of the pipe, the water enters and leaves at the same velocity. For that portion therefore the work of the external forces and of the surface friction must be equal. Let fig. 80 represent a very short portion of the pipe, of length dl, between cross sections at z and $z+dz$ feet above any horizontal datum line xx, the pressures at the cross sections being p and $p+dp$ ℔ per square foot. Further, let Q be the volume of flow or discharge of the pipe per second, Ω the area of a normal cross section, and χ the perimeter of the pipe. The Q cubic feet, which flow through the space considered per second, weigh GQ ℔, and fall through a height $-dz$ feet. The work done by gravity is then

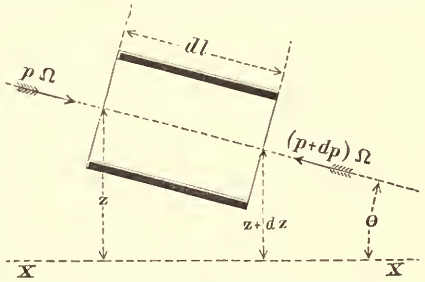


Fig. 80.

$$-\mathrm{GQ}dz\,;$$

a positive quantity if dz is negative, and *vice versa*. The resultant pressure parallel to the axis of the pipe is $p-(p+dp)=-dp$ ℔ per square foot of the cross section. The work of this pressure on the volume Q is

$$-\mathrm{Q}dp\,.$$

The only remaining force doing work on the system is the friction against the surface of the pipe. The area of that surface is $\chi\, dl$.

The work expended in overcoming the frictional resistance per second is (see § 64, eq. 3)

$$-\zeta \mathrm{G}\chi dl\frac{v^3}{2g}\,,$$

or, since $\mathrm{Q}=\Omega v$,

$$-\zeta \mathrm{G}\frac{\chi}{\Omega}\mathrm{Q}\frac{v^2}{2g}dl\,;$$

the negative sign being taken because the work is done against a resistance. Adding all these portions of work, and equating the result to zero, since the motion is uniform,—

$$-\mathrm{GQ}dz-\mathrm{Q}dp-\zeta\mathrm{G}\frac{\chi}{\Omega}\mathrm{Q}\frac{v^2}{2g}dl=0\,.$$

Dividing by GQ,

$$dz+\frac{dp}{\mathrm{G}}+\zeta\frac{\chi}{\Omega}\,\frac{v^2}{2g}dl=0\,.$$

Integrating,

$$z+\frac{p}{\mathrm{G}}+\zeta\frac{\chi}{\Omega}\,\frac{v^2}{2g}l=\text{constant} \quad . \quad . \quad . \quad . \quad . \quad (1).$$

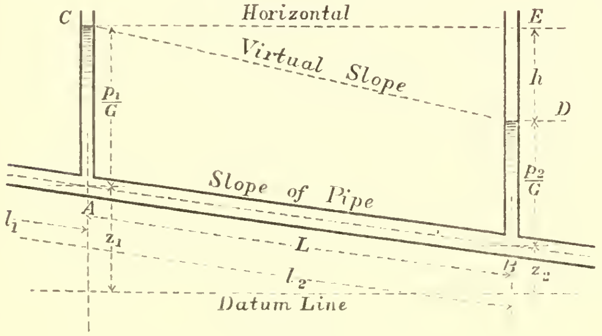


Fig. 81.

69. Let A and B (fig. 81) be any two sections of the pipes for which p, z, l have the values p_1, z_1, l_1, and p_2, z_2, l_2 respectively. Then

$$z_1+\frac{p_1}{\mathrm{G}}+\zeta\frac{\chi}{\Omega}\,\frac{v^2}{2g}l_1=z_2+\frac{p_2}{\mathrm{G}}+\zeta\frac{\chi}{\Omega}\,\frac{v^2}{2g}l_2\,;$$

or, if $l_2-l_1=\mathrm{L}$, rearranging the terms,

$$\zeta\frac{v^2}{2g}=\frac{1}{\mathrm{L}}\left\{\left(z_1+\frac{p_1}{\mathrm{G}}\right)-\left(z_2+\frac{p_2}{\mathrm{G}}\right)\right\}\frac{\Omega}{\chi} \quad . \quad . \quad . \quad (2).$$

Suppose pressure columns introduced at A and B. The water will rise in those columns to the heights $\frac{p_1}{\mathrm{G}}$ and $\frac{p_2}{\mathrm{G}}$ due to the pressures p_1 and p_2 at A and B. Hence $\left(z_1+\frac{p_1}{\mathrm{G}}\right)-\left(z_2+\frac{p_2}{\mathrm{G}}\right)$ is the quantity represented in the figure by DE, the fall of level of the pressure columns, or *virtual fall* of the pipe. If there were no friction in the pipe, then by Bernoulli's equation there would be no fall of level of the pressure columns, the velocity being the same at A and B. Hence DE or h is the head lost in friction in the distance AB. The quantity $\frac{\mathrm{DE}}{\mathrm{AB}}=\frac{h}{\mathrm{L}}$ is termed the virtual slope of the pipe or virtual fall per foot of length. It is sometimes termed very conveniently the relative fall. It will be denoted by the symbol i.

The quantity $\frac{\Omega}{\chi}$ which appears in many hydraulic equations is called the hydraulic mean radius of the pipe. It will be denoted by m.

Introducing these values,

$$\zeta\frac{v^2}{2g}=m\frac{h}{\mathrm{L}}=mi\,. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

For pipes of circular section, and diameter d,

$$m=\frac{\Omega}{\chi}=\frac{\frac{\pi}{4}d^2}{\pi d}=\frac{d}{4}\,.$$

Then

$$\zeta\frac{v^2}{2g}=\frac{d}{4}\cdot\frac{h}{\mathrm{L}}=\frac{di}{4}\,, \quad . \quad . \quad . \quad . \quad . \quad (4);$$

or

$$h=\zeta\,\frac{4\mathrm{L}}{d}\cdot\frac{v^2}{2g}\,, \quad . \quad . \quad . \quad . \quad . \quad . \quad (4a);$$

which shows that the head lost in friction is proportional to the head due to the velocity, and is found by multiplying that head by the coefficient $\zeta\frac{4\mathrm{L}}{d}$.

70. *Hydraulic Gradient or Line of Virtual Slope.*—Join CD. Since the head lost in friction is proportional to L, any intermediate pressure column between A and B will have its free surface on the line CD, and the vertical distance between CD and the pipe at any point measures the pressure, exclusive of atmospheric pressure, in the pipe at that point. If the pipe were laid along the line CD instead of AB, the water would flow at the same velocity by gravity without any change of pressure from section to section. Hence CD is termed the virtual slope or hydraulic gradient of the pipe. It is the line of free surface level for each point of the pipe.

If an ordinary pipe, connecting reservoirs open to the air, rises at any point above the line of virtual slope, the pressure at that point is less than the atmospheric pressure transmitted through the pipe. At such a point there is a liability that air may be disengaged from the water, and the flow stopped or impeded by the accumulation of air. If the pipe rises more than 34 feet above the line of virtual slope, the pressure is negative. But as this is impossible, the continuity of the flow will be broken.

If the pipe is not straight, the line of virtual slope becomes a curved line, but since in actual pipes the vertical alterations of level are generally small, compared with the length of the pipe, distances measured along the pipe are sensibly proportional to distances measured along the horizontal projection of the pipe. Hence the line of hydraulic gradient may be taken to be a straight line without error of practical importance.

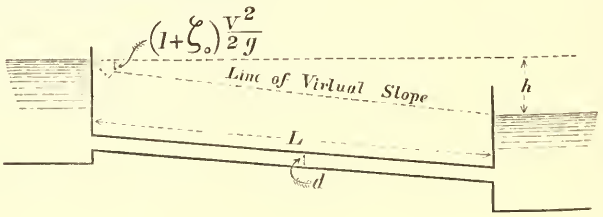


Fig. 82.

71. *Case of a Uniform Pipe connecting two Reservoirs, when all the Resistances are taken into account.*—Let h (fig. 82) be the difference of level of the reservoirs, and v the velocity, in a pipe of length L and diameter d. The whole work done per second is virtually the removal of Q cubic feet of water from the surface of the upper

reservoir to the surface of the lower reservoir, that is GQh foot-pounds. This is expended in three ways. (1) The head $\frac{v^2}{2g}$, corresponding to an expenditure of $GQ\frac{v^2}{2g}$ foot-pounds of work, is employed in giving energy of motion to the water. This is ultimately wasted in eddying motions in the lower reservoir. (2) A portion of head, which experience shows may be expressed in the form $\zeta_0\frac{v^2}{2g}$, corresponding to an expenditure of $GQ\zeta_0\frac{v^2}{2g}$ foot-pounds of work, is employed in overcoming the resistance at the entrance to the pipe. (3) As already shown the head expended in overcoming the surface friction of the pipe is $\zeta\frac{4L}{d}\frac{v^2}{2g}$ corresponding to $GQ\zeta\frac{4L}{d}\cdot\frac{v^2}{2g}$ foot-pounds of work. Hence

$$GQh = GQ\frac{v^2}{2g} + GQ\zeta_0\frac{v^2}{2g} + GQ\zeta\frac{4L}{d}\frac{v^2}{2g};$$

$$\left.\begin{aligned} h &= \left(1+\zeta_0+\zeta\frac{4L}{d}\right)\frac{v^2}{2g}, \\ v &= 8{\cdot}025\sqrt{\frac{hd}{(1+\zeta_0)d+4\zeta L}}. \end{aligned}\right\} \quad . \quad . \quad (5).$$

If the pipe is bellmouthed, ζ_0 is about $= {\cdot}08$. If the entrance to the pipe is cylindrical, $\zeta_0 = 0{\cdot}505$. Hence $1+\zeta_0 = 1{\cdot}08$ to $1{\cdot}505$. In general this is so small compared with $\zeta\frac{4L}{d}$ that, for practical calculations, it may be neglected; that is, the losses of head other than the loss in surface friction are left out of the reckoning. It is only in short pipes and at high velocities that it is necessary to take account of the first two terms in the bracket, as well as the third. For instance, in pipes for the supply of turbines, v is usually limited to 2 feet per second, and the pipe is bellmouthed. Then $1{\cdot}08\frac{v^2}{2g} = 0{\cdot}067$ foot. In pipes for towns' supply v may range from 2 to $4\frac{1}{2}$ feet per second, and then $1{\cdot}5\frac{v^2}{2g} = 0{\cdot}1$ to $0{\cdot}5$ foot. In either case this amount of head is small compared with the whole virtual fall in the cases which most commonly occur.

When d and v or d and h are given, the equations above are solved quite simply. When v and h are given and d is required, it is better to proceed by approximation. Find an approximate value of d by assuming a probable value for ζ as mentioned below. Then from that value of d find a corrected value for ζ and repeat the calculation.

The equation above may be put in the form

$$h = \frac{4\zeta}{d}\left\{\frac{(1+\zeta_0)d}{4\zeta} + L\right\}\frac{v^2}{2g}, \quad . \quad . \quad . \quad . \quad . \quad (6);$$

from which it is clear that the head expended at the mouthpiece is equivalent to that of a length

$$\frac{(1+\zeta_0)d}{4\zeta}$$

of the pipe. Putting $1+\zeta_0 = 1{\cdot}505$ and $\zeta = 0{\cdot}01$, the length of pipe equivalent to the mouthpiece is $37{\cdot}6\,d$ nearly. This may be added to the actual length of the pipe to allow for mouthpiece resistance in approximate calculations.

72. *Coefficient of Friction for Pipes Discharging Water*—From the average of a large number of experiments, the value of ζ for ordinary iron pipes is

$$\zeta = 0{\cdot}007567 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

But practical experience shows that no single value can be taken applicable to very different cases. The earlier hydraulicians occupied themselves chiefly with the dependence of ζ on the velocity. Having regard to the difference of the law of resistance at very low and at ordinary velocities, they assumed that ζ might be expressed in the form

$$\zeta = \alpha + \frac{\beta}{v}.$$

The following are the best numerical values obtained for ζ so expressed:—

	α	β
Prony (from 51 experiments)	0·006836	0·001116
D'Aubuisson	0·00673	0·001211
Eytelwein	0·005493	0·00143

Weisbach proposed the formula

$$\zeta = \alpha + \frac{\beta}{\sqrt{v}} = 0{\cdot}003598 + \frac{0{\cdot}004289}{\sqrt{v}} \quad . \quad . \quad . \quad . \quad (8).$$

The following short table gives Weisbach's values of the coefficient of friction for different velocities in feet per second:—

$v =$	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	3	4	6	8	12	20
$\zeta =$	0·0686	0·0527	0·0457	0·0415	0·0387	0·0365	0·0349	0·0336	0·0325	0·0315	0·0297	0·0284	0·0265	0·0243	0·0230	0·0214	0·0205	0·0193	0·0182

73. *Darcy's Experiments.*—All previous experiments on the resistance of pipes have been superseded by the remarkable researches carried out by the late Inspector-General of the Paris Water Works, M. Darcy. His experiments were carried out on a scale, under a variation of conditions, and with a degree of accuracy which leaves little to be desired, and the results obtained are of very great practical importance. These results may be stated thus:—

(1) For new and clean pipes the friction varies considerably with the nature and polish of the surface of the pipe. For clean cast-iron it is about $1\frac{1}{2}$ times as great as for cast-iron covered with pitch.

(2) The nature of the surface has less influence when the pipes are old and incrusted with deposits, due to the action of the water. Thus old and incrusted pipes give twice as great a frictional resistance as new and clean pipes. M. Darcy's coefficients were chiefly determined from experiments on new pipes. He doubles these coefficients for old and incrusted pipes, in accordance with the results of a very limited number of experiments on pipes containing incrustations and deposits.

(3) The coefficient of friction may be expressed in the form $\zeta = \alpha + \frac{\beta}{v}$; but in pipes which have been some time in use it is sufficiently accurate to take $\zeta = \alpha_1$ simply, where α_1 depends on the diameter of the pipe alone, but α and β on the other hand depend both on the diameter of the pipe and the nature of its surface. The following are the values of the constants.

For pipes which have been some time in use, neglecting the term depending on the velocity;

$$\zeta = \alpha\left(1 + \frac{\beta}{d}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

	α	β
For drawn wrought-iron or smooth cast-iron pipes	·004973	·084
For pipes altered by light incrustations	·00996	·084

These coefficients may be put in the following very simple form, without sensibly altering their value:—

$$\left.\begin{aligned} &\text{For clean pipes} \ldots\ldots\ldots\ldots \quad \zeta = {\cdot}005\left(1+\frac{1}{12d}\right) \\ &\text{For slightly incrusted pipes} \ldots\ldots \quad \zeta = {\cdot}01\left(1+\frac{1}{12d}\right) \end{aligned}\right\} (9a).$$

Darcy's Value of the Coefficient of Friction ζ for Velocities not less than 4 inches per second.

Diameter of Pipe in Inches.	ζ New Pipes.	ζ Incrusted Pipes.	Diameter of Pipe in Inches.	ζ New Pipes.	ζ Incrusted Pipes.
2	0·00750	0·01500	18	·00528	·01056
3	·00667	·01333	21	·00524	·01048
4	·00625	·01250	24	·00521	·01042
5	·00600	·01200	27	·00519	·01037
6	·00583	·01167	30	·00517	·01033
7	·00571	·01143	36	·00514	·01028
8	·00563	·01125	42	·00512	·01024
9	·00556	·01111	48	·00510	·01021
12	·00542	·01083	54	·00509	·01019
15	·00533	·01067			

These values of ζ are, however, only applicable when the velocity exceeds 4 inches per second. To embrace all cases Darcy proposes the expression

$$\zeta = \left(\alpha + \frac{\alpha_1}{d}\right) + \frac{\beta + \frac{\beta_1}{d^2}}{v}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (10);$$

which is a modification of Coulomb's, including terms expressing the influence of the diameter and of the velocity. For clean pipes Darcy found these values

$\alpha = {\cdot}001262$
$\alpha_1 = {\cdot}000833$
$\beta = {\cdot}00206$
$\beta_1 = {\cdot}00001042$

74. *Scraping Water Mains.*—The influence of the condition of the surface of a pipe on the friction is shown by various facts known to the engineers of waterworks. Pipes are very often heated and dipped in pitch, which gives them a smooth hard surface and protects them from oxidation. Such pipes are known to give a discharge larger than that calculated by the ordinary formulæ. In pipes which convey certain kinds of water oxidation proceeds rapidly, and the discharge is very perceptibly and sometimes very greatly diminished. In a main laid at Torquay the discharge diminished from this cause more than 50 per cent., and the supply became insufficient for the town. Mr Appold suggested an apparatus for scraping the interior of the pipe, and this was constructed and tried under the direction of Mr Froude. It was found that by scraping the interior of the pipe the discharge was increased 56 per cent. The scraping requires to be repeated at intervals. After each scraping the discharge diminishes rather rapidly by 10 per cent. and afterwards more slowly, the diminution in a year being about 25 per cent.

Fig. 83 shows a scraper for water mains, similar to Mr Appold's but modified in details, as constructed by the Glenfield Company, at Kilmarnock. A is a longitudinal section of the pipe, showing the scraper in place; B is an end view of the plungers, and C, D sections of the boxes placed at intervals on the main for introducing or withdrawing the scraper. The apparatus consists of two plungers, packed with leather so as to fit the main pretty closely. On the spindle of these plungers are fixed eight steel scraping blades, with curved scraping edges fitting the surface of the main. The apparatus is placed in the main by removing the cover from one of the boxes shown at C, D. The cover is then replaced, water pressure is admitted behind the plungers, and the apparatus driven through the main. At Lancaster, after twice scraping the discharge was increased $56\frac{1}{2}$ per cent., at Oswestry $54\frac{1}{2}$ per cent. The increased discharge is due to the diminution of the friction of the pipe by removing the roughnesses due to oxidation.

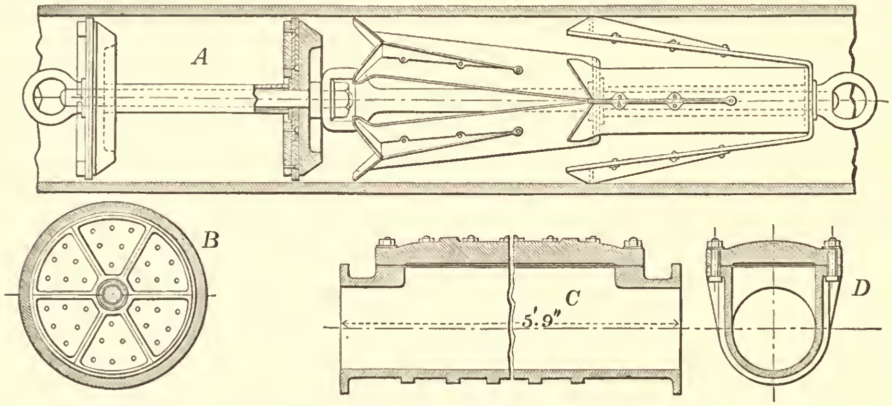


Fig. 83.—Scale $\frac{1}{25}$.

75. *Reduction of a long Pipe of Varying Diameter to an Equivalent Pipe of Uniform Diameter. Dupuit's Equation.*—Water mains for the supply of towns often consist of a series of lengths, the diameter being the same for each length, but differing from length to length. In approximate calculations of the head lost in such mains, it is generally accurate enough to neglect the smaller losses of head and to have regard to the pipe friction only, and then the calculations may be facilitated by reducing the main to a main of uniform diameter, in which there would be the same loss of head. Such a uniform main will be termed an equivalent main.

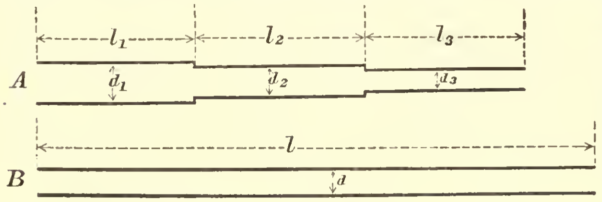


Fig. 84.

In fig. 84, let A be the main of variable diameter, and B the equivalent uniform main. In the given main of variable diameter A, let

$l_1,\ l_2$ . . be the lengths,
$d_1,\ d_2$ . . . . the diameters,
$v_1,\ v_2$ . . . . the velocities,
$i_1,\ i_2$ . . . . the slopes,

for the successive portions, and let l, d, v, and i be corresponding quantities for the equivalent uniform main B. The total loss of head in A due to friction is

$$h = i_1 l_1 + i_2 l_2 + \ldots\ldots\ldots$$
$$= \zeta \frac{v_1^2}{2g}\frac{4l_1}{d_1} + \zeta \frac{v_2^2}{2g}\frac{4l_2}{d_2} + \ldots\ldots ;$$

and in the uniform main

$$il = \zeta \frac{v^2}{2g} \cdot \frac{4l}{d}$$

If the mains are equivalent, as defined above,

$$\zeta \frac{v^2}{2g}\frac{4l}{d} = \zeta \frac{v_1^2}{2g} \cdot \frac{4l_1}{d_1} + \zeta \frac{v_2^2}{2g}\frac{4l_2}{d_2} + \ldots\ldots$$

But, since the discharge is the same for all portions,

$$\frac{\pi}{4} d^2 v = \frac{\pi}{4} d_1^2 v_1 = \frac{\pi}{4} d_2^2 v_2 = \ldots\ldots$$
$$v_1 = v\frac{d^2}{d_1^2}\ ;\ v_2 = v\frac{d^2}{d_2^2} \quad \ldots\ldots$$

Also suppose that ζ may be treated as constant for all the pipes. Then

$$\frac{l}{d} = \frac{d^4}{d_1^4} \cdot \frac{l_1}{d_1} + \frac{d^4}{d_2^4} \cdot \frac{l_2}{d_2} + \ldots\ldots$$
$$l = \frac{d^5}{d_1^5} l_1 + \frac{d^5}{d_2^5} l_2 + \ldots\ldots\ldots$$

which gives the length of the equivalent uniform main which would have the same total loss of head for any given discharge.

76. *Case of a Pipe of Uniform Diameter with Discharge diminishing uniformly along its Length.*—In the case of a branch main the water is delivered at nearly equal distances to service pipes along the route. Such a main approximates to the case of a main of uniform diameter, with a discharge at each point diminished by an amount proportional to the distance from the origin. Let AB (fig. 85) be a main of diameter d and length L; let Q_0 cubic feet per second enter at A, and let q cubic feet be delivered to service pipes per foot of its length. Then at any point C, l feet from A, the discharge is $Q = Q_0 - ql$. Consider a short length dl at c. The loss of head in that length is

$$\zeta \frac{v^2}{2g} \cdot \frac{4dl}{d} = \zeta \frac{Q^2}{\frac{\pi^2}{16} d^4} \cdot \frac{4dl}{d} = 64\,\zeta \frac{Q^2 dl}{\pi^2 d^5} = \frac{64\zeta}{\pi^2 d^5}(Q_0 - ql)^2 dl\,.$$

Hence the whole head lost in the length AB will be

$$h = \frac{64\zeta}{\pi^2 d^5}\int_0^L (Q_0 - ql)^2 dl$$
$$= \frac{64\zeta L}{\pi^2 d^5}\left\{ Q_0^2 - qQ_0 L + \tfrac{1}{3} q^2 L^2 \right\}, \quad \ldots \quad (1);$$

or, putting $P = qL$, the total discharge through the service pipes between A and B,

$$h = \frac{64\zeta L}{\pi^2 d^5}\left\{ Q_0^2 - PQ_0 + \tfrac{1}{3}P^2 \right\}. \quad \ldots \quad (2).$$

The discharge at the end B of the pipe is $Q_1 = Q_0 - P$. If Q' is put for the discharge of the pipe when the flow into the service pipes is stopped, under the same head h, it may be shown that

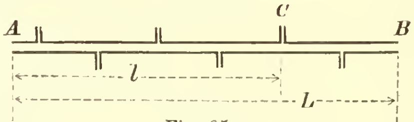


Fig. 85.

$$Q_1 = Q' - 0{\cdot}55P \text{ nearly}$$

If the pipe is so long that

$$Q_1 = Q_0 - P = 0,$$

all the water passing into service pipes *en route*,

$$h = \frac{1}{3}\frac{64\zeta L}{\pi^2 d^5} Q_0^2\,. \quad \ldots\ldots \quad (3).$$

77. *Other Losses of Head in Pipes.*—Most of the losses of head in pipes, other than that due to surface friction against the pipe, are due

to abrupt changes in the velocity of the stream producing eddies. The kinetic energy of these is deducted from the general energy of translation, and practically wasted.

Sudden Enlargement of Section.—Suppose a pipe enlarges in section from an area ω_0 to an area ω_1 (fig. 86); then

$$\frac{v_1}{v_0} = \frac{\omega_0}{\omega_1};$$

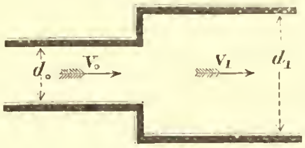


Fig. 86.

or, if the section is circular,

$$\frac{v_1}{v_0} = \left(\frac{d_0}{d_1}\right)^2.$$

The head lost at the abrupt change of velocity has already been shown to be the head due to the relative velocity of the two parts of the stream. Hence head lost

$$\mathfrak{h}_e = \frac{(v_0 - v_1)^2}{2g} = \left(\frac{\omega_1}{\omega_0} - 1\right)^2 \frac{v_1^2}{2g} = \left\{\left(\frac{d_1}{d_0}\right)^2 - 1\right\}^2 \frac{v_1^2}{2g}$$

or

$$\mathfrak{h}_e = \zeta_e \frac{v_1^2}{2g}, \quad \ldots \quad (1),$$

if ζ_e is put for the expression in brackets.

$\frac{\omega_1}{\omega_0} =$	1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2·0	2·5	3·0	3·5	4·0	5·0	6·0	7·0	8·0
$\frac{d_1}{d_0} =$	1·05	1·10	1·14	1·18	1·22	1·26	1·30	1·34	1·38	1·41	1·58	1·73	1·87	2·00	2·24	2·45	2·65	2·83
$\zeta_e =$	·01	·04	·09	·16	·25	·36	·49	·64	·81	1·00	2·25	4·00	6·25	9·00	16·00	25·00	36·0	49·0

Abrupt Contraction of Section.—When water passes from a larger to a smaller section, as in figs. 87, 88, a contraction is formed, and

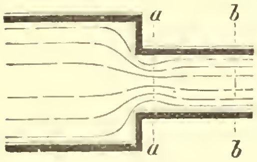


Fig. 87.

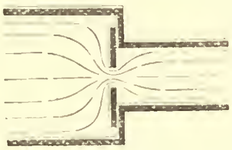


Fig. 88.

the contracted stream abruptly expands to fill the section of the pipe. Let ω be the section and v the velocity of the stream at *bb*. At *aa* the section will be $c_c\omega$, and the velocity $\frac{\omega}{c_c\omega} v = \frac{v}{c_c}$, where c_c is the coefficient of contraction. Then the head lost is

$$\mathfrak{h}_m = \frac{\left(\frac{v}{c_c} - v\right)^2}{2g} = \left(\frac{1}{c_c} - 1\right)^2 \frac{v^2}{2g};$$

and, if c_c is taken 0·64,

$$\mathfrak{h}_m = 0{\cdot}316 \frac{v^2}{2g} \quad \ldots \quad (2).$$

The value of the coefficient of contraction for this case is, however, not well ascertained, and the result is somewhat modified by friction. For water entering a cylindrical, not bellmouthed, pipe from a reservoir of indefinitely large size, experiment gives

$$\mathfrak{h}_a = 0{\cdot}505 \frac{v^2}{2g} \quad \ldots \quad (3).$$

If there is a diaphragm at the mouth of the pipe as in fig. 88, let ω_1 be the area of this orifice. Then the area of the contracted stream is $c_c\omega_1$, and the head lost is

$$\mathfrak{h}_c = \left(\frac{\omega}{c_c\omega_1} - 1\right)^2 \frac{v^2}{2g}$$
$$= \zeta_c \frac{v^2}{2g} \quad \ldots \quad (4)$$

if ζ_c is put for $\left(\frac{\omega}{c_c\omega_1} - 1\right)^2$.

Weisbach has found experimentally the following values of the coefficient, when the stream approaching the orifice was considerably larger than the orifice:—

$\frac{\omega_1}{\omega} =$	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0
$c_c =$	·616	·614	·612	·610	·607	·605	·603	·601	·598	·596
$\zeta_c =$	231·7	50·99	19·78	9·612	5·256	3·077	1·876	1·169	0·734	0·480

When a diaphragm was placed in a tube of uniform section (fig. 89),


Fig. 89.

the following values were obtained, ω_1 being the area of the orifice, and ω that of the pipe:—

$\frac{\omega_1}{\omega} =$	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0
$c_c =$	·624	·632	·643	·659	·681	712	·755	·813	·892	1·00
$\zeta_c =$	225·9	47·77	30·83	7·801	1·753	1·796	·797	·290	·060	·000

Elbows.—Weisbach considers the loss of head at elbows (fig. 90) to be due to a contraction formed by the stream. From experiments with a pipe $1\frac{1}{4}$ inches diameter, he found the loss of head

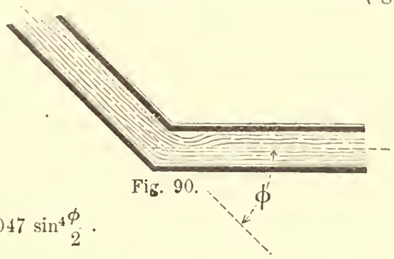


Fig. 90.

$$\mathfrak{h}_e = \zeta_e \frac{v^2}{2g} \quad \ldots \quad (5);$$

$$\zeta_e = 0{\cdot}9457 \sin^2\frac{\phi}{2} + 2{\cdot}047 \sin^4\frac{\phi}{2}.$$

$\phi =$	20°	40°	60°	80°	90°	100°	110°	120°	130°	140°
$\zeta_e =$	0·046	0·139	0·364	0·740	0·984	1·260	1·556	1·861	2·158	2·431

Hence at a right-angled elbow the whole head due to the velocity very nearly is lost.

Bends.—Weisbach traces the loss of head at curved bends to a similar cause to that at elbows, but the coefficients for bends are not very satisfactorily ascertained. Weisbach obtained for the loss of head at a bend in a pipe of circular section

$$\mathfrak{h}_b = \zeta_b \frac{v^2}{2g} \quad \ldots \quad (6);$$

$$\zeta_b = 0{\cdot}131 + 1{\cdot}847 \left(\frac{d}{2\rho}\right)^{\frac{7}{2}},$$

where d is the diameter of the pipe and ρ the radius of curvature of the bend. For bends with rectangular cross sections

$$\zeta_b = 0{\cdot}124 + 3{\cdot}104 \left(\frac{s}{2\rho}\right)^{\frac{7}{2}},$$

where s is the length of the side of the section parallel to the radius of curvature ρ.

$\frac{d}{2\rho} =$	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0
$\zeta_b =$	0·131	·138	·158	·206	·294	·440	·661	·977	1·408	1·978

$\frac{s}{2\rho} =$	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0
$\zeta_b =$	·124	·135	·180	·250	·398	·643	1·015	1·546	2·271	3·228

Valves, Cocks, and Sluices.—These produce a contraction of the water-stream, similar to that for an abrupt diminution of section already discussed. The loss of head may be taken as before to be

$$\mathfrak{h}_v = \zeta_v \frac{v^2}{2g} \quad \ldots \quad (7);$$

where v is the velocity in the pipe beyond the valve and ζ_v a coefficient determined by experiment. The following are Weisbach's results.

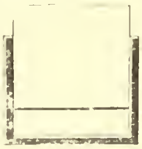


Fig. 91.

Sluice in Pipe of Rectangular Section (fig. 91). Section at sluice $= \omega_1$ in pipe $= \omega$.

$\frac{\omega_1}{\omega} =$	1·0	0·9	0·8	0·7	0·6	0·5	0·4	0·3	0·2	0·1
$\zeta_v =$	0·00	·09	·39	·95	2·0[illegible]	4·02	8·12	17·8	44·5	193

Sluice in Cylindrical Pipe (fig. 92).

Ratio of height of opening to diameter of pipe	1·0	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{8}$
$\frac{\omega_1}{\omega}=$	1·00	0·948	·856	·740	·609	·466	·315	·159
$\zeta_v=$	0·00	0·07	0·26	0·81	2·06	5·52	17·0	97·8

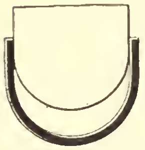


Fig. 92.

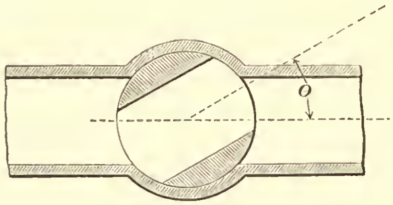


Fig. 93.

Cock in a Cylindrical Pipe (fig. 93). Angle through which cock is turned $=\theta$.

$\theta=$	5°	10°	15°	20°	25°	30°	35°
Ratio of cross sections . . .	·926	·850	·772	·692	·613	·535	·458
$\zeta_v=$	·05	·29	·75	1·56	3·10	5·47	9·68

$\theta=$	40°	45°	50°	55°	60°	65°	82°
Ratio of cross sections . . .	·385	·315	·250	·190	·137	·091	0
$\zeta_v=$	17·3	31·2	52·6	106	206	486	∞

Throttle Valve in a Cylindrical Pipe (fig. 94).

$\theta=$	5°	10°	15°	20°	25°	30°	35°	40°
$\zeta_v=$	·24	·52	·90	1·54	2·51	3·91	6·22	10·8

$\theta=$	45°	50°	55°	60°	65°	70°	90
$\zeta_v=$	18·7	32·6	58·8	118	256	751	∞

78. *Practical Calculations on the Flow of Water in Pipes.*—In the following explanations it will be assumed that the pipe is of so great a length that only the loss of head in friction against the surface of the pipe needs to be considered. In general it is one of the four quantities d, i, v, or Q which requires to be determined.

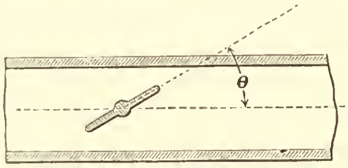


Fig. 94.

For since the loss of head h is given by the relation $h=il$, this need not be separately considered.

There are then three equations (see eq. 4, § 69, and 9*a*, § 73) for the solution of such problems as arise :—

$$\zeta=\alpha\left(1+\frac{1}{12d}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1);$$

where $\alpha=0·005$ for new and $=0·01$ for incrusted pipes.

$$\zeta\frac{v^2}{2g}=\frac{di}{4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

$$Q=\frac{\pi}{4}d^2v \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Problem 1. Given the diameter of the pipe and its virtual slope, to find the discharge and velocity of flow. Here d and i are given, and Q and v are required. Find ζ from (1); then v from (2); lastly Q from (3). This case presents no difficulty.

By combining equations (1) and (2), v is obtained directly :—

$$v=\sqrt{\frac{g}{2\zeta}}\,di=\sqrt{\frac{g}{2\alpha}}\sqrt{\frac{di}{1+\frac{1}{12d}}} \quad . \quad . \quad . \quad . \quad (4).$$

For new pipes $\sqrt{\frac{g}{2\alpha}}=56·72$

For incrusted pipes $=80·24$

For pipes not less than 1, or more than 4 feet in diameter, the mean values of ζ are

For new pipes ....0·00526
For incrusted pipes ....0·01052.

Using these values we get the very simple expressions—

$$\left.\begin{aligned} v&=55·31\sqrt{di} \text{ for new pipes} \\ &=39·11\sqrt{di} \text{ for incrusted pipes} \end{aligned}\right\} \quad . \quad . \quad . \quad (4a).$$

Within the limits stated, these are accurate enough for practical purposes, especially as the precise value of the coefficient ζ cannot be known for each special case.

Problem 2. Given the diameter of a pipe and the velocity of flow, to find the virtual slope and discharge. The discharge is given by (3); the proper value of ζ by (1); and the virtual slope by (2). This also presents no special difficulty.

Problem 3. Given the diameter of the pipe and the discharge, to find the virtual slope and velocity. Find v from (3); ζ from (1); lastly i from (2). If we combine (1) and (2) we get

$$i=\zeta\frac{v^2}{2g}\cdot\frac{4}{d}=2\alpha\left(1+\frac{1}{12d}\right)\frac{v^2}{gd} \quad . \quad . \quad . \quad . \quad (5);$$

and, taking the mean values of ζ for pipes from 1 to 4 feet diameter, given above, the approximate formulæ are

$$\left.\begin{aligned} i&=0·0003268\,\frac{v^2}{d} \text{ for new pipes} \\ &=0·0006536\,\frac{v^2}{d} \text{ for incrusted pipes} \end{aligned}\right\} \quad . \quad . \quad . \quad (5a).$$

Problem 4. Given the virtual slope and the velocity, to find the diameter of the pipe and the discharge. The diameter is obtained from equations (2) and (1), which give the quadratic expression

$$d^2-d\,\frac{2\alpha v^2}{gi}-\frac{\alpha v^2}{6gi}=0\,.$$

$$\therefore\quad d=\frac{\alpha v^2}{gi}+\sqrt{\left\{\frac{\alpha v^2}{gi}\left(\frac{\alpha v^2}{gi}+\frac{1}{6}\right)\right\}} \quad . \quad . \quad . \quad . \quad (6).$$

For practical purposes, the approximate equations

$$d=\frac{2\alpha v^2}{gi}+\frac{1}{12} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6a)$$

$$=0·00031\,\frac{v^2}{i}+·083 \text{ for new pipes}$$

$$=0·00062\,\frac{v^2}{i}+·083 \text{ for incrusted pipes}$$

are sufficiently accurate.

Problem 5. Given the virtual slope and the discharge, to find the diameter of the pipe and velocity of flow. This case, which often occurs in designing, is the one which is least easy of direct solution. From equations (2) and (3) we get—

$$d^5=\frac{32\zeta Q^2}{g\pi^2 i} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

If now the value of ζ in (1) is introduced, the equation becomes very cumbrous. Various approximate methods of meeting the difficulty may be used.

(*a*) Taking the mean values of ζ given above for pipes of 1 to 4 feet diameter we get

$$d=\sqrt[5]{\frac{32\zeta}{g\pi^2}}\sqrt[5]{\frac{Q^2}{i}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$=0·2216\sqrt[5]{\frac{Q^2}{i}} \text{ for new pipes}$$

$$=0·2541\sqrt[5]{\frac{Q^2}{i}} \text{ for incrusted pipes ;}$$

equations which are interesting as showing that when the value of ζ is doubled the diameter of pipe for a given discharge is only increased by 13 per cent.

(*b*) A second method is to obtain a rough value of d by assuming $\zeta=\alpha$. This value is

$$d'=\sqrt[5]{\frac{32Q^2}{g\pi^2 i}}\sqrt[5]{\alpha}=0·6319\sqrt[5]{\frac{Q^2}{i}}\sqrt[5]{\alpha}\,.$$

Then a very approximate value of ζ is

$$\zeta'=\alpha\left(1+\frac{1}{12d'}\right);$$

and a revised value of d, not sensibly differing from the exact value, is

$$d''=\sqrt[5]{\frac{32Q^2}{g\pi^2 i}}\sqrt[6]{\zeta'}=0·6319\sqrt[5]{\frac{Q^2}{i}}\sqrt[5]{\zeta'}\,.$$

(*c*) Equation 7 may be put in the form

$$d=\sqrt[5]{\frac{32\alpha Q^2}{g\pi^2 i}}\left(1+\frac{1}{12d}\right)^{\frac{1}{5}} \quad . \quad . \quad . \quad . \quad . \quad (9).$$

Expanding the term in brackets,

$$\left(1+\frac{1}{12d}\right)^{\frac{1}{5}}=1+\frac{1}{60d}-\frac{1}{1800d^2}\ \cdots\cdots$$

Neglecting the terms after the second,

$$d=\sqrt[5]{\frac{32a}{g\pi^2}}\sqrt[5]{\frac{Q^2}{i}}\left(1+\frac{1}{60d}\right)$$

$$=\sqrt[5]{\frac{32a}{g\pi^2}}\sqrt[5]{\frac{Q^2}{i}}+0\cdot01667\quad . \quad . \quad . \quad . \quad (9a);$$

and

$$\sqrt[5]{\frac{32a}{g\pi^2}}=0\cdot219 \text{ for new pipes}$$

$$=0\cdot252 \text{ for incrusted pipes.}$$

79. *Arrangement of a Pipe Network for Town's Supply.*—Excluding the service pipes which directly supply the houses, the smallest branch water mains are made 3 to 4 inches in diameter. For the smallest districts supplied, these are sufficient or more than sufficient to convey the necessary supply, and in that case the only question arising is, to lay them out so that their total length is as small as possible.

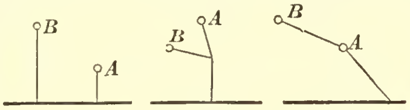


Fig. 95.

Thus if there are two places of consumption A and B there is choice of any of the three arrangements shown in fig 95, the principal main being shown by the dark line, and the branch mains by the thinner ones. If, however, the supply through the branch mains requires pipes of more than the minimum diameter, then the condition to be fulfilled is that the sum of the products of the lengths and diameters should be a minimum, because the cost of the mains when laid in place is very approximately proportional to their length and diameter.

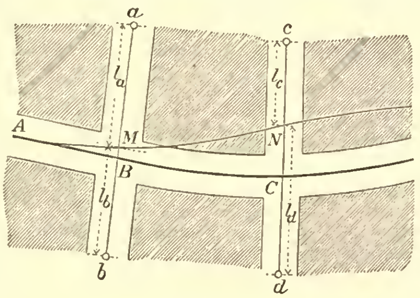


Fig. 96.

For a main delivering water to branch mains on each side, the best position is that which makes the branch mains of equal diameter. Suppose water is to be supplied from an intermediate main along branch mains to a and b (fig. 96). Let Q_a, Q_b be the quantities to be delivered at a and b, and $\mathfrak{h}_a$, $\mathfrak{h}_b$ the virtual fall of the two branch mains. Then, according to Dupuit, the best position for the intersection M is that for which

$$\frac{l_a}{l_b}=\frac{\mathfrak{h}_a Q_b^2}{\mathfrak{h}_b Q_a^2};$$

or, if the consumption of water occurs uniformly throughout the length of the branch mains, then

$$\frac{l_a}{l_b}=\sqrt[3]{\frac{\mathfrak{h}_a}{\mathfrak{h}_b}}.$$

In this way various points MN may be determined giving the position AMN for the main, and afterwards the nearest convenient position ABC may be fixed.

In determining the consumption of water Q for any given locality, the mode of supply must be taken into account. On the intermittent system, water is supplied for a period of t seconds daily. Then the discharge per second is $\frac{NQ_d}{t}$, where N is the number of inhabitants, and Q_d the daily supply to each in cubic feet. With a constant supply the rate of flow is variable at different periods of the day, and the maximum rate of flow may be taken at 2·1 times the mean rate. Hence in this case the discharge to be provided for in the mains is $\frac{2\cdot1NQ_d}{24\times60\times60}$. The daily supply to a district NQ_d is sometimes taken proportional to the area supplied, sometimes to the length of house frontage in the district.

Determination of the Diameters of Different Parts of a Water Main.

When the plan of the arrangement of mains is determined upon, and the supply to each locality and the pressure required is ascertained, it remains to determine the diameters of the pipes. Let fig. 97 show an elevation of a main ABCD . . ., R being the reservoir from which the supply is derived. Let NN be the datum line of the levelling operations, and H_a, H_b . . . the heights of the main above the datum line, H_r being the height of the water surface in the reservoir from the same datum. Set up next heights AA_1, BB_1, . . . representing the minimum pressure height necessary for the adequate supply of each locality. Then $A_1B_1C_1D_1$ . . . is a line which should form a lower limit to the line of virtual slope. Then if heights $\mathfrak{h}_a$, $\mathfrak{h}_b$, $\mathfrak{h}_c$ . . . are taken representing the actual losses of head in each length l_a, l_b, l_c . . . of the main, $A_0B_0C_0$ will be the line of virtual slope, and it will be obvious at what points such as D_0 and E_0, the pressure is deficient, and a different choice of diameter of main is required. For any point z in the length of the main, we have

$$\text{Pressure height}=H_r-H_z-(\mathfrak{h}_a+\mathfrak{h}_b+\ .\ .\ .\ .\ .\ .\ \mathfrak{h}_z).$$

Where no other circumstance limits the loss of head to be assigned to a given length of main, a consideration of the safety of the main from fracture by hydraulic shock leads to a limitation of the velocity of flow. Generally the velocity in water mains lies between $1\frac{1}{2}$ and $4\frac{1}{2}$ feet per second. Occasionally the velocity in pipes reaches 10 feet per second, and in hydraulic machinery working under enormous pressures even 20 feet per second. Usually the velocity diminishes along the main as the discharge diminishes, so as to reduce somewhat the total loss of head which is liable to render the pressure insufficient at the end of the main.

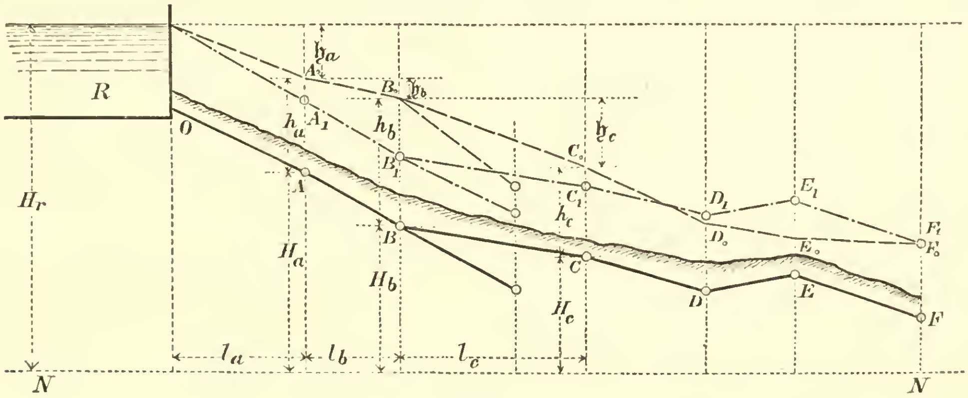


Fig. 97.

Mr Fanning gives the following velocities as suitable in pipes for towns' supply:—

Diameter in inches	4	8	12	18	24	30	36
Velocity in feet per sec. ...	2·5	3·0	3·5	4·5	5·3	6·2	7·0

80. *Branched Pipe connecting Reservoirs at Different Levels.*—Let A, B, C (fig. 98) be three reservoirs connected by the arrangement of pipes shown,—l_1, d_1, Q_1, v_1; l_2, d_2, Q_2, v_2; l_3, d_3, Q_3, v_3 being the length, diameter, discharge, and velocity in the three portions of the main pipe. Suppose the dimensions and positions of the pipes known and the discharges required.

If a pressure column is introduced at X, the water will rise to a height XR, measuring the pressure at X, and aR, Rb, Rc will be the lines of virtual slope. If the free surface level at R is above b, the reservoir A supplies B and C, and if R is below b, A and B supply C. Consequently there are three cases:—

I. R above b; $Q_1=Q_2+Q_3$.
II. R level with b; $Q_1=Q_3$; $Q_2=0$.
III. R below b; $Q_1+Q_2=Q_3$.

To determine which case has to be dealt with in the given conditions, suppose the pipe from X to B closed by a sluice. Then there is a simple main, and the height of free surface h' at X can be determined. For this condition

$$h_a - h' = \zeta \frac{v_1^2}{2g} \cdot \frac{4l_1}{d_1} = \frac{32\zeta Q'^2 l_1}{g\pi^2 d_1^5} ;$$

$$h' - h_c = \zeta \frac{v_3^2}{2g} \cdot \frac{4l_3}{d_3} = \frac{32\zeta Q'^2 l_3}{g\pi^2 d_3^5} ;$$

where Q′ is the common discharge of the two portions of the pipe. Hence

$$\frac{h_a - h'}{h' - h_c} = \frac{l_1 d_3^5}{l_3 d_1^5} ,$$

from which h' is easily obtained. If then h' is greater than hb, opening the sluice between X and B will allow flow towards B, and the case in hand is case I. If h' is less than h_b, opening the sluice will allow flow from B, and the case is case III. If $h' = h_b$, the case is case II., and is already completely solved.

The true value of h must lie between h' and h_b. Choose a new value of h, and recalculate Q_1, Q_2, Q_3. Then if

$$Q_1 > Q_2 + Q_3 \text{ in case I.,}$$

or

$$Q_1 + Q_2 > Q_3 \text{ in case III.,}$$

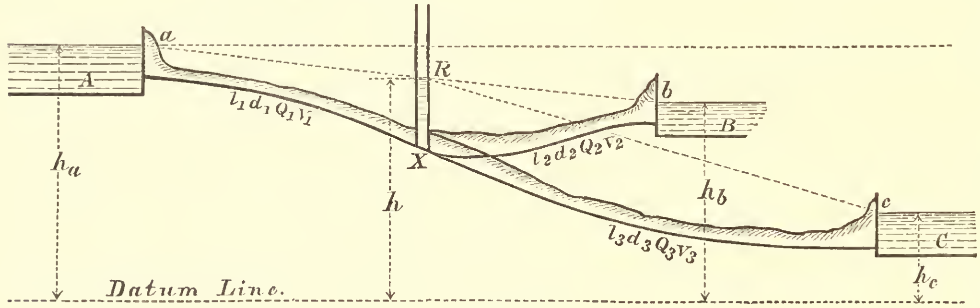


Fig. 98.

the value chosen for h is too small, and a new value must be chosen If

$$Q_1 < Q_2 + Q_3 \text{ in case I.,}$$

or

$$Q_1 + Q_2 < Q_3 \text{ in case III.,}$$

the value of h is too great.

Since the limits between which h can vary are in practical cases not very distant, it is easy to approximate to values sufficiently accurate.

IX. FLOW OF COMPRESSIBLE FLUIDS IN PIPES.

81. *Flow of Air in Long Pipes.*[1]—When air flows through a long pipe, by far the greater part of the work expended is used in overcoming frictional resistances due to the surface of the pipe. The work expended in friction generates heat, which for the most part must be developed in and given back to the air. Some heat may be transmitted through the sides of the pipe to surrounding materials, but in experiments hitherto made the amount so conducted away appears to be very small, and if no heat is transmitted the air in the tube must remain sensibly at the same temperature during expansion. In other words, the expansion may be regarded as isothermal expansion, the heat generated by friction exactly neutralizing the cooling due to the work done. Experiments on the pneumatic tubes used for the transmission of messages, by Messrs Culley & Sabine, show that the change of temperature of the air flowing along the tube is much less than it would be in adiabatic expansion.

82. *Differential Equation of the Steady Motion of Air Flowing in a Long Pipe of Uniform Section.*—When air expands at a constant absolute temperature τ, the relation between the pressure p in pounds per square foot and the density or weight per cubic foot G is given by the equation

$$\frac{p}{G} = c\tau \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

where $c = 53{\cdot}15$. Taking $\tau = 521$, corresponding to a temperature of 60° Fahr.,

$$c\tau = 27690 \text{ foot-pounds} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

The equation of continuity, which expresses the condition that in steady motion the same weight of fluid, W, must pass through each cross section of the stream in the unit of time, is

$$G\Omega u = W = \text{constant} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3),$$

where Ω is the section of the pipe and u the velocity of the air. Combining (1) and (3),

$$\frac{\Omega u p}{W} = c\tau = \text{constant} \quad . \quad . \quad . \quad . \quad (3a).$$

[1] This investigation was first given in the *Proc Inst. of Civil Engineers*, vol. xliii.

Since the work done by gravity on the air during its flow through a pipe due to variations of its level is generally small compared with the work done by changes of pressure, the former may in many cases be neglected.

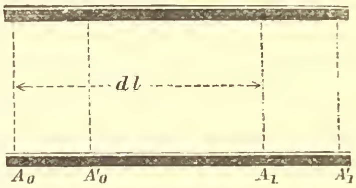


Fig. 99.

Consider a short length dl of the pipe limited by sections A_0, A_1 at a distance dl (fig. 99). Let p, u be the pressure and velocity at A_0, $p + dp$ and $u + du$ those at A_1. Further, suppose that in a very short time dt the mass of air between A_0A_1 comes to $A'_0A'_1$ so that $A_0A'_0 = udt$ and $A_1A'_1 = (u + du)dt$. Let Ω be the section, and m the hydraulic mean radius of the pipe, and W the weight of air flowing through the pipe per second.

From the steadiness of the motion the weight of air between the sections $A_0A'_0$, and $A_1A'_1$ is the same. That is,

$$Wdt = G\Omega u dt = G\Omega(u + du)dt .$$

By analogy with liquids the head lost in friction is, for the length dl (see § 69, eq. 3),

$$\zeta \frac{u^2}{2g} \cdot \frac{dl}{m} .$$

Let $H = \frac{u^2}{2g}$. Then the head lost is

$$\zeta \frac{H}{m} dl ;$$

and, since Wdt pounds of air flow through the pipe in the time considered, the work expended in friction is

$$-\zeta \frac{H}{m} W dl\, dt .$$

The change of kinetic energy in dt seconds is the difference of the kinetic energy of $A_0A'_0$ and $A_1A'_1$, that is,

$$\frac{W}{g} dt \frac{(u + du)^2 - u^2}{2}$$

$$= \frac{W}{g} u du dt = W dH dt .$$

The work of expansion when $\Omega u dt$ cubic feet of air at a pressure p expand to $\Omega(u + du)dt$ cubic feet is

$$\Omega\, p du dt .$$

But from (3a)

$$u = \frac{c\tau W}{\Omega p} ,$$

$$\therefore \quad \frac{du}{dp} = -\frac{c\tau W}{\Omega p^2} .$$

And the work done by expansion is

$$-\frac{c\tau W}{p} dp dt .$$

The work done by gravity on the mass between A_0 and A_1 is zero if the pipe is horizontal, and may in other cases be neglected without great error. The work of the pressures at the sections A_0A_1 is

$$p\Omega u dt - (p + dp)\Omega(u + du)dt$$
$$= -(pdu + udp)\Omega dt .$$

But from (3a)

$$pu = \text{constant} ,$$
$$pdu + udp = 0 ,$$

and the work of the pressures is zero. Adding together the quantities of work, and equating them to the change of kinetic energy,

$$W dH dt = -\frac{c\tau W}{p} dp dt - \zeta \frac{H}{m} W dl dt$$

$$dH + \frac{c\tau}{p} dp + \zeta \frac{H}{m} dl = 0 ,$$

$$\frac{dH}{H} + \frac{c\tau}{Hp} dp + \zeta \frac{dl}{m} = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

But

$$u = \frac{c\tau W}{\Omega p} ,$$

and

$$H = \frac{u^2}{2g} = \frac{c^2\tau^2 W^2}{2g\Omega^2 p^2} ,$$

$$\therefore \quad \frac{dH}{H} + \frac{2g\Omega^2 p}{c\tau W^2} dp + \zeta \frac{dl}{m} = 0 \quad . \quad . \quad . \quad . \quad (4a).$$

For tubes of uniform section m is constant; for steady motion W is constant; and for isothermal expansion τ is constant. Integrating,

$$\log \mathrm{H} + \frac{g\Omega^2 p^2}{\mathrm{W}^2 c\tau} + \zeta \frac{l}{m} = \text{constant} \quad . \quad . \quad . \quad . \quad (5);$$

for $\quad l=0$, let $\mathrm{H}=\mathrm{H}_0$, and $p=p_0$;

and for $\quad l=l$, let $\mathrm{H}=\mathrm{H}_1$, and $p=p_1$.

$$\log \frac{\mathrm{H}_1}{\mathrm{H}_0} + \frac{g\Omega^2}{\mathrm{W}^2 c\tau}(p_1^2 - p_0^2) + \zeta \frac{l}{m} = 0 \quad . \quad . \quad . \quad (5a),$$

where p_0 is the greater pressure and p_1 the less, and the flow is from A_0 towards A_1.

By replacing W and H,

$$\log \frac{p_0}{p_1} + \frac{gc\tau}{u_0^2 p_0^2}(p_1^2 - p_0^2) + \zeta \frac{l}{m} = 0 \quad . \quad . \quad . \quad (6).$$

Hence the initial velocity in the pipe is

$$u_0 = \sqrt{\left\{ \frac{gc\tau(p_0^2 - p_1^2)}{p_0^2\left(\zeta \frac{l}{m} + \log \frac{p_0}{p_1}\right)} \right\}} \quad . \quad . \quad . \quad . \quad (7).$$

When l is great, $\log \frac{p_0}{p_1}$ is comparatively small, and then

$$u_0 = \sqrt{\left\{ \frac{gc\tau m}{\zeta l} \frac{p_0^2 - p_1^2}{p_0^2} \right\}} \quad . \quad . \quad . \quad . \quad (7a),$$

a very simple and easily used expression. For pipes of circular section $m = \frac{d}{4}$, where d is the diameter:—

$$u_0 = \sqrt{\left\{ \frac{gc\tau d}{4\zeta l} \frac{p_0^2 - p_1^2}{p_0^2} \right\}} \quad . \quad . \quad . \quad . \quad (7b);$$

or approximately

$$u_0 = \left(1{\cdot}1319 - 0{\cdot}7264 \frac{p_1}{p_0}\right) \sqrt{\frac{gc\tau d}{4\zeta l}} \quad . \quad . \quad . \quad (7c).$$

83. *Coefficient of Friction for Air.*—A discussion by Professor Unwin of the experiments by Messrs Culley & Sabine on the rate of transmission of light carriers through pneumatic tubes, in which there is steady flow of air not sensibly affected by any resistances other than surface friction, furnished the value $\zeta = {\cdot}007$. The pipes were lead pipes, slightly moist, $2\frac{1}{4}$ inches (0·187 ft.) in diameter, and in lengths of 2000 to nearly 6000 feet.

Some experiments on the flow of air through cast-iron pipes have been made by M. Arson. He found the coefficient of friction to vary with the velocity and diameter of the pipe. Putting

$$\zeta = \frac{\alpha}{v} + \beta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8),$$

he obtained the following values—

Diameter of Pipe in Feet.	α	β	ζ for 100 feet per second.
1·64	·00129	·00483	·00484
1·07	·00972	·00640	·00650
·83	·01525	·00704	·00719
·338	·03604	·00941	·00977
·266	·03790	·00959	·00997
·164	·04518	·01167	·01212

It is worth while to try if these numbers can be expressed in the form proposed by Darcy for water. For a velocity of 100 feet per second, and without much error for higher velocities, these numbers agree fairly with the formula

$$\zeta = {\cdot}005\left(1 + \frac{3}{10d}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (9),$$

which only differs from Darcy's value for water in that the second term, which is always small except for very small pipes, is larger.

Some more recent experiments on a very large scale, by M. Stockalper at the St Gotthard Tunnel, agree better with the value

$$\zeta = 0{\cdot}0028\left(1 + \frac{3}{10d}\right).$$

These pipes were probably less rough than M. Arson's.

When the variation of pressure is very small, it is no longer safe to neglect the variation of level of the pipe. For that case we may neglect the work done by expansion, and then

$$z_0 - z_1 - \frac{p_0}{\mathrm{G}_0} - \frac{p_1}{\mathrm{G}_1} - \zeta \frac{v^2}{2g} \frac{l}{m} = 0 \quad . \quad . \quad . \quad . \quad (10),$$

precisely equivalent to the equation for the flow of water, z_0 and z_1 being the elevations of the two ends of the pipe above any datum, p_0 and p_1 the pressures, G_0 and G_1 the densities, and v the mean velocity in the pipe. This equation may be used for the flow of coal gas.

84. *Distribution of Pressure in a Pipe in which Air is Flowing.*—From equation (7a) it results that the pressure p, at l feet from that end of the pipe where the pressure is p_0, is

$$p = p_0 \sqrt{\left\{ 1 - \frac{\zeta l u_0^2}{mgc\tau} \right\}} \quad . \quad . \quad . \quad . \quad . \quad (11);$$

which is of the form

$$p = \sqrt{al + b}$$

for any given pipe with given end pressures. The curve of free surface level for the pipe is, therefore, a parabola with horizontal axis. Fig. 100 shows calculated curves of pressure for two of Mr Sabine's

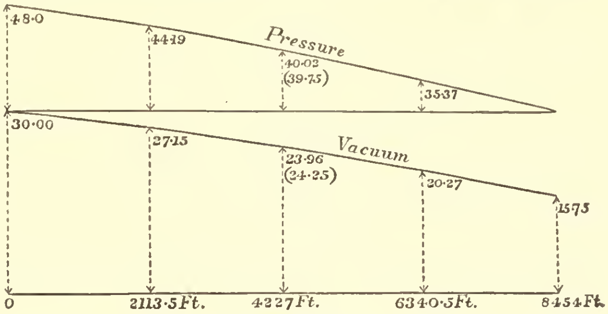


Fig. 100.

experiments, in one of which the pressure was greater than atmospheric pressure, and in the other less than atmospheric pressure. The observed pressures are given in brackets and the calculated pressures without brackets. The pipe was the pneumatic tube between Fenchurch Street and the Central Station, 2818 yards in length. The pressures are given in inches of mercury.

Variation of Velocity in the Pipe.—Let p_0, u_0 be the pressure and velocity at a given section of the pipe; p, u, the pressure and velocity at any other section. From equation (3a)

$$u\,p = \frac{c\tau \mathrm{W}}{\Omega} = \text{constant};$$

so that, for any given uniform pipe,

$$u\,p = u_0 p_0,$$

$$u = u_0 \frac{p_0}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12);$$

which gives the velocity at any section in terms of the pressure, which has already been determined. Fig. 101 gives the velocity

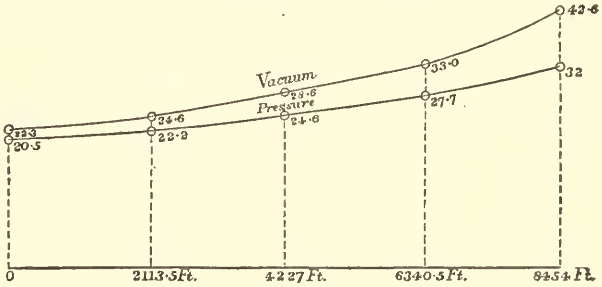


Fig. 101.

curves for the two experiments of Messrs Culley & Sabine, for which the pressure curves have already been drawn. It will be seen that the velocity increases considerably towards that end of the pipe where the pressure is least.

85. *Weight of Air Flowing per Second.*—The weight of air discharged per second is (equation 3a)—

$$\mathrm{W} = \frac{\Omega u_0 p_0}{c\tau}.$$

From equation (7b), for a pipe of circular section and diameter d,

$$\mathrm{W} = \frac{\pi}{4} \sqrt{\left\{ \frac{gd^5}{\zeta l c\tau}(p_0^2 - p_1^2) \right\}},$$

$$= {\cdot}611 \sqrt{\left\{ \frac{d^5}{\zeta l\tau}(p_0^2 - p_1^2) \right\}} \quad . \quad . \quad . \quad . \quad (13).$$

Approximately

$$\mathrm{W} = ({\cdot}6916 p_0 - {\cdot}4438 p_1)\left(\frac{d^5}{\zeta l\tau}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad (13a).$$

86. *Application to the Case of Pneumatic Tubes for the Transmission of Messages.*—In Paris, Berlin, London, and other towns, it has been found cheaper to transmit messages in pneumatic tubes than to telegraph by electricity. The tubes are laid underground with easy curves; the messages are made into a roll and placed in

a light felt carrier, the resistance of which in the tubes in London is only ¾ oz. A current of air forced into the tube or drawn through it propels the carrier. In most systems the current of air is steady and continuous, and the carriers are introduced or removed without materially altering the flow of air.

Time of Transit through the Tube.—Putting t for the time of transit from 0 to l,

$$t=\int_0^l \frac{dl}{u},$$

From (4*a*) neglecting $\frac{dH}{H}$, and putting $m=\frac{d}{4}$,

$$dl=\frac{gd\Omega^2 p}{2\zeta W^2 c\tau}dp\,.$$

From (1) and (3)

$$u=\frac{Wc\tau}{p\Omega};$$

$$\frac{dl}{u}=\frac{gd\Omega^3 p^2}{2\zeta W^3 c^2\tau^2}dp;$$

$$t=\int_{p_1}^{p_0}\frac{gd\Omega^3 p^2}{2\zeta W^3 c^2\tau^2}dp,$$

$$=\frac{gd\Omega^3}{6\zeta W^3 c^2\tau^2}(p_0^3-p_1^3) \quad . \quad . \quad . \quad . \quad . \quad (14).$$

But

$$W=\frac{p_0 u_0 \Omega}{c\tau};$$

$$\therefore\ t=\frac{1}{6}\,\frac{gdc\tau}{\zeta p_0^3 u_0^3}(p_0^3-p_1^3),$$

$$=\frac{1}{6}\,\frac{\zeta^{\frac12} l^{\frac32}}{(gc\tau d)^{\frac12}}\,\frac{p_0^3-p_1^3}{(p_0^2-p_1^2)^{\frac32}} \quad . \quad . \quad . \quad . \quad (15).$$

If $\tau=521°$, corresponding to 60° F.,

$$t=\cdot001412\frac{\zeta^{\frac12} l^{\frac32}}{d^{\frac12}}\,\frac{p_0^3-p_1^3}{(p_0^2-p_1^2)^{\frac32}} \quad . \quad . \quad . \quad . \quad (15a);$$

which gives the time of transmission in terms of the initial and final pressures and the dimensions of the tube.

Mean Velocity of Transmission.—The mean velocity is $\frac{l}{t}$; or, for $\tau=521°$,

$$u_{\text{mean}}=0\cdot708\sqrt{\left\{\frac{d}{\zeta l}\,\frac{(p_0^2-p_1^2)^{\frac32}}{p_0^3-p_1^3}\right\}} \quad . \quad . \quad . \quad (16).$$

The following table gives some results:—

Absolute Pressures in lb per sq. inch.		Mean Velocities for Tubes of a length in ft.				
p_0	p_1	1000	2000	3000	4000	5000
		Vacuum Working.				
15	5	99·4	70·3	57·4	49·7	44·5
15	10	67·2	47·5	38·8	34·4	30·1
		Pressure Working.				
20	15	57·2	40·5	33·0	28·6	25·6
25	15	74·6	52·7	43·1	37·3	33·3
30	15	84·7	60·0	49·0	42·4	37·9

Limiting Velocity in the Pipe when the Pressure at one End is diminished indefinitely.—If in the last equation there be put $p_1=0$, then

$$u'_{\text{mean}}=0\cdot708\sqrt{\frac{d}{\zeta l}};$$

where the velocity is independent of the pressure p_0 at the other end, a result which apparently must be absurd. Probably for long pipes, as for orifices, there is a limit to the ratio of the initial and terminal pressures for which the formula is applicable.

X. FLOW IN RIVERS AND CANALS.

87. *Flow of Water in Open Canals and Rivers.*—When water flows in a pipe the section at any point is determined by the form of the boundary. When it flows in an open channel with free upper surface, the section depends on the velocity due to the dynamical conditions.

Suppose water admitted to an unfilled canal. The channel will gradually fill, the section and velocity at each point gradually changing. But if the inflow to the canal at its head is constant, the increase of cross section and diminution of velocity at each point attain after a time a limit. Thenceforward the section and velocity at each point are constant, and the motion is steady, or permanent regime is established.

If when the motion is steady the sections of the stream are all equal, the motion is uniform. By hypothesis, the inflow Ωv is constant for all sections, and Ω is constant; therefore v must be constant also from section to section. The case is then one of uniform steady motion. In most artificial channels the form of section is constant, and the bed has a uniform slope. In that case the motion is uniform, the depth is constant, and the stream surface is parallel to the bed. If when steady motion is established the sections are unequal, the motion is steady motion with varying velocity from section to section. Ordinary rivers are in this condition, especially where the flow is modified by weirs or obstructions. Short unobstructed lengths of a river may be treated as of uniform section without great error, the mean section in the length being put for the actual sections.

In all actual streams the different fluid filaments have different velocities, those near the surface and centre moving faster than those near the bottom and sides. The ordinary formulæ for the flow of streams rest on an hypothesis that this variation of velocity may be neglected, and that all the filaments may be treated as having a common velocity equal to the mean velocity of the stream. On this hypothesis, a plane layer *abab* (fig. 102) between sections normal to the direction of motion is treated as sliding down the channel to *a'a'b'b'* without deformation. The component of the weight parallel to the channel bed balances the friction against the channel, and in estimating the friction the velocity of rubbing is taken to be the mean velocity of the stream. In actual streams, however, the velocity of rubbing on which the friction depends is not the mean velocity of the stream, and is not in any simple relation with it, for channels of different forms. The theory is therefore obviously based on an imperfect hypothesis. However, by taking variable values for the coefficient of friction, the errors of the ordinary formulæ are to a great extent neutralized, and they may be used without leading to practical errors. Formulæ have been obtained based on less restricted hypotheses, but at present they are not practically so reliable, and are more complicated than the formulæ obtained in the manner described above.

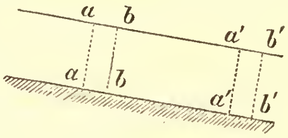


Fig. 102.

88. *Steady Flow of Water with Uniform Velocity in Channels of Constant Section.*—Let *aa'*, *bb'* (fig. 103) be two cross sections normal to the direction of motion at a distance *dl*. Since the mass *aa'bb'* moves uniformly, the external forces acting on it are in equilibrium. Let Ω be the area of the cross sections, χ the wetted perimeter, $pq+qr+rs$, of a section. Then the quantity $m=\frac{\Omega}{\chi}$ is termed the hydraulic mean depth of the section. Let v be the mean velocity of the stream, which is taken as the common velocity of all the particles, i, the slope or fall of the stream in feet, per foot, being the ratio $\frac{bc}{ab}$.

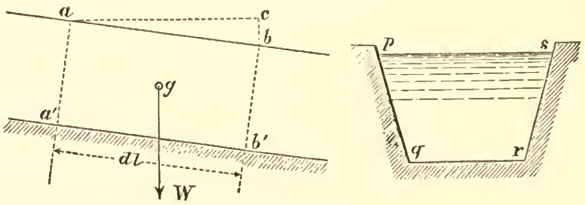


Fig. 103.

The external forces acting on *aa'bb'* parallel to the direction of motion are three:—(*a*) The pressures on *aa'* and *bb'*, which are equal and opposite since the sections are equal and similar, and the mean pressures on each are the same. (*b*) The component of the weight W of the mass in the direction of motion, acting at its centre of gravity *g*. The weight of the mass *aa'bb'* is $G\Omega dl$, and the component of the weight in the direction of motion is $G\Omega dl\times$ the cosine of the angle between W*g* and *ab*, that is, $G\Omega dl \cos abc=G\Omega dl\frac{bc}{ab}=G\Omega i dl$. (*c*) There is the friction of the stream on the sides and bottom of the channel. This is proportional to the area χdl of rubbing surface and to a function of the velocity which may be written $f(v)$; $f(v)$ being the friction per square foot at a velocity v. Hence the friction is $-\chi dl\,f(v)$. Equating the sum of the forces to zero,

$$G\,\Omega\, i\, dl-\chi dl\, f(v)=0\,,$$

$$\frac{f(v)}{G}=\frac{\Omega}{\chi}i=mi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

But it has been already shown (§ 63) that $f(v)=\zeta G\frac{v^2}{2g}$,

$$\therefore\ \zeta\frac{v^2}{2g}=mi\,. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

This may be put in the form

$$v=\sqrt{\frac{2g}{\zeta}}\sqrt{mi}=c\sqrt{mi} \quad . \quad . \quad . \quad . \quad . \quad (2a);$$

where c is a coefficient depending on the roughness and form of the channel.

The coefficient of friction ζ varies greatly with the degree of roughness of the channel sides, and somewhat also with the velocity. It must also be made to depend on the absolute dimensions of the section, to eliminate the error of neglecting the variations of velocity in the cross section. A common mean value assumed for ζ is 0·00757. The range of values will be discussed presently.

It is often convenient to estimate the fall of the stream in feet per mile, instead of in feet per foot. If f is the fall in feet per mile

$$f=5280\ i.$$

Putting this and the above value of ζ in (2a), we get the very simple and long-known approximate formula for the mean velocity of a stream—

$$v=1\tfrac{1}{2}\sqrt{2mf} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

The flow down the stream per second, or discharge of the stream, is

$$Q=\Omega v=\Omega c\sqrt{mi} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

89. *Coefficient of Friction for Open Channels.*—Various expressions have been proposed for the coefficient of friction for channels as for pipes. Weisbach, giving attention chiefly to the variation of the coefficient of friction with the velocity, proposed an expression of the form

$$\zeta=\alpha\left(1+\frac{\beta}{v}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5),$$

and from 255 experiments obtained for the constants the values

$$\alpha=0·007409\ ;\ \beta=0·1920.$$

This gives the following values at different velocities:—

$v=$	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1	1½	2	3	5	7	10	15
$\zeta=$	0·01215	0·91907	0·01025	0·00978	0·00944	0·06918	0·00899	0·00883	0·00836	0·00812	0·9C788	0·00769	0·00761	0·00755	0·00750

In using this value of ζ when v is not known, it is best to proceed by approximation. Calculate a rough value of v by taking any mean value of ζ, for instance the one given in the preceding section. Then from this value of v calculate a revised value of ζ, and from this a new value of v.

90. *Darcy & Bazin's Expression for the Coefficient of Friction.*—Darcy & Bazin's researches have shown that ζ varies very greatly for different degrees of roughness of the channel bed, and that it also varies with the dimensions of the channel. They give for ζ an empirical expression (similar to that for pipes) of the form

$$\zeta=\alpha\left(1+\frac{\beta}{m}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6);$$

where m is the hydraulic mean depth. For different kinds of channels they give the following values of the coefficient of friction:—

Kind of Channel.	α	β
I. Very smooth channels, sides of smooth cement or planed timber..................	0·00316	0·1
II. Smooth channels, sides of ashlar, brickwork, planks..................................	0·00401	0·23
III. Rough channels, sides of rubble masonry or pitched with stone	0·00507	0·82
IV. Very rough canals in earth....................	0·00592	4·10
V. Torrential streams encumbered with detritus	0·00846	8·2

The last values (Class V.) are not Darcy & Bazin's, but are taken from experiments by Ganguillet & Kutter on Swiss streams.

The following table very much facilitates the calculation of the mean velocity and discharge of channels, when Darcy & Bazin's value of the coefficient of friction is used. Taking the general formula for the mean velocity already given in equation (2a) above,

$$v=c\sqrt{mi},$$

where $c=\sqrt{\frac{2g}{\zeta}}$, the following table gives values of c for channels of different degrees of roughness, and for such values of the hydraulic mean depths as are likely to occur in practical calculations:—

Values of c *in* $v=c\sqrt{mi}$, *deduced from Darcy & Bazin's Values.*

Hydraulic Mean Depth $=m$.	Very Smooth Channels. Cement.	Smooth Channels. Ashlar or Brickwork.	Rough Channels. Rubble Masonry.	Very Rough Channels. Canals in Earth.	Excessively Rough Channels encumbered with Detritus.	Hydraulic Mean Depth $=m$.	Very Smooth Channels. Cement.	Smooth Channels. Ashlar or Brickwork.	Rough Channels. Rubble Masonry.	Very Rough Channels. Canals in Earth.	Excessively Rough Channels encumbered with Detritus.
·25	125	95	57	26	18·5	8·5	147	130	112	89	...
·5	135	110	72	36	25·6	9·0	147	130	112	90	71
·75	139	116	81	42	30·8	9·5	147	130	112	90	...
1·0	141	119	87	48	34·9	10·0	147	130	112	91	72
1·5	143	122	94	56	41·2	11	147	130	113	92	...
2·0	144	124	98	62	46·0	12	147	130	113	93	74
2·5	145	126	101	67	...	13	147	130	113	94	...
3·0	115	126	104	70	53	14	147	130	113	95	...
3·5	146	127	105	73	...	15	147	130	114	96	77
4·0	146	128	106	76	58	16	147	130	114	97	...
4·5	146	128	107	78	...	17	147	130	114	97	...
5·0	146	128	108	80	62	18	147	130	114	98	..
5·5	146	129	109	82	...	20	147	131	114	98	80
6·0	147	129	110	84	65	25	148	131	115	100	...
6·5	147	129	110	85	...	30	148	131	115	102	83
7·0	147	129	110	86	67	40	148	131	116	103	85
7·5	147	129	111	87	...	50	148	131	110	104	86
8·0	147	130	111	88	69	∞	148	131	117	108	91

91. *Ganguillet & Kutter's modified Darcy Formula.*—Starting from the general expression $v=c\sqrt{mi}$, Messrs Ganguillet & Kutter have examined the variations of c for a wider variety of cases than those discussed by Darcy & Bazin. Darcy & Bazin's experiments are confined to channels of moderate section, and to a limited variation of slope. Ganguillet & Kutter brought into the discussion two very distinct and important additional series of results. The gaugings of the Mississippi by Messrs Humphreys & Abbot afford data of discharge for the case of a stream of exceptionally large section and of very low slope. On the other hand, their own measurements of the flow in the regulated channels of some Swiss torrents gave data for cases in which the inclination and roughness of the channels were exceptionally great. Darcy & Bazin's experiments alone were conclusive as to the dependence of the coefficient c on the dimensions of the channel and on its roughness of surface. Plotting values of c for channels of different inclination indicated to Ganguillet & Kutter that it also depended on the slope of the stream. Taking the Mississippi data only, they found

c = 256 for an inclination of 0·0034 per thousand,
= 154 ,, ,, 0·02 ,,

so that for very low inclinations no constant value of c independent of the slope would furnish good values of the discharge. In small rivers, on the other hand, the values of c vary little with the slope. As regards the influence of roughness of the sides of the channel a different law holds. For very small channels differences of roughness have a great influence on the discharge, but for very large channels different degrees of roughness have but little influence, and for indefinitely large channels the influence of different degrees of roughness must be assumed to vanish. The coefficients given by Darcy & Bazin are different for each of the classes of channels of different roughness, even when the dimensions of the channel are infinite. But, as it is much more probable that the influence of the nature of the sides diminishes indefinitely as the channel is larger, this must be regarded as a defect in their formula.

Comparing their own measurements in torrential streams in Switzerland with those of Darcy & Bazin, Ganguillet & Kutter found that the four classes of coefficients proposed by Darcy & Bazin were insufficient to cover all cases. Some of the Swiss streams gave results which showed that the roughness of the bed was markedly greater than in any of the channels tried by the French engineers. It was necessary therefore in adopting the plan of arranging the different channels in classes of approximately similar roughness to increase the number of classes. Especially an additional class was required for channels obstructed by detritus.

To obtain a new expression for the coefficient in the formula

$$v=\sqrt{\frac{2g}{\zeta}}\sqrt{mi}=c\sqrt{mi},$$

in which Darcy & Bazin take

$$c=\sqrt{\frac{2g}{\alpha\left(1+\frac{\beta}{m}\right)}},$$

Ganguillet & Kutter proceeded in a purely empirical way. They found that an expression of the form

$$c=\frac{a}{1+\frac{\beta}{\sqrt{m}}}$$

could be made to fit the experiments somewhat better than Darcy's expression. Inverting this, we get

$$\frac{1}{c}=\frac{1}{a}+\frac{\beta}{a\sqrt{m}},$$

an equation to a straight line having $\frac{1}{\sqrt{m}}$ for abscissa, $\frac{1}{c}$ for ordinate, and inclined to the axis of abscissæ at an angle the tangent of which is $\frac{\beta}{\alpha}$.

Plotting the experimental values of $\frac{1}{c}$ and $\frac{1}{\sqrt{m}}$, the points so found indicated a curved rather than a straight line, so that β must depend on α. After much comparison the following form was arrived at—

$$c=\frac{\mathrm{A}+\frac{l}{n}}{1+\frac{\mathrm{A}n}{\sqrt{m}}},$$

where n is a coefficient depending only on the roughness of the sides of the channel, and A and l are new coefficients, the value of which remains to be determined. From what has been already stated, the coefficient c depends on the inclination of the stream, decreasing as the slope i increases.

Let $$\mathrm{A}=a+\frac{p}{i}.$$

Then $$c=\frac{a+\frac{l}{n}+\frac{p}{i}}{1+\left(a+\frac{p}{i}\right)\frac{n}{\sqrt{m}}},$$

the form of the expression for c ultimately adopted by Ganguillet & Kutter.

For the constants a, l, p Ganguillet & Kutter obtain the values 23, 1, and 0·00155 for metrical measures, or 41·6, 1·811, and 0·00281 for English feet. The coefficient of roughness n is found to vary from 0·008 to 0·050 for either metrical or English measures.

The most practically useful values of the coefficient of roughness n are given in the following table:—

Nature of Sides of Channel.	Coefficient of Roughness n.
Well-planed timber	0·009
Cement plaster	0·010
Plaster of cement with one-third sand	0·011
Unplaned planks	0·012
Ashlar and brickwork	0·013
Canvass on frames	0·015
Rubble masonry	0·017
Canals in very firm gravel	0·020
Rivers and canals in perfect order, free from stones or weeds	0·025
Rivers and canals in moderately good order, not quite free from stones and weeds	0·030
Rivers and canals in bad order, with weeds and detritus	0·035
Torrential streams encumbered with detritus	0·050

Ganguillet & Kutter's formula is so cumbrous that it is difficult to use without the aid of tables.

Mr Lowis D'A. Jackson has published complete and extensive tables for facilitating the use of the Ganguillet & Kutter formula (*Canal and Culvert Tables*, London, 1878). To lessen calculation he puts the formula in this form:—

$$\mathrm{M}=n\left(41{\cdot}6+\frac{0{\cdot}00281}{i}\right);$$

$$v=\frac{\sqrt{m}}{n}\left(\frac{\mathrm{M}+1{\cdot}811}{\mathrm{M}+\sqrt{m}}\right)\sqrt{mi}.$$

The following table gives a selection of values of M, taken from Mr Jackson's tables:—

	Values of M for n =						
	0·010	0·012	0·015	0·017	0·020	0·025	0·030
·00001	3·2260	3·8712	4·8390	5·4842	6·4520	8·0650	9·6780
·00002	1·8210	2·1852	2·7315	3·0957	3·6120	4·5525	5·4630
·00004	1·1185	1·3422	1·6777	1·9011	2·2370	2·7962	3·3555
·00006	0·8843	1·0612	1·3264	1·5033	1·7686	2·2107	2·6529
·00008	0·7672	0·9206	1·1508	1·3042	1·5344	1·9180	2·3016
·00010	0·6970	0·8364	1·0455	1·1849	1·3940	1·7425	2·0910
·00025	0·5284	0·6341	0·7926	0·8983	1·0568	1·3210	1·5852
·00050	0·4722	0·5666	0·7083	0·8027	0·9444	1·1805	1·4166
·00075	0·4535	0·5442	0·6802	0·7709	0·9070	1·1337	1·3605
·00100	0·4441	0·5329	0·6661	0·7550	0·8882	1·1102	1·3323
·00200	0·4300	0·5160	0·6450	0·7310	0·8600	1·0750	1·2900
·00300	0·4254	0·5105	0·6381	0·7232	0·8508	1·0635	1·2762

One principal difficulty in the use of this formula is the selection of the coefficient of roughness. The difficulty is one which no theory will overcome, because no absolute measure of the roughness of stream beds is possible. For channels lined with timber or masonry the difficulty is not so great. The constants in that case are few and sufficiently defined. But in the case of ordinary canals and rivers the case is different, the coefficients having a much greater range. For artificial canals in rammed earth or gravel n varies from 0·0163 to 0·0301. For natural channels or rivers n varies from 0·020 to 0·035.

In Mr Jackson's opinion even Kutter's numerous classes of channels seem inadequately graduated, and after careful examination he proposes for artificial canals the following classification:—

I.	Canals in very firm gravel, in perfect order	$n=0{\cdot}02$
II.	Canals in earth, above the average in order	$n=0{\cdot}0225$
III.	Canals in earth, in fair order	$n=0{\cdot}025$
IV.	Canals in earth, below the average in order	$n=0{\cdot}0275$
V.	Canals in earth, in rather bad order, partially overgrown with weeds and obstructed by detritus	$n=0{\cdot}03$

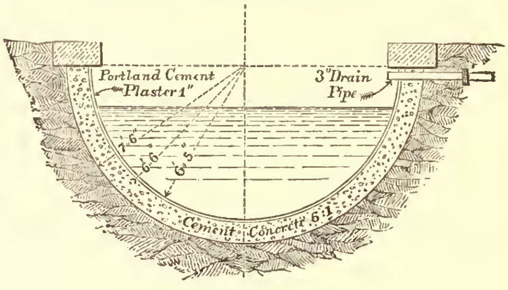


Fig 104.

92. *Forms of Section of Channels.*—The simplest form of section for channels is the semicircular or nearly semicircular channel (fig. 104), a form now often adopted from the facility with which it can be

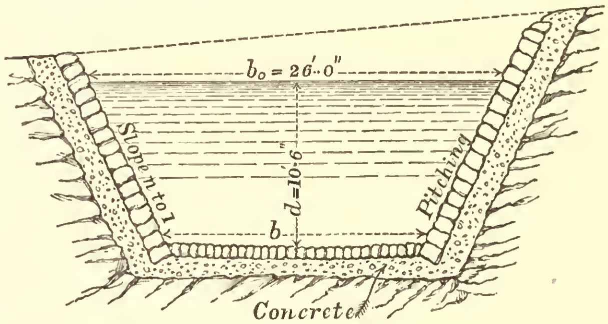


Fig. 105.

executed in concrete. It has the advantage that the rubbing surface is less in proportion to the area than in any other form.

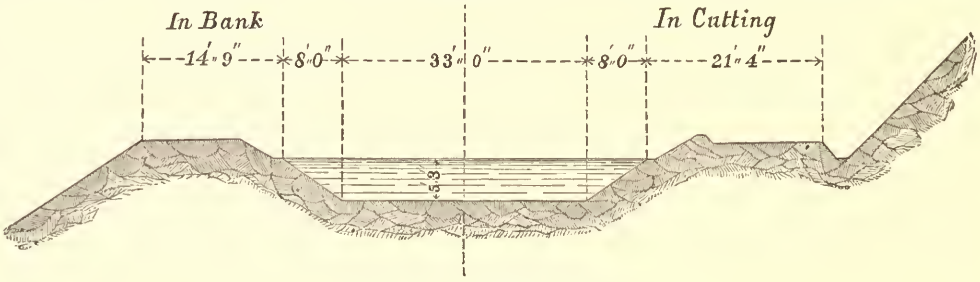


Fig. 106.—Scale 20 feet = 1 inch.

Wooden channels or flumes, of which there are examples on a large scale in America, are rectangular in section, and the same form is adopted for wrought and cast-iron aqueducts. Channels built with brickwork or masonry may be also rectangular, but they are often trapezoidal, and are always so if the sides are pitched with masonry laid dry. In a trapezoidal channel, let b (fig. 105) be the bottom breadth, b_0 the top breadth, d the depth, and let the slope of the sides be n horizontal to 1 vertical. Then the area of section is $\Omega=(b+nd)d=(b_0-nd)d$, and the wetted perimeter $\chi=b+2d\sqrt{n^2+1}$.

When a channel is simply excavated in earth it is always originally trapezoidal, though it becomes more or less rounded in course of time. The slope of the sides then depends on the stability of the earth, a slope of 2 to 1 being the one most commonly adopted.

Figs. 106, 107 show the form of canals excavated in earth, the former being the section of a Navigation Canal and the latter the section of an Irrigation Canal.

93. *Channels of Circular Section.*—The following short table facilitates calculations of the discharge with different depths of water in the channel. Let r be the radius of the channel section; then for a depth of water $=\kappa r$, the hydraulic mean radius is μr and the area of section of the waterway νr^2, where κ, μ, and ν have the following values:—

Depth of water in terms of radius	$\kappa=$	·01	·05	·10	·15	·20	·25	·30	·35	·40	·45	·50	·55	·60	·65	·70	·75	·8	·85	·9	·95	1·0
Hydraulic mean depth in terms of radius ...	$\mu=$	·00668	·0321	·0523	·0963	·1278	·1574	·1852	·2142	242	·269	·293	·320	·343	·365	·387	·408	·429	·449	·466	·484	·500
Waterway in terms of square of radius......	$\nu=$	00189	·0211	·0598	·1067	·1651	·228	·294	·370	·450	·532	614	·709	·795	885	·979	1·075	1·175	1·276	1·371	1·470	1·571

94. *Egg-Shaped Channels or Sewers.*—In sewers for discharging storm water and house drainage the volume of flow is extremely variable; and there is a great liability for deposits to be left when the flow is small, which are not removed during the short periods when the flow is large. The sewer in consequence becomes choked. To

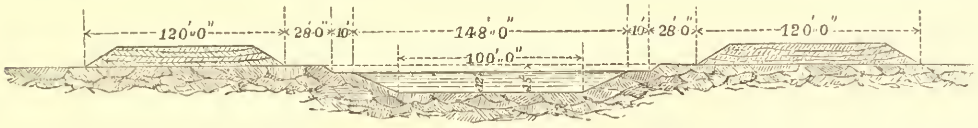


FIG. 107.—Scale 80 feet = 1 inch.

obtain uniform scouring action, the velocity of flow should be constant or nearly so; a complete uniformity of velocity cannot be obtained with any form of section suitable for sewers, but an approximation to uniform velocity is obtained by making the sewers of oval section. Various forms of oval have been suggested, the simplest being one in which the radius of the crown is double the radius of the invert, and the greatest width is two-thirds the height. The section of such a sewer is shown in fig. 108, the numbers marked on the figure being proportional numbers.

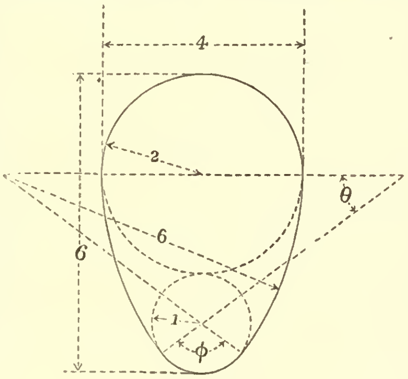


Fig. 108.

95. *Problems on Channels in which the Flow is Steady and at Uniform Velocity.*—The general equations given in §§ 88, 90 are

$$\zeta = \alpha\left(1 + \frac{\beta}{m}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1);$$

$$\zeta \frac{v^2}{2g} = mi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2);$$

$$Q = \Omega v \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Problem I. Given the transverse section of stream and discharge, to find the slope. From the dimensions of the section find Ω and m; from (1) find ζ, from (3) find v, and lastly from (2) find i.

Problem II. Given the transverse section and slope, to find the discharge. Find v from (2), then Q from (3).

Problem III. Given the discharge and slope, and either the breadth, depth, or general form of the section of the channel, to determine its remaining dimensions. This must generally be solved by approximations. A breadth or depth or both are chosen, and the discharge calculated. If this is greater than the given discharge, the dimensions are reduced and the discharge recalculated.

Since m lies generally between the limits $m=d$ and $m=\frac{1}{2}d$, where d is the depth of the stream, and since, moreover, the velocity varies as $\sqrt{m}$ so that an error in the value of m leads only to a much less error in the value of the velocity calculated from it, we may proceed thus. Assume a value for m, and calculate v from it. Let v_1 be this first approximation to v. Then $\frac{Q}{v_1}$ is a first approximation to Ω, say Ω_1. With this value of Ω design the section of the channel; calculate a second value for m; calculate from it a second value of v, and from that a second value for Ω. Repeat the process till the successive values of m approximately coincide.

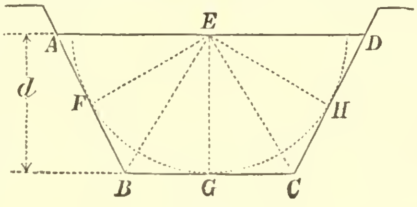


Fig. 109.

96. *Problem* IV. *Most Economical Form of Channel for given Side Slopes.*—Suppose the channel is to be trapezoidal in section (fig. 109), and that the sides are to have a given slope. Let the longitudinal slope of the stream be given, and also the mean velocity. An infinite number of channels could be found satisfying the foregoing conditions. To render the problem determinate, let it be remembered that, since for a given discharge $\Omega \propto \sqrt[3]{\chi}$, other things being the same, the amount of excavation will be least for that channel which has the least wetted perimeter. Let d be the depth and b the bottom width of the channel, and let the sides slope n horizontal to 1 vertical (fig. 110), then

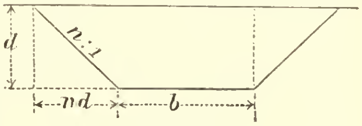


Fig. 110.

$$\Omega = (b + nd)d\;;$$
$$\chi = b + 2d\sqrt{n^2+1}\,.$$

Both Ω and χ are to be minima. Differentiating, and equating to zero,

$$\left(\frac{db}{dd} + n\right)d + b + nd = 0\,,$$

$$\frac{db}{dd} + 2\sqrt{n^2+1} = 0\;;$$

eliminating $\frac{db}{dd}$,

$$(n - 2\sqrt{n^2+1})d + b + nd = 0\,,$$

$$b = 2(\sqrt{n^2+1} - n)d\,.$$

But

$$\frac{\Omega}{\chi} = \frac{(b+nd)d}{b+2d\sqrt{n^2+1}}\,.$$

Inserting the value of b,

$$m = \frac{\Omega}{\chi} = \frac{2d\sqrt{n^2+1} - nd}{4d\sqrt{n^2+1} - 2nd} = \frac{d}{2}\,.$$

That is, with given slide slopes, the section is least for a given discharge when the hydraulic mean depth is half the actual depth.

A simple construction gives the form of the channel which fulfils this condition, for it can be shown that when $m = \frac{d}{2}$ the sides of the channel are tangential to a semi-circle drawn on the water line.

Since

$$\frac{\Omega}{\chi} = \frac{d}{2}\,,$$

therefore

$$\Omega = \tfrac{1}{2}\chi d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Let ABCD be the channel (fig. 109); from E the centre of AD drop perpendiculars EF, EG, EH on the sides.

Let

$$AB = CD = a\;;\;\; BC = b\;;\;\; EF = EH = c\;;\; \text{and } EG = d.$$

$$\Omega = \text{area } AEB + BEC + CED\,,$$
$$= ac + \tfrac{1}{2}bd\,.$$
$$\chi = 2a + b\,.$$

Putting these values in (1),

$$ac + \tfrac{1}{2}bd = (a + \tfrac{1}{2}b)d\;;\;\text{and hence } c = d.$$

That is, EF, EG, EH are all equal, hence a semicircle struck from E with radius equal to the depth of the stream will pass through F and H and be tangential to the sides of the channel.

To draw the channel, describe a semicircle on a horizontal line with radius = depth of channel. The bottom will be a horizontal tangent of that semicircle, and the sides tangents drawn at the required side slopes.

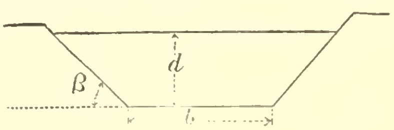


Fig. 111.

The above result may be obtained thus (fig. 111):—

$$\chi = b + \frac{2d}{\sin\beta} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

$$\Omega = d(b + d\cot\beta)\ ;$$

$$\frac{\Omega}{d} = b + d\cot\beta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)\ ;$$

$$\frac{\Omega}{d^2} = \frac{b}{d} + \cot\beta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

From (1) and (2),

$$\chi = \frac{\Omega}{d} - d\cot\beta + \frac{2d}{\sin\beta}\,.$$

This will be a minimum for

$$\frac{d\chi}{dd} = \frac{\Omega}{d^2} + \cot\beta - \frac{2}{\sin\beta} = 0\,,$$

or

$$\frac{\Omega}{d^2} = 2\ \text{cosec.}\ \beta - \cot\beta \quad . \quad . \quad . \quad . \quad . \quad (4).$$

or

$$d = \sqrt{\frac{\Omega\sin\beta}{2 - \cos\beta}}\,.$$

From (3) and (4),

$$\frac{b}{d} = \frac{2(1-\cos\beta)}{\sin\beta} = 2\tan\tfrac{1}{2}\beta\,.$$

Proportions of Channels of Maximum Discharge for given Area and Side Slopes. Depth of channel $=d$; *Hydraulic mean depth* $=\frac{1}{2}d$; *Area of section* $=\Omega$.

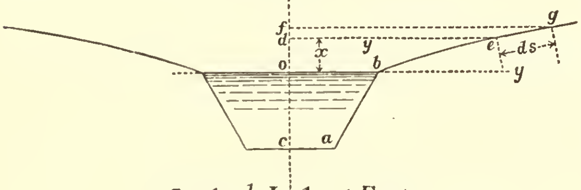
	Inclination of Sides to Horizon.	Ratio of Side Slopes.	Area of Section Ω.	Bottom Width.	Top width = twice length of each Side Slope.
Semicircle	...	...	$1\cdot571d^2$	0	$2d$
Semi-hexagon...	60° 0′	3 : 5	$1\cdot732d^2$	$1\cdot155d$	$2\cdot310d$
Semi-square	90° 0′	0 : 1	$2d^2$	$2d$	$2d$
	75° 58′	1 : 4	$1\cdot812d^2$	$1\cdot562d$	$2\cdot062d$
	63° 26′	1 : 2	$1\cdot736d^2$	$1\cdot236d$	$2\cdot236d$
	53° 8′	3 : 4	$1\cdot750d^2$	d	$2\cdot500d$
	45° 0′	1 : 1	$1\cdot828d^2$	$0\cdot828d$	$2\cdot828d$
	38° 40′	1¼ : 1	$1\cdot952d^2$	$0\cdot702d$	$3\cdot202d$
	33° 42′	1½ : 1	$2\cdot106d^2$	$0\cdot606d$	$3\cdot606d$
	29° 44′	1¾ : 1	$2\cdot282d^2$	$0\cdot532d$	$4\cdot032d$
	26° 34′	2 : 1	$2\cdot472d^2$	$0\cdot472d$	$4\cdot472d$
	23° 58′	2¼ : 1	$2\cdot674d^2$	$0\cdot424d$	$4\cdot924d$
	21° 48′	2½ : 1	$2\cdot885d^2$	$0\cdot385d$	$5\cdot385d$
	19° 58′	2¾ : 1	$3\cdot104d^2$	$0\cdot354d$	$5\cdot854d$
	18° 26′	3 : 1	$3\cdot325d^2$	$0\cdot325d$	$6\cdot325d$

Half the top width is the length of each side slope. The wetted perimeter is the sum of the top and bottom widths.

97. *Form of Cross Section of Channel in which the Mean Velocity is Constant with Varying Discharge.*

In designing waste channels from canals, and in some other cases, it is desirable that the mean velocity should be restricted within narrow limits with very different volumes of discharge. In channels of trapezoidal form the velocity increases and diminishes with the discharge. Hence when the discharge is large there is danger of erosion, and when it is small of silting or obstruction by weeds. A theoretical form of section for which the mean velocity would be constant can be found, and, although this is not very suitable for practical purposes, it can be more or less approximated to in actual channels.

Let fig. 112 represent the cross section of the channel. From the symmetry of the section, only half the channel need be considered.



Scale $\frac{1}{10}$ *Inch = 1 Foot.*

Fig. 112.

Let $obac$ be any section suitable for the minimum flow, and let it be required to find the curve beg for the upper part of the channel so that the mean velocity shall be constant. Take o as origin of coordinates, and let de, fg be two levels of the water above ob.

Let $ob = \frac{b}{2}$; $de = y$, $fg = y + dy$, $od = x$, $of = x + dx$; $eg = ds$.

The condition to be satisfied is that

$$v = c\sqrt{mi}$$

should be constant, whether the water level is at ob, de, or fg. Consequently

$$m = \text{constant} = k$$

for all three sections, and can be found from the section $obac$. Hence also

$$\frac{\text{Increment of section}}{\text{Increment of perimeter}} = \frac{ydx}{ds} = k\,.$$

$$y^2dx^2 = k^2ds^2 = k^2(dx^2 + dy^2)\ ; \text{and}\ dx = \frac{kdy}{\sqrt{y^2 - k^2}}\,.$$

Integrating,

$$x = k\log_\epsilon\left(y + \sqrt{y^2 - k^2}\right) + \text{constant}\ ;$$

and, since $y = \frac{b}{2}$ when $x = 0$,

$$x = k\left\{\log_\epsilon \frac{y + \sqrt{y^2 - k^2}}{\frac{b}{2} + \sqrt{\frac{b^2}{4} - k^2}}\right\}.$$

Assuming values for y, the values of x can be found and the curve drawn.

The figure has been drawn for a channel the minimum section of which is a half hexagon of 4 feet depth. Hence $k = 2$; $b = 9\cdot2$; the rapid flattening of the side slopes is remarkable.

98. *Variation of Velocity in Different Parts of the Cross Section of a Uniform Stream.*

Vertical Velocity Curve in a Stream.—If it is assumed that the resistance to the relative sliding of the layers of water in a stream is of the nature of a viscous resistance, then the law of the distribution of velocity in a vertical longitudinal section of the stream can be determined theoretically. For simplicity, suppose the stream of uniform depth and indefinite width. Let fig. 113 show a portion of a vertical longitudinal section of the stream, and let OA, O′A′ be the intersections with this of two transverse sections at a distance apart l. Let ab, cd be the traces of two planes parallel to the free surface or to the bed, and let us consider the equilibrium of a layer $abcd$ of width unity. Let $Oa = y$, $ac = dy$, and let v be the velocity of the particles comprised in $abcd$, v being a function of y which is to be determined.

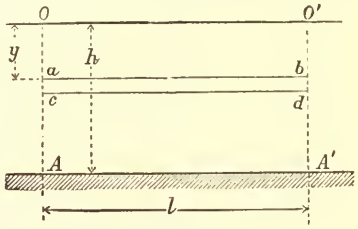


Fig. 113.

Taking the components of the forces acting on $abcd$, parallel to OO, the pressures on ac, bd, being proportional to the depth from the free surface, are equal and opposite; also, the frictions or viscous resistances on the lateral faces of the prism are zero, since in a wide stream there is no relative sliding between $abcd$ and the layers on each side. There remain only the resistances on the upper and lower surface, and the component of the weight.

The weight of the layer is $Gl\,dy$, and if i is the slope of the stream the component of the weight parallel to OO is $Gli\,dy$. The friction or viscous resistance on the face ab is proportional to its area and to the differential coefficient $\frac{dv}{dy}$ (§ 3). The resistance is, therefore, $-kl\frac{dv}{dy}$, the negative sign being used because, if v increases with y, $\frac{dv}{dy}$ is positive, while the action of the layers above ab is a retarding action. The resistance on the face cd is similarly $kl\frac{dv}{dy} + kld\frac{dv}{dy}$. The resultant of the action of the layers above and below is, therefore, $kld\frac{dv}{dy}$.

When the motion is uniform,

$$Glidy + kld\frac{dv}{dy} = 0\ ;$$

$$\frac{d^2v}{dy^2} = -\frac{Gi}{k}\ ;$$

integrating,

$$\frac{dv}{dy} = -\frac{Gi}{k}y + C\ ;$$

$$v = -\frac{1}{2}\frac{Gi}{k}y^2 + Cy + v_0 \quad . \quad . \quad (1)\ ;$$

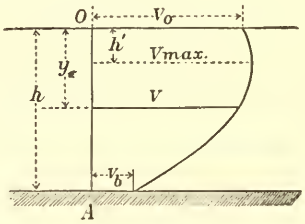


Fig. 114.

an equation which gives the velocity v at any depth y. If on a vertical line OA (fig. 114), representing the depth of the stream, the values of v are set off horizontally, a parabolic curve is obtained, termed the vertical velocity curve for the section considered. The constant v_0 is evidently the surface velocity, being the value of v for $y = 0$. The parabola has a horizontal axis corresponding to the position of the filament of maximum velocity. If there is no resistance at the surface of the stream like that at the bottom and sides, the maximum velocity should be at the surface, and then $c=0$, and the equation becomes

$$v=v_0-\frac{1}{2}\frac{Gi}{k}y^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Assuming this for the present, the mean velocity is

$$v_m=\frac{\int_0^h vdy}{h}=v_0-\frac{1}{6}\frac{Gi}{k}h^2 \quad . \quad . \quad . \quad . \quad (3).$$

The bottom velocity is, putting the depth h for y in (2);

$$v_b=v_0-\frac{1}{2}\frac{Gi}{k}h^2 ;$$

and therefore

$$v_m=\tfrac{1}{3}(2v_0+v_b) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

It is now understood that the motion in a stream is much more complete than the viscous theory just stated assumes. The retardation of the stream is much greater than it would be in simple motion of that kind. This has already been partly explained in the introduction to the present article. Nevertheless the viscous theory may probably be so modified as to furnish ultimately a true theory of streams.

99. *Experimental Observations on the Vertical Velocity Curve.*—In obtaining the vertical velocity curve from direct observations in streams, a preliminary difficulty arises from the fact that the velocity at any given depth is not constant, and hence the motion in the strict sense is not steady. The velocities taken on a given vertical section at any given moment do not form when plotted any regular curve. But if a series of observations are taken at each depth and the results averaged, the mean velocities at each depth when plotted give a regular curve, agreeing very fairly with the parabola, which might be expected from the theory above. Hence it may be inferred that the velocity at any given point fluctuates about a mean value, the fluctuations being due to irregular eddying motions superposed on the general steady motion of the stream, and having an effect which disappears in the mean of a series of observations. For certain purposes these irregular motions may be ignored, and the constant mean velocity substituted for the actual varying velocities at each point. In the next place, all the best observations show that the maximum velocity is to be found, not at the free surface of the stream, but at some distance below it.[1]

Influence of the Wind.—In the experiments on the Mississippi the vertical velocity curve in calm weather was found to agree fairly with a parabola, the greatest velocity being at $\frac{3}{10}$ths of the depth of the stream from the surface. With a wind blowing down stream the surface velocity is increased, and the axis of the parabola approaches the surface. On the contrary, with a wind blowing up stream the surface velocity is diminished, and the axis of the parabola is lowered, sometimes to half the depth of the stream. The American observers drew from their observations the conclusion that there was an energetic retarding action at the surface of a stream like that due to the bottom and sides. If there were such a retarding action the position of the filament of maximum velocity below the surface would be explained.

It is not difficult to understand that a wind acting on surface ripples should accelerate or retard the surface motion of the stream, and the Mississippi results may be accepted so far as showing that the surface velocity of a stream is variable when the mean velocity of the stream is constant. Hence observations of surface velocity by floats or otherwise should only be made in very calm weather. But it is very difficult to suppose that, in still air, there is a resistance at the free surface of the stream at all analogous to that at the sides and bottom. Further, in very careful experiments, Boileau found the maximum velocity, though raised a little above its position for calm weather, still at a considerable distance below the surface, even when the wind was blowing down stream with a velocity greater than that of the stream, and when the action of the air must have been an accelerating and not a retarding action. Professor James Thomson has given a much more probable explanation of the diminution of the velocity at and near the free surface. He points out that portions of water, with a diminished velocity from retardation by the sides or bottom, are thrown off in eddying masses and mingle with the rest of the stream. These eddying masses modify the velocity in all parts of the stream, but have their greatest influence at the free surface. Reaching the free surface they spread out and remain there, mingling with the water at that level and diminishing the velocity which would otherwise be found there.

100. *Influence of the Wind on the Depth at which the Maximum Velocity is found.*—In the gaugings of the Mississippi the vertical velocity curve was found to agree well with a parabola having a horizontal axis at some distance below the water surface, the ordinate of the parabola at the axis being the maximum velocity of the section. During the gaugings the force of the wind was registered on a scale ranging from 0 for a calm to 10 for a hurricane. Arranging the velocity curves in three sets—(1) with the wind blowing up stream, (2) with the wind blowing down stream, (3) calm or wind blowing across stream—it was found that an up stream wind lowered, and a down stream wind raised, the axis of the parabolic velocity curve. In calm weather the axis was at $\frac{3}{10}$ths of the total depth from the surface for all conditions of the stream.

Let h' be the depth of the axis of the parabola, m the hydraulic mean depth, f the number expressing the force of the wind, which may range from $+10$ to -10, positive if the wind is up stream, negative if it is down stream. Then Messrs Humphreys and Abbot find their results agree with the expression

$$\frac{h'}{m}=0{\cdot}317\pm0{\cdot}06f .$$

Fig. 115 shows the parabolic velocity curves according to the American observers for calm weather, and for an up or down stream wind of a force represented by 4.

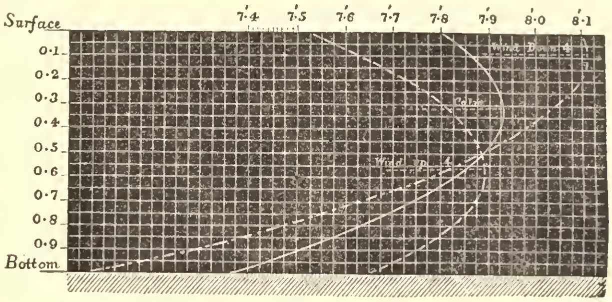


Fig. 115.

101. *Bazin's Formulæ for the Variation of Velocity in a Vertical Longitudinal Section of a Stream.*—M. Bazin assumes that the vertical velocity curve is a parabola, and has investigated numerical values for the constants from his own and other experiments. Assuming the general equation already found, § 98,

$$v=v_0+cy-\frac{1}{2}\frac{Gi}{k}y^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

v will have the maximum value V, for a value of h' of y which makes $\frac{dv}{dy}$ zero. That is,

$$h'=\frac{ck}{Gi}, \quad \text{or} \quad c=\frac{Gi}{k}h' ;$$

and the maximum velocity is

$$V=v_0+\frac{1}{2}\frac{Gi}{k}h'^2 ;$$

$$\therefore \quad v_0=V-\frac{1}{2}\frac{Gi}{k}h'^2 .$$

Inserting these values of v_0 and c in (1),

$$v=V-\frac{Gi}{2k}(y-h')^2 ;$$

or putting $M=\frac{Gih^2}{2k}$, where h is the whole depth of the section,

$$v=V-M\left(\frac{y-h'}{h}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

where M is constant for any given stream. Let $\frac{y}{h}=x$ and $\frac{h'}{h}=\alpha$,

$$v=V-M(x-\alpha)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2a).$$

Then the mean velocity on the vertical is

$$v_m=\int_0^h\left\{V-M(x-\alpha)^2\right\}dx=V-M(\tfrac{1}{3}-\alpha+\alpha^2) .$$

Let v_n be the velocity at nh feet from the surface, v_{1-n} the velocity at an equal depth from the bottom,

$$\tfrac{1}{2}(v_n+v_{1-n})=V-M(n^2-n+\alpha^2-\alpha+\tfrac{1}{2}) ,$$

$$=v_m-M(n^2-n+\tfrac{1}{6}) ,$$

Let $n=\frac{1}{2}$, and put $v_{\frac{1}{2}}$ for the velocity at mid depth, then

$$v_{\frac{1}{2}}=v_m+\tfrac{1}{12}M \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3) ;$$

so that the mid depth velocity differs from the mean velocity by the small quantity $\frac{1}{12}$ M only, whatever be the position of the axis of the parabola. Messrs Humphreys and Abbot have based on this property a method of rapidly gauging rivers which will be described hereafter.

[1] Pitot first showed, in 1732, that the velocity in a stream diminishes from the surface downwards; about sixty years after, Woltmann concluded that the vertical velocity curve was a parabola.

From a discussion of experiments in which the maximum velocity was at the surface, Bazin was led to take

$$M = 36{\cdot}3\sqrt{hi} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4);$$

and for that case the equation to the vertical velocity curve is ($\alpha = 0$)

$$v = V - 36{\cdot}3\sqrt{hi}x^2.$$

In the cases in which the maximum velocity was below the surface, Bazin found that the difference between the maximum velocity V and the bottom velocity v_b remained constant.

But, putting $x = \frac{h}{h} = 1$ in the equation ($2a$), and v_b for the bottom velocity,

$$v_b = V - M(1-\alpha)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5);$$

$$V - v_b = M(1-\alpha)^2 = \text{constant},$$

for different positions of the axis of the parabola.
Let

$$M = \frac{N}{(1-\alpha)^2},$$

where N is a constant; then

$$v = V - N\left(\frac{x-\alpha}{1-\alpha}\right)^2$$

for any position of the axis of the parabola. But this must agree with the equation (4) above, for $\alpha = 0$; hence,

$$N = 36{\cdot}3\sqrt{hi};$$

and the general equation for all cases becomes

$$v = V - 36{\cdot}3\sqrt{hi}\left(\frac{x-\alpha}{1-\alpha}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

Bazin has shown that this equation agrees well with experiments on artificial channels by himself, and on the Saone, Seine, Garonne, and Rhine. In all these the ratio $\frac{V}{v_m}$ ranged from 1·10 to 1·13, except in the case of the Rhine at Basel, for which the ratio was 1·17. The parameter $\frac{36{\cdot}3\sqrt{hi}}{(1-\alpha)^2}$ lies between 13 and 20, and the ratio of the depth at which the maximum velocity is found to the whole depth, $=\alpha$, ranges from zero to 0·2, except in some of the artificial channels, where it reached 0·35. The Mississippi experiments give different results, and Bazin inclines to believe that the method of experimenting was untrustworthy.

The extreme difference $V - v_b$ between the maximum and bottom velocity is found by Bazin to range from $\frac{1}{4}$ V to $\frac{1}{2}$ V in artificial channels, being greater the greater the roughness of the sides. In natural streams it is more generally $\frac{1}{3}$ V, but in the Rhine at Basel it reached $\frac{1}{2}$V, the bed being covered with boulders.

Boileau's Formulæ.—Boileau also assumes the vertical velocity curve to be a parabola; below the filament of greatest velocity the curve is expressed by the relation

$$v = A - By^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

That is, the velocity curve is a parabola having its axis at the free surface of the stream. Above the filament of greatest velocity this law fails, and the velocities diminish instead of increasing. The vertical velocity curve is therefore such a curve as M′MM″ (fig. 116), where the part MM″ is a parabola having its vertex at S, and DM is the maximum velocity. The part M′M does not follow the parabolic law. Let V be the maximum velocity DM, CM its depth $=\theta$. Draw at M the tangent and normal to the parabola. Then PC is the half parameter $\frac{1}{2B}$. Let OS $= V + c$, then CT $= 2$CS $= 2c$.

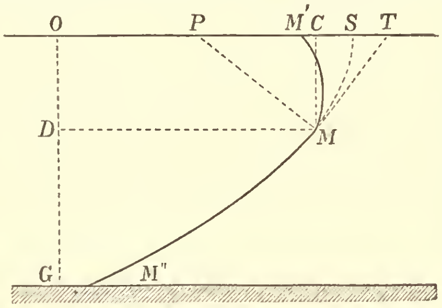


Fig. 116.

$$B = \frac{1}{2}\,\frac{1}{PC}, \text{ and } CM^2 = PC \cdot CT;$$

$$\therefore \quad B = \frac{1}{2}\,\frac{CT}{CM^2} = \frac{c}{\theta^2}.$$

Boileau finds $c = B\theta^2$ to be nearly constant for very different streams. Thus from two experiments of his own on streams 0·2 and 0·3 metres deep, $c = 0{\cdot}01070$ and $0{\cdot}01072$. In Hennocque's experiments on the Rhine, 2·45 metres deep, $c = 0{\cdot}0107$; and in the Mississippi experiments with a depth of 32 metres, $c = 0{\cdot}0093$ to $0{\cdot}0113$. Replacing A and B in (1) by the values now given

$$v = V - c\frac{y^2}{\theta^2} + c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

an equation which gives the velocity v at any depth y from the surface in the region below the filament of maximum velocity. For the region above the filament of maximum velocity Boileau assumes

$$v_s = V' - c\frac{y^2}{\theta^2} + (V - V' + c)\frac{z}{\theta} \quad . \quad . \quad . \quad . \quad (3),$$

where v is the velocity at the depth y and V′ is the surface velocity.

102. *Ratio of Mean to Greatest Surface Velocity, for the whole Cross Section in Trapezoidal Channels.*—It is often very important to be able to deduce the mean velocity, and thence the discharge, from observation of the greatest surface velocity. The simplest method of gauging small streams and channels is to observe the greatest surface velocity by floats, and thence to deduce the mean velocity. Now, for channels not widely differing from those experimented on by Bazin, the expression obtained by him for the ratio of surface to mean velocity may be relied on as at least a good approximation to the truth. Let v_0 be the greatest surface velocity, v_m the mean velocity of the stream. Then, according to Bazin,

$$v_m = v_0 - 25{\cdot}4\sqrt{mi}.$$

But

$$v_m = c\sqrt{mi},$$

where c is a coefficient, the values of which have been already given in the table in § 90. Hence

$$v_m = \frac{c}{c + 25{\cdot}4}v_0.$$

Values of Coefficient $\frac{c}{c+25{\cdot}4}$ *in the Formula* $v_m = \frac{c}{c+25{\cdot}4}v_0$.

Hydraulic Mean Depth $=m$.	Very Smooth Channels. Cement.	Smooth Channels. Ashlar or Brickwork.	Rough Channels. Rubble Masonry.	Very Rough Channels. Canals in Earth.	Channels encumbered with Detritus.
0·25	·83	·79	·69	·51	·42
0·5	·84	·81	·74	·58	·50
0·75	·84	·82	·76	·63	·55
1·0	·85	...	·77	·65	·58
2·0	...	·83	·79	·71	·64
3·0	...	...	·80	·73	·67
4·0	...	...	·81	·75	·70
5·0	...	...	...	·76	·71
6·0	...	·84	...	·77	·72
7·0	...	...	...	·78	·73
8·0	...	...	...	...	...
9·0	...	...	·82	...	·74
10·0	...	...	...	...	...
15·0	...	...	...	·79	·75
20·0	...	...	...	·80	·76
30·0	...	...	·82	...	·77
40·0	...	...	...	...	...
50·0	...	...	...	...	...
∞	...	...	...	...	·79

103. *River Bends.*—In rivers flowing in alluvial plains, the windings which already exist tend to increase in curvature by the scouring away of material from the outer bank and the deposition of detritus along the inner bank. The sinuosities sometimes increase till a loop is formed with only a narrow strip of land between the two encroaching branches of the river. Finally a "cut off" may occur, a waterway being opened through the strip of land and the loop left separated from the stream, forming a horse-shoe shaped lagoon or marsh. Professor James Thomson has pointed out (*Proc. Royal Soc.* 1877, p. 356; *Proc. Inst. of Mech. Engineers*, 1879, p. 456) that the usual supposition is that the water tending to go forwards in a straight line, rushes against the outer bank and scours it, at the same time creating deposits at the inner bank. That view is very far from a complete account of the matter, and Professor Thomson has given a much more ingenious account of the action at the bend, which he has completely confirmed by experiment.

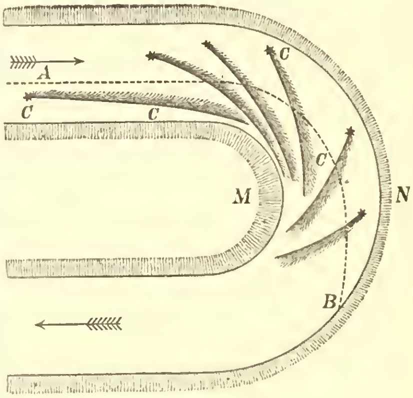


Fig. 117.

When water moves round a circular curve under the action of gravity only, it takes a motion like that in a free vortex. Its velocity is greater parallel to the axis of the stream at the inner than at the outer side of the bend. Hence the scouring at the outer side and the deposit at the inner side of the bend are not due to mere difference of velocity of flow in the general direction of the stream; but, in virtue of the centrifugal force, the water passing round the bend presses outwards, and the free surface in a radial cross section has a slope from the inner side upwards to the outer side (fig. 118). For the greater part of the water flowing in curved paths, this difference of pressure produces no tendency to transverse motion. But the water immediately in contact with the rough bottom and sides of the channel is retarded, and its centrifugal force is insufficient to balance the pressure due to the greater depth at the outside of the bend. It therefore flows inwards towards the inner side of the bend, carrying with it detritus which is deposited at the inner bank. Conjointly with this flow inwards along the bottom and sides, the general mass of water must flow outwards to take its place. Fig. 117 shows the directions of flow as observed in a small artificial stream, by means of light seeds and specks of aniline dye. The lines CC show the directions of flow immediately in contact with the sides and bottom. The dotted line AB shows the direction of motion of floating particles on the surface of the stream.

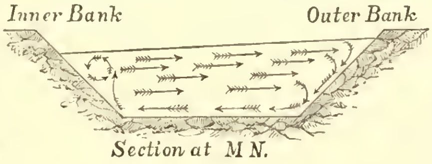


Fig. 118.

Steady Motion of Water in Open Channels of Varying Cross Section and Slope.

104. In every stream the discharge of which is constant, or may be regarded as constant for the time considered, the velocity at different places depends on the slope of the bed. Except at certain exceptional points the velocity will be greater as the slope of the bed is greater, and, as the velocity and cross section of the stream vary inversely, the section of the stream will be least where the velocity and slope are greatest. If in a stream of tolerably uniform slope an obstruction such as a weir is built, that will cause an alteration of flow similar to that of an alteration of the slope of the bed for a greater or less distance above the weir, and the originally uniform cross section of the stream will become a varied one. In such cases it is often of much practical importance to determine the longitudinal section of the stream.

The cases now considered will be those in which the changes of velocity and cross section are gradual and not abrupt, and in which the only internal work which needs to be taken into account is that due to the friction of the stream bed, as in cases of uniform motion. Further, the motion will be supposed to be steady, the mean velocity at each given cross section remaining constant, though it varies from section to section along the course of the stream.

Let fig. 119 represent a longitudinal section of the stream, A_0A_1 being the water surface, B_0B_1 the stream bed. Let A_0B_0, A_1B_1 be

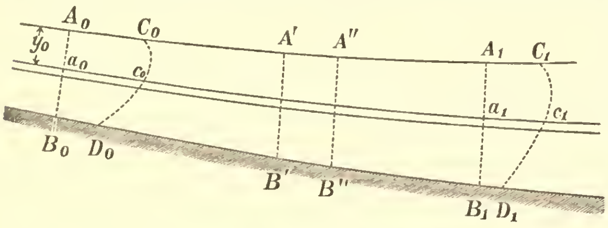


Fig. 119.

cross sections normal to e direction of flow. Suppose the mass of water $A_0B_0A_1B_1$ comes in a short time θ to $C_0D_0C_1D_1$, and let the work done on the mass be equated to its change of kinetic energy during that period. Let l be the length A_0A_1 of the portion of the stream considered, and z the fall of surface level in that distance. Let Q be the discharge of the stream per second.

Change of Kinetic Energy.—At the end of the time θ there are as many particles possessing the same velocities in the space $C_0D_0A_1B_1$ as at the beginning. The change of kinetic energy is therefore the difference of the kinetic energies of $A_0B_0C_0D_0$ and $A_1B_1C_1D_1$.

Let fig. 120 represent the cross section A_0B_0, and let ω be a small element of its area at a point where the velocity is v. Let Ω_0 be the whole area of the cross section and u_0 the mean velocity for the whole cross section. From the definition of mean velocity we have

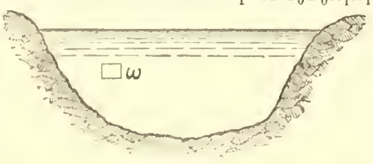


Fig. 120.

$$u_0 = \frac{\Sigma\omega v}{\Omega_0}.$$

Let $v = u_0 + w$, where w is the difference between the velocity at the small element ω and the mean velocity. For the whole cross section, $\Sigma\omega w = 0$.

The mass of fluid passing through the element of section ω, in θ seconds, is $\frac{G}{g}\omega v\theta$, and its kinetic energy is $\frac{G}{2g}\omega v^3\theta$. For the whole section, the kinetic energy of the mass $A_0B_0C_0D_0$ passing in θ seconds is

$$\frac{G\theta}{2g}\Sigma\omega v^3,$$

$$= \frac{G\theta}{2g}\Sigma\omega(u_0^3 + 3u_0^2 w + 3u_0 w^2 + w^3),$$

$$= \frac{G\theta}{2g}\left\{u_0^3\Omega + \Sigma\omega w^2(3u_0 + w)\right\}.$$

The factor $3u_0 + w$ is equal to $2u_0 + v$, a quantity necessarily positive. Consequently $\Sigma\omega v^3 > \Omega_0 u_0^3$, and consequently the kinetic energy of $A_0B_0C_0D_0$ is greater than

$$\frac{G\theta}{2g}\Omega_0 u_0^3 \text{ or } \frac{G\theta}{2g}Qu_0^2,$$

which would be its value if all the particles passing the section had the same velocity u_0. Let the kinetic energy be taken at

$$\alpha\frac{G\theta}{2g}\Omega_0 u_0^3 = \alpha\frac{G\theta}{2g}Qu_0^2,$$

where α is a corrective factor, the value of which has been estimated by Belanger at 1·1.[1] Its precise value is not of great importance.

In a similar way we should obtain for the kinetic energy of $A_1B_1C_1D_1$ the expression

$$\alpha\frac{G\theta}{2g}\Omega_1 u_1^3 = \alpha\frac{G\theta}{2g}Qu_1^2,$$

where Ω_1, u_1 are the section and mean velocity at A_1B_1, and where α may be taken to have the same value as before without any important error.

Hence the change of kinetic energy in the whole mass $A_0B_0A_1B_1$ in θ seconds is

$$\alpha\frac{G\theta}{2g}Q(u_1^2 - u_0^2) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Motive Work of the Weight and Pressures.—Consider a small filament a_0a_1 which comes in θ seconds to c_0c_1. The work done by gravity during that movement is the same as if the portion a_0c_0 were carried to a_1c_1. Let $dQ\theta$ be the volume of a_0c_0 or a_1c_1, and y_0, y_1 the depths of a_0, a_1 from the surface of the stream. Then the volume $dQ\theta$ or $GdQ\theta$ pounds falls through a vertical height $z + y_1 - y_0$, and the work done by gravity is

$$G\, dQ\, \theta(z + y_1 - y_0).$$

Putting p_a for atmospheric pressure, the whole pressure per unit of area at a_0 is $Gy_0 + p_a$, and that at a_1 is $-(Gy_1 + p_a)$. The work of these pressures is

$$G\left(y_0 + \frac{p_a}{G} - y_1 - \frac{p_a}{G}\right)dQ\,\theta,$$

$$= G(y_0 - y_1)\,dQ\,\theta.$$

Adding this to the work of gravity, the whole work is $GzdQ\theta$; or, for the whole cross section,

$$GzQ\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Work expended in Overcoming the Friction of the Stream Bed.—Let A′B′, A″B″ be two cross sections at distances s and $s + ds$ from A_0B_0. Between these sections the velocity may be treated as uniform, because by hypothesis the changes of velocity from section to section are gradual. Hence, to this short length of stream the equation for uniform motion is applicable. But in that case the work in overcoming the friction of the stream bed between A′B′ and A″B″ is

$$GQ\theta\zeta\frac{u^2}{2g}\frac{\chi}{\Omega}ds,$$

where u, χ, Ω are the mean velocity, wetted perimeter, and section at A′B′. Hence the whole work lost in friction from A_0B_0 to A_1B_1 will be

$$GQ\theta\int_0^l \zeta\frac{u^2}{2g}\frac{\chi}{\Omega}ds \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Equating the work given in (2) and (3) to the change of kinetic energy given in (1),

$$\alpha\frac{GQ\theta}{2g}(u_1^2 - u_0^2) = GQz\theta - GQ\theta\int_0^l \zeta\frac{u^2}{2g}\frac{\chi}{\Omega}ds;$$

$$\therefore \quad z = \alpha\frac{(u_1^2 - u_0^2)}{2g} + \int_0^l \zeta\frac{u^2}{2g}\frac{\chi}{\Omega}ds.$$

[1] Boussinesq has shown that this mode of determining the corrective factor α is not satisfactory.

105. *Fundamental Differential Equation of Steady Varied Motion.*—Suppose the equation just found to be applied to an indefinitely short length ds of the stream, limited by the end sections ab, a_1b_1, taken for simplicity normal to the stream bed (fig. 121). For that

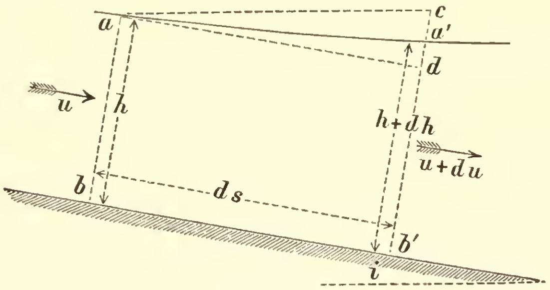


Fig. 121.

short length of stream the fall of surface level, or difference of level of a and a_1, may be written dz. Also, if we write u for u_0, and $u+du$ for u_1, the term $\frac{u_0^2-u_1^2}{2g}$ becomes $\frac{udu}{g}$. Hence the equation applicable to an indefinitely short length of the stream is

$$dz=\frac{udu}{g}+\frac{\chi}{\Omega}\zeta\frac{u^2}{2g}ds \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

From this equation some general conclusions may be arrived at as to the form of the longitudinal section of the stream, but, as the investigation is somewhat complicated, it is convenient to simplify it by restricting the conditions of the problem.

Modification of the Formula for the Restricted Case of a Stream flowing in a Prismatic Stream Bed of Constant Slope.—Let i be the constant slope of the bed. Draw ad parallel to the bed, and ac horizontal. Then dz is sensibly equal to $a'c$. The depths of the stream, h and $h+dh$, are sensibly equal to ab and $a'b'$, and therefore $dh=a'd$. Also cd is the fall of the bed in the distance ds, and is equal to ids. Hence

$$dz=a'd=cd-a'c=ids-dh \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Since the motion is steady—

$$Q=\Omega u=\text{constant}.$$

Differentiating,

$$\Omega du+ud\Omega=0\,;$$

$$\therefore \quad du=-\frac{ud\Omega}{\Omega}.$$

Let x be the width of the stream, then $d\Omega=xdh$ very nearly. Inserting this value,

$$du=-\frac{ux}{\Omega}dh \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Putting the values of du and dz found in (2) and (3) in equation (1),

$$ids-dh=\frac{u^2x}{g\Omega}dh+\frac{\chi}{\Omega}\zeta\frac{u^2}{2g}ds.$$

$$\frac{dh}{ds}=\frac{i-\frac{\chi}{\Omega}\zeta\frac{u^2}{2g}}{1-\frac{u^2}{g}\frac{x}{\Omega}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

Further Restriction to the Case of a Stream of Rectangular Section and of Indefinite Width.—The equation might be discussed in the form just given, but it becomes a little simpler if restricted in the way just stated. For, if the stream is rectangular, $xh=\Omega$, and if x is large compared with h, $\frac{\Omega}{\chi}=\frac{xh}{x}=h$ nearly. Then equation (4) becomes

$$\frac{dh}{ds}=i\frac{1-\zeta\frac{u^2}{2gih}}{1-\frac{u^2}{gh}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

106. *General Indications as to the Form of Water Surface furnished by Equation* (5).—Let A_0A_1 (fig. 122) be the water surface, B_0B_1 the bed in a longitudinal section of the stream, and ab any section at a distance s from B_0, the depth ab being h. Suppose B_0B_1, B_0A_0 taken as rectangular coordinate axes, then $\frac{dh}{ds}$ is the trigonometric tangent of the angle which the surface of the stream at a makes with the axis B_0B_1. This tangent $\frac{dh}{ds}$ will be positive, if the stream is increasing in depth in the direction B_0B_1; negative, if the stream is diminishing in depth from B_0 towards B_1. If $\frac{dh}{ds}=0$, the surface of the stream is parallel to the bed, as in cases of uniform motion. But from equation (4)

$$\frac{dh}{ds}=0, \text{ if } \quad i-\frac{\chi}{\Omega}\zeta\frac{u^2}{2g}=0\,;$$

$$\therefore \quad \zeta\frac{u^2}{2g}=\frac{\Omega}{\chi}i=mi\,,$$

which is the well-known general equation for uniform motion, based on the same assumptions as the equation for varied steady motion now being considered. The case of uniform motion is therefore a limiting case between two different kinds of varied motion.

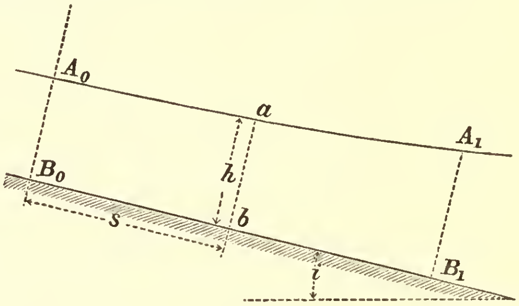


Fig. 122.

Consider the possible changes of value of the fraction

$$\frac{1-\zeta\frac{u^2}{2gih}}{1-\frac{u^2}{gh}}.$$

As h tends towards the limit 0, and consequently u is large, the numerator tends to the limit $-\infty$. On the other hand if $h=\infty$, in which case u is small, the numerator becomes equal to 1. For a value H of h given by the equation

$$1-\zeta\frac{u^2}{2gi\mathrm{H}}=0\,,$$

$$\mathrm{H}=\zeta\frac{u^2}{2gi}\,,$$

we fall upon the case of uniform motion. The results just stated may be tabulated thus:—

For	$h=0$	H	$>$H	∞
the numerator has the value	$-\infty$	0	>0	1.

Next consider the denominator. If h becomes very small, in which case u must be very large, the denominator tends to the limit $-\infty$. As h becomes very large and u consequently very small, the denominator tends to the limit 1. For $h=\frac{u^2}{g}$, or $u=\sqrt{gh}$, the denominator becomes zero. Hence, tabulating these results as before:—

For	$h=0$	$\frac{u^2}{g}$	$>\frac{u^2}{g}$	∞
the denominator becomes	$-\infty$	0	>0	1.

107. *Case* 1.—Suppose $h>\frac{u^2}{g}$, and also $h>$H, or the depth greater than that corresponding to uniform motion. In this case $\frac{dh}{ds}$ is positive, and the stream increases in depth in the direction of flow. In fig. 123 let B_0B_1 be the bed, C_0C_1 a line parallel to the bed and

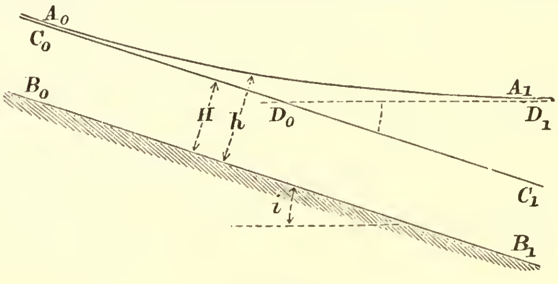


Fig. 123.

at a height above it equal to H. By hypothesis, the surface A_0A_1 of the stream is above C_0C_1, and it has just been shown that the depth of the stream increases from B_0 towards B_1. But going up stream h approaches more and more nearly the value H, and therefore $\frac{dh}{ds}$

approaches the limit 0, or the surface of the stream is asymptotic to C_0C_1. Going down stream h increases and u diminishes, the numerator and denominator of the fraction $\dfrac{1-\zeta\dfrac{2gih}{u^2}}{1-\dfrac{u^2}{gh}}$ both tend towards the limit 1, and $\dfrac{dh}{ds}$ to the limit i. That is, the surface of the stream tends to become asymptotic to a horizontal line D_0D_1.

The form of water surface here discussed is produced when the flow of a stream originally uniform is altered by the construction of a weir. The raising of the water surface above the level C_0C_1 is termed the backwater due to the weir.

108. *Case* 2.—Suppose $h>\dfrac{u^2}{g}$, and also $h<$H. Then $\dfrac{dh}{ds}$ is negative, and the stream is diminishing in depth in the direction of flow. In fig. 124 let B_0B_1 be the stream bed as before; C_0C_1 a line drawn parallel to B_0B_1 at a height above it equal to H. By hypothesis the surface A_0A_1 of the stream is below C_0C_1, and the depth has just been shown to diminish from B_0 towards B_1.

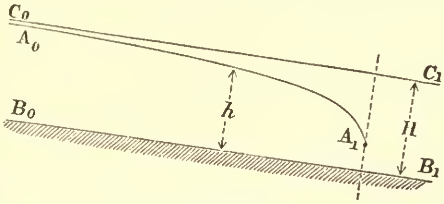


Fig. 124.

Going up stream h approaches the limit H, and $\dfrac{dh}{ds}$ tends to the limit zero. That is, up stream A_0A_1 is asymptotic to C_0C_1. Going down stream h diminishes and u increases; the inequality $h>\dfrac{u^2}{g}$ diminishes; the denominator of the fraction $\dfrac{1-\zeta\dfrac{u^2}{2gih}}{1-\dfrac{u^2}{gh}}$ tends to the limit zero, and consequently $\dfrac{dh}{ds}$ tends to ∞. That is, down stream A_0A_1 tends to a direction perpendicular to the bed. Before, however, this limit was reached the assumptions on which the general equation is based would cease to be even approximately true, and the equation would cease to be applicable. The filaments would have a relative motion, which would make the influence of internal friction in the fluid too important to be neglected. A stream surface of this form may be produced if there is an abrupt fall in the bed of the stream (fig. 125).

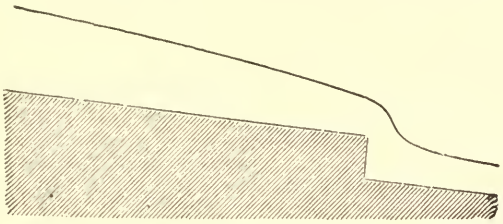


Fig. 125.

On the Ganges canal, as originally constructed, there were abrupt falls precisely of this kind, and it appears that the lowering of the water surface and increase of velocity which such falls occasion, for a distance of some miles up stream, was not foreseen. The result was that, the velocity above the falls being greater than was intended, the bed was scoured and considerable damage was done to the works. "When the canal was first opened the water was allowed to pass freely over the crests of the overfalls, which were laid on the level of the bed of the earthen channel; erosion of bed and sides for some miles up rapidly followed, and it soon became apparent that means must be adopted for raising the surface of the stream at those points (that is, the crests of the falls). Planks were accordingly fixed in the grooves above the bridge arches, or temporary weirs were formed over which the water was allowed to fall; in some cases the surface of the water was thus raised above its normal height, causing a backwater in the channel above" (Crofton's *Report on the Ganges Canal*, p. 14). Fig. 126 represents in an exaggerated form what probably occurred, the diagram being intended to represent some miles' length of the canal bed above the fall. AA parallel to the canal bed is the level corresponding to uniform motion with the intended velocity of the canal. In consequence of the presence of the ogee fall, however, the water surface would take some such form as BB, corresponding to Case 2 above, and the velocity would be greater than the intended velocity, nearly in the inverse ratio of the actual to the intended depth. By constructing a weir on the crest of the fall, as shown by dotted lines, a new water surface CC corresponding to Case 1 would be produced, and by suitably choosing the height of the weir this might be made to agree approximately with the intended level AA.

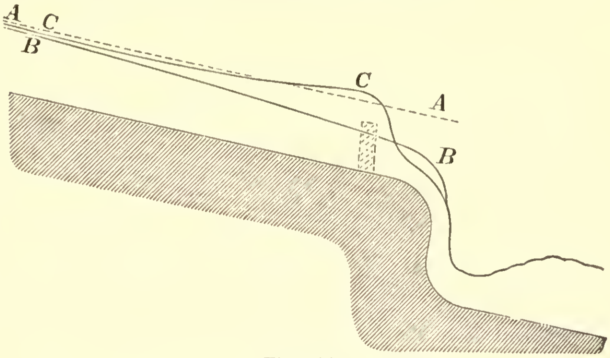


Fig. 126.

109. Case 3.—Suppose a stream flowing uniformly with a depth $H<\dfrac{u^2}{g}$. For a stream in uniform motion $\zeta\dfrac{u^2}{2g}=mi$, or if the stream is of indefinitely great width, so that $m=$H, then $\zeta\dfrac{u^2}{2g}=i$H, and $H=\zeta\dfrac{u^2}{2gi}$. Consequently the condition stated above involves that

$$\zeta\frac{u^2}{2gi}<\frac{u^2}{g}\text{, or that } i>\frac{\zeta}{2}\,.$$

If such a stream is interfered with by the construction of a weir which raises its level, so that its depth at the weir becomes $h_1>\dfrac{u^2}{g}$, then for a portion of the stream the depth h will satisfy the conditions $h<\dfrac{u^2}{g}$ and $h>$H, which are not the same as those assumed in the two previous cases. At some point of the stream above the weir the depth h becomes equal to $\dfrac{u^2}{g}$, and at that point $\dfrac{dh}{ds}$ becomes infinite, or the surface of the stream is normal to the bed. It is obvious that at that point the influence of internal friction will be too great to be neglected, and the general equation will cease to represent the true conditions of the motion of the water. It is known that, in cases such as this, there occurs an abrupt rise of the free surface of the stream, or a standing wave is formed, the conditions of motion in which will be examined presently.

It appears that the condition necessary to give rise to a standing wave is that $i>\dfrac{\zeta}{2}$. Now ζ depends for different channels on the roughness of the channel and its hydraulic mean depth. M. Bazin has calculated the values of ζ for channels of different degrees of roughness and different depths given in the following table, and the corresponding minimum values of i for which the exceptional case of the production of a standing wave may occur.

Nature of Bed of Stream.	Slope below which a Standing Wave is impossible in feet per foot.	Standing Wave Formed.	
		Slope in feet per foot.	Least Depth in feet.
Very smooth cemented surface	0·00147	0·002	0·262
		0·003	·098
		0·004	·065
Ashlar or brickwork	0·00186	0·003	·394
		0·004	·197
		0·006	·098
Rubble masonry	0·00235	0·004	1·181
		0·006	·525
		0·010	·262
Earth	0·00275	0·006	3·478
		0 010	1·542
		0·015	·919

Standing Waves.

110. The formation of a standing wave was first observed by Bidone. Into a small rectangular masonry channel, having a slope of 0·023 feet per foot, he admitted water till it flowed uniformly with a depth of 0·2 feet. He then placed a plank across the stream which raised the level just above the obstruction to 0·95 feet. He found that the stream above the obstruction was sensibly unaffected up to a point 15 feet from it. At that point the depth suddenly increased from 0·2 feet to 0·56 feet. The velocity of the stream in

the part unaffected by the obstruction was 5·54 feet per second. Above the point where the abrupt change of depth occurred $u^2 = 5·51^2 = 30·7$, and $gh = 32·2 \times 0·2 = 6·44$; hence u^2 was $> gh$. Just below the abrupt change of depth $u = 5·54 \times \frac{0·2}{0·56} = 1·97$; $u^2 = 3·88$; and $gh = 32·2 \times 0·56 = 18·03$; hence at this point $u^2 < gh$. Between these two points, therefore, $u = gh$; and the condition for the production of a standing wave occurred.

The change of level at a standing wave may be found thus. Let fig. 127 represent the longitudinal section of a stream and

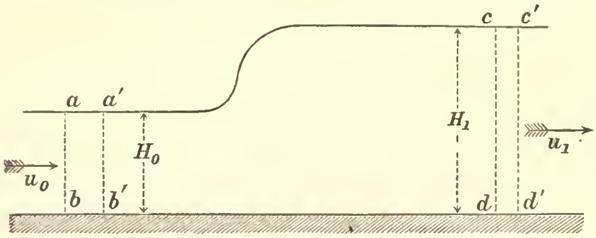


Fig. 127.

ab, *cd* cross sections normal to the bed, which for the short distance considered may be assumed horizontal. Suppose the mass of water *abcd* to come to *a′b′c′d′* in a short time t; and let u_0, u_1 be the velocities at *ab* and *cd*, Ω_0, Ω_1 the areas of the cross sections. The force causing change of momentum in the mass *abcd* estimated horizontally is simply the difference of the pressures on *ab* and *cd*. Putting h_0, h_1 for the depths of the centres of gravity of *ab* and *cd* measured down from the free water surface, the force is $G(h_0\Omega_0 - h_1\Omega_1)$ pounds, and the impulse in t seconds is $G\ (h_0\Omega_0 - h_1\Omega_1)\ t$ second pounds. The horizontal change of momentum is the difference of the momenta of *cdc′d′* and *aba′b′*; that is,

$$\frac{G}{g}(\Omega_1 u_1^2 - \Omega_0 u_0^2)t\,.$$

Hence, equating impulse and change of momentum,

$$G(h_0\Omega_0 - h_1\Omega_1)t = \frac{G}{g}(\Omega_1 u_1^2 - \Omega_0 u_0^2)t\,;$$

$$\therefore\ h_0\Omega_0 - h_1\Omega_1 = \frac{\Omega_1 u_1^2 - \Omega_0 u_0^2}{g} \quad . \quad . \quad . \quad . \quad . \quad (1).$$

For simplicity let the section be rectangular, of breadth B and depths H_0 and H_1, at the two cross sections considered; then $h_0 = \frac{1}{2}H_0$, and $h_1 = \frac{1}{2}H_1$. Hence

$$H_0^2 - H_1^2 = \frac{2}{g}(H_1 u_1^2 - H_0 u_0^2)\,.$$

But, since $\Omega_0 u_0 = \Omega_1 u_1$, we have

$$u_1^2 = u_0^2 \frac{H_0^2}{H_1^2}\,,$$

$$H_0^2 - H_1^2 = \frac{2u_0^2}{g}\left(\frac{H_0^2}{H_1} - H_0\right) \quad . \quad . \quad . \quad . \quad (2).$$

This equation is satisfied if $H_0 = H_1$, which corresponds to the case of uniform motion. Dividing by $H_0 - H_1$, the equation becomes

$$\frac{H_1}{H_0}(H_0 + H_1) = \frac{2u_0^2}{g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)\,;$$

$$\therefore\ H_1 = \sqrt{\left\{\frac{2u_0^2}{g}H_0 + \frac{1}{4}H_0^2\right\}} - \frac{1}{2}H_0\,. \quad . \quad . \quad (4).$$

In Bidone's experiment $u_0 = 5·54$, and $H = 0·2$. Hence $H_1 = 0·52$, which agrees very well with the observed height.

Fig. 128.

111. A standing wave is frequently produced at the foot of a weir. Thus in the ogee falls originally constructed on the Ganges canal a standing wave was observed as shown in fig. 128. The water falling over the weir crest A acquired a very high velocity on the steep slope AB, and the section of the stream at B became very small. It easily happened, therefore, that at B the depth $h < \frac{u^2}{g}$. In flowing along the rough apron of the weir the velocity u diminished and the depth h increased. At a point C, where h became equal to $\frac{u^2}{g}$, the conditions for producing the standing wave occurred. Beyond C the free surface abruptly rose to the level corresponding to uniform motion with the assigned slope of the lower reach of the canal.

A standing wave is sometimes formed on the down stream side of bridges the piers of which obstruct the flow of the water. Some interesting cases of this kind are described in a paper on the "Floods in the Nerbudda Valley" in the *Proc. Inst. of Civil Engineers*, vol. xxvii. p. 222, by Mr A. C. Howden. Fig. 129 is compiled from the data given in that paper. It represents the section of the stream at pier 8 of the Towah Viaduct, during the flood of 1865. The ground level is not exactly given by Mr Howden, but has been inferred from data given on another drawing. The velocity of the stream was not observed, but the author states it was probably the same as at the Gunjal river during a similar flood, that is 16·58 feet per second. Now, taking the depth on the down stream face of the pier at 26 feet, the velocity necessary for the production of a standing wave would be $u = \sqrt{gh} = \sqrt{(32·2 \times 26)} = 29$ feet per second nearly. But the velocity at this point was probably from Mr Howden's statements $16·58 \times \frac{40}{26} = 25·5$ feet, an agreement as close as the approximate character of the data would lead us to expect.

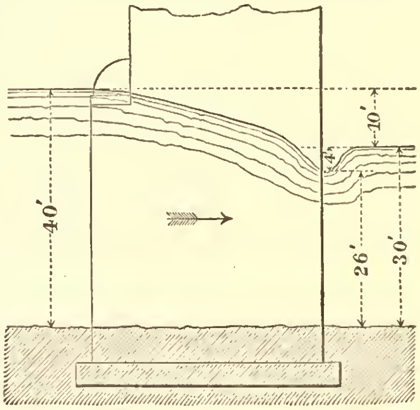


Fig. 129.

XI. ON STREAMS AND RIVERS.

112. *Catchment Basin.*—A stream or river is the channel for the discharge of the available rainfall of a district, termed its catchment basin. The catchment basin is surrounded by a ridge or watershed line, continuous except at the point where the river finds an outlet. The area of the catchment basin may be determined from a suitable contoured map on a scale of at least 1 in 100,000. Of the whole rainfall on the catchment basin, a part only finds its way to the stream. Part is directly re-evaporated, part is absorbed by vegetation, part may escape by percolation into neighbouring districts. The following table gives the relation of the average stream discharge to the average rainfall on the catchment basin (Tiefenbacher).

	Ratio of average Discharge to average Rainfall.	Loss by Evaporation, &c., in per cent. of total Rainfall.
Cultivated land and spring-forming declivities	·3 to ·33	67 to 70
Wooded hilly slopes	·35 to ·45	55 to 65
Naked unfissured mountains ...	·55 to ·60	40 to 45

113. *Flood Discharge.*—The flood discharge can generally only be determined by examining the greatest height to which floods have been known to rise. To produce a flood the rainfall must be heavy and widely distributed, and to produce a flood of exceptional height the duration of the rainfall must be so great that the flood waters of the most distant affluents reach the point considered, simultaneously with those from nearer points. The larger the catchment basin the less probable is it that all the conditions tending to produce a maximum discharge should simultaneously occur. Further, lakes and the river bed itself act as storage reservoirs during the rise of water level and diminish the rate of discharge, or serve as flood moderators. The influence of these is often important, because very heavy rain storms are in most countries of comparatively short duration. Tiefenbacher gives the following estimate of the flood discharge of streams in Europe:—

	Flood discharge of Streams per Second per Square Mile of Catchment Basin.
In flat country	8·7 to 12·5 cub. ft.
In hilly districts	17·5 to 22·5 ,,
In moderately mountainous districts	36·2 to 45·0 ,,
In very mountainous districts	50·0 to 75·0 ,,

It has been attempted to express the decrease of the rate of flood discharge with the increase of extent of the catchment basin by empirical formulae. Thus Colonel O'Connell proposes the formula $y = \mathrm{M}\sqrt{x}$, where M is a constant called the modulus of the river, the value of which depends on the amount of rainfall, the physical characters of the basin, and the extent to which the floods are moderated by storage of the water. If M is small for any given river, it shows that the rainfall is small, or that the permeability or slope of the sides of the valley is such that the water does not drain rapidly to the river, or that lakes and river bed moderate the rise of the floods. If values of M are known for a number of rivers, they may be used in inferring the probable discharge of other similar rivers. For British rivers M varies from 0·43 for a small stream draining meadow land to 37 for the Tyne. Generally it is about 15 or 20. For large European rivers M varies from 16 for the Seine to 67·5 for the Danube. For the Nile M = 11, a low value which results from the immense length of the Nile throughout which it receives no affluent, and probably also from the influence of lakes. For different tributaries of the Mississippi M varies from 13 to 56. For various Indian rivers it varies from 40 to 303, this variation being due to the great variations of rainfall, slope, and character of Indian rivers.

In some of the tank projects in India, the flood discharge has been calculated from the formula $\mathrm{D} = \mathrm{C}\sqrt[3]{n^2}$, where D is the discharge in cubic yards per hour from n square miles of basin. The constant C was taken = 61,523 in the designs for the Ekrooka tank, = 75,000 on Ganges and Godavery works, and = 10,000 on Madras works.

114. *Action of a Stream on its Bed.*—If the velocity of a stream exceeds a certain limit, depending on its size, and on the size, heaviness, form, and coherence of the material of which its bed is composed, it scours its bed and carries forward the materials. The quantity of material which a given stream can carry in suspension depends on the size and density of the particles in suspension, and is greater as the velocity of the stream is greater. If in one part of its course the velocity of a stream is great enough to scour the bed and the water becomes loaded with silt, and in a subsequent part of the river's course the velocity is diminished, then part of the transported material must be deposited. Probably deposit and scour go on simultaneously over the whole river bed, but in some parts the rate of scour is in excess of the rate of deposit, and in other parts the rate of deposit is in excess of the rate of scour. Deep streams appear to have the greatest scouring power at any given velocity. It is possible that the difference is strictly a difference of transporting, not of scouring action. Let fig. 130 represent a section of a stream. The material lifted at a will be diffused through the mass of the stream and deposited at different distances down stream. The average path of a particle lifted at a will be some such curve as abc, and the average distance of transport each time a particle is lifted will be represented by ac. In a deeper stream such as that in fig. 131, the average height to which particles are lifted, and, since the rate of vertical fall through the water may be assumed the same as before, the average distance $a'c'$ of transport, will be greater. Consequently, although the scouring action may be identical in the two streams, the velocity of transport of material down stream is greater as the depth of the stream is greater. The effect is that the deep stream excavates its bed more rapidly than the shallow stream.

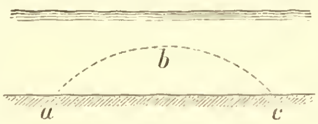


Fig. 130.

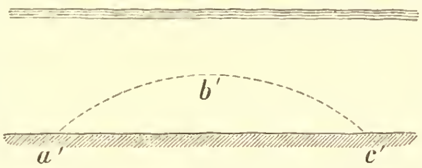


Fig. 131.

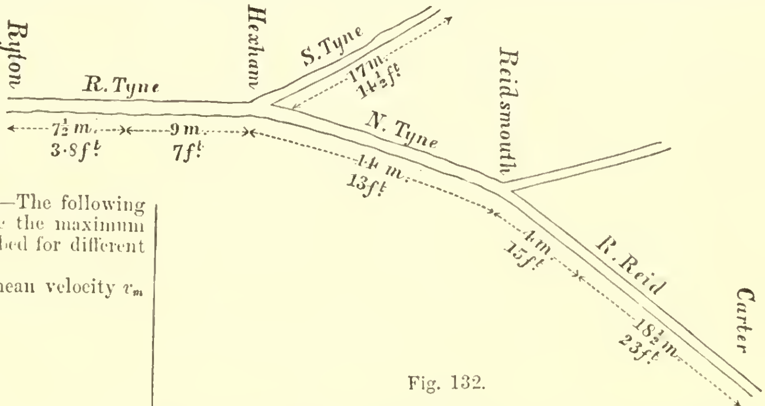


Fig. 132.

115. *Bottom Velocity at which Scour commences.*—The following bottom velocities were determined by Dubuat to be the maximum velocities consistent with stability of the stream bed for different materials.

Darcy and Bazin give, for the relation of the mean velocity v_m and bottom velocity v_b,

$$v_m = v_b + 10{\cdot}87\sqrt{mi}\,.$$

But

$$\sqrt{mi} = v_m\sqrt{\frac{\zeta}{2g}}\,;$$

$$\therefore\quad v_m = v_b \div \left(1 - 10{\cdot}87\sqrt{\frac{\zeta}{2g}}\right).$$

Taking a mean value for ζ, we get

$$v_m = 1{\cdot}312 v_b\,,$$

and from this the following values of the mean velocity are obtained :—

	Bottom Velocity $= v_b$.	Mean Velocity $= v_m$.
1. Soft earth	0·25	·33
2. Loam	0·50	·65
3. Sand	1·00	1·30
4. Gravel	2·00	2·62
5. Pebbles	3·40	4·46
6. Broken stone, flint	4·00	5·25
7. Chalk, soft shale	5·00	6·56
8. Rock in beds	6·00	7·87
9. Hard rock	10·00	13·12

The following table of velocities which should not be exceeded in channels is given in the *Ingenieurs Taschenbuch* of the Verein "Hütte":—

	Surface Velocity.	Mean Velocity.	Bottom Velocity.
Slimy earth or brown clay	·49	·36	·26
Clay	·98	·75	·52
Firm sand	1·97	1·51	1·02
Pebbly bed	4·00	3·15	2·30
Boulder bed	5·00	4·03	3·08
Conglomerate of slaty fragments	7·28	6·10	4·90
Stratified rocks	8·00	7·45	6·00
Hard rocks	14·00	12·15	10·36

116. *Regime of a River Channel.*—A river channel is said to be in a state of regime, or stability, when it changes little in draught or form in a series of years. In some rivers the deepest part of the channel changes its position perpetually, and is seldom found in the same place in two successive years. The sinuousness of the river also changes by the erosion of the banks, so that in time the position of the river is completely altered. In other rivers the change from year to year is very small, but probably the regime is never perfectly stable except where the rivers flow over a rocky bed.

If a river had a constant discharge it would gradually modify its bed till a permanent regime was established. But as the volume discharged is constantly changing, and therefore the velocity, silt is deposited when the velocity decreases, and scour goes on when the velocity increases in the same place. When the scouring and silting are considerable, a perfect balance between the two is rarely established, and hence continual variations occur in the form of the river and the direction of its currents. In other cases, where the action is less violent, a tolerable balance may be established, and the deepening of the bed by scour at one time is compensated by the silting at another. In that case the general regime is permanent, though alteration is constantly going on. This is more likely to happen if by artificial means the erosion of the banks is prevented. If a river flows in soil incapable of resisting its tendency to scour it is necessarily sinuous (§ 103), for the slightest deflexion of the current to either side begins an erosion which increases progressively till a considerable bend is formed. If such a river is straightened it becomes sinuous again unless its banks are protected from scour.

117. *Longitudinal Section of River Bed.*—The declivity of rivers decreases from source to mouth. In their higher parts rapid and torrential, flowing over beds of gravel or boulders, they enlarge in volume by receiving affluent streams, their slope diminishes, their bed consists of smaller materials, and finally they reach the sea. Fig. 132 shows the length in miles, and the surface fall in feet per mile, of the Tyne and its tributaries.

The decrease of the slope is due to two causes. (1) The action of the transporting power of the water, carrying the smallest debris the greatest distance, causes the bed to be less stable near the mouth than in the higher parts of the river; and, as the river adjusts its slope to the stability of the bed by scouring or increasing its sinousness when the slope is too great, and by silting or straightening its course if the slope is too small, the decreasing stability of the bed would coincide with a decreasing slope. (2) The increase of volume and section of the river leads to a decrease of slope; for the larger the section the less slope is necessary to ensure a given velocity.

The following investigation, though it relates to a purely arbitrary case, is not without interest. Let it be assumed, to make the conditions definite—(1) that a river flows over a bed of uniform resistance to scour, and let it be further assumed that to maintain stability the velocity of the river in these circumstances is constant from source to mouth · (2) suppose the sections of the river at all points are similar, so that, b being the breadth of the river at any point, its hydraulic mean depth is ab and its section is cb^2, where a and c are constants applicable to all parts of the river; (3) let us further assume that the discharge increases uniformly in consequence of the supply from affluents, so that, if l is the length of the river from its source to any given point, the discharge there will be kl, where k is another constant applicable to all points in the course of the river.

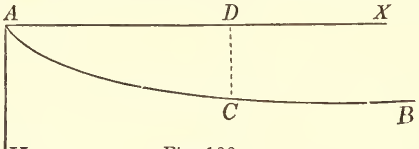


Fig. 133.

Let AB (fig. 133) be the longitudinal section of the river, whose source is at A; and take A for the origin of vertical and horizontal coordinates. Let C be a point whose ordinates are x and y, and let the river at C have the breadth b, the slope i, and the velocity v.

Since velocity × area of section = discharge, $vcb^2=kl$, or $b=\sqrt{\frac{kl}{cv}}$.

Hydraulic mean depth $=ab=a\sqrt{\frac{kl}{cv}}$.

But, by the ordinary formula for the flow of rivers, $mi=\zeta v^2$;

$$\therefore \quad i=\frac{\zeta v^2}{m}=\frac{\zeta v^{\frac{3}{2}}}{a}\sqrt{\frac{c}{kl}}\,.$$

But i is the tangent of the angle which the curve at C makes with the axis of X, and is therefore $=\frac{dy}{dx}$. Also, as the slope is small, $l=\text{AC}=\text{AD}=x$ nearly.

$$\therefore \quad \frac{dy}{dx}=\frac{\zeta v^{\frac{3}{2}}}{a}\sqrt{\frac{c}{kx}}\,;$$

and, remembering that v is constant,

$$y=\frac{2\zeta v^{\frac{3}{2}}}{a}\sqrt{\frac{cx}{k}}\,;$$

or

$$y^2=\text{constant}\times x\,;$$

so that the curve is a common parabola, of which the axis is horizontal and the vertex at the source. This may be considered an ideal longitudinal section, to which actual rivers approximate more or less, with exceptions due to the varying hardness of their beds, and the irregular manner in which their volume increases.

118. *Surface Level of River.*—The surface level of a river is a plane changing constantly in position from changes in the volume of water discharged, and more slowly from changes in the river bed, and the circumstances affecting the drainage into the river.

For the purposes of the engineer, it is important to determine (1) the extreme low water level, (2) the extreme high water or flood level, and (3) the highest navigable level.

(1) *Low Water Level* cannot be absolutely known, because a river reaches its lowest level only at rare intervals, and because alterations in the cultivation of the land, the drainage, the removal of forests, the removal or erection of obstructions in the river bed, &c., gradually alter the conditions of discharge. The lowest level of which records can be found is taken as the conventional or approximate low water level, and allowance is made for possible changes.

(2) *High Water or Flood Level.*—The engineer assumes as the highest flood level the highest level of which records can be obtained. In forming a judgment of the data available, it must be remembered that the highest level at one point of a river is not always simultaneous with the attainment of the highest level at other points, and that the rise of a river in flood is very different in different parts of its course. In temperate regions, the floods of rivers seldom rise more than 20 feet above low water level, but in the tropics the rise of floods is greater.

(3) *Highest Navigable Level.*—When the river rises above a certain level, navigation becomes difficult from the increase of the velocity of the current, or from submersion of the tow paths, or from the headway under bridges becoming insufficient. Ordinarily the highest navigable level may be taken to be that at which the river begins to overflow its banks.

119. *Relative Value of Different Materials for Submerged Works.*—That the power of water to remove and transport different materials depends on their density has an important bearing on the selection of materials for submerged works. In many cases, as in the aprons or floorings beneath bridges, or in front of locks or falls, and in the formation of training walls and breakwaters by *pierres perdus*, which have to resist a violent current, the materials of which the structures are composed should be of such a size and weight as to be able individually to resist the scouring action of the water. The heaviest materials will therefore be the best; and the different value of materials in this respect will appear much more striking, if it is remembered that all materials lose part of their weight in water. A block whose volume is V cubic feet, and whose density in air is w lb per cubic foot, weighs in air wV lb, but in water only $(w-62{\cdot}4)$ V lb.

	Weight of a Cubic Foot in lb.	
	In Air.	In Water.
Basalt	187·3	124·9
Brick	130·0	67·6
Brickwork	112·0	49·6
Granite and limestone	170·0	107·6
Sandstone	144·0	81·6
Masonry	116–144	53·6–81·6

120. *Inundation Deposits from a River.*—When a river carrying silt periodically overflows its banks, it deposits silt over the area flooded, and gradually raises the surface of the country. The silt is deposited in greatest abundance where the water first leaves the river. It hence results that the section of the country assumes a peculiar form, the river flowing in a trough along the crest of a ridge, from which the land slopes downwards on both sides. The silt deposited from the water forms two wedges, having their thick ends towards the river (fig. 134).

Fig. 134.

This is strikingly the case with the Mississippi, and that river is now kept from flooding immense areas by artificial embankments or levees. In India, the term *deltaic segment* is sometimes applied to that portion of a river running through deposits formed by inundation, and having this characteristic section. The irrigation of the country in this case is very easy, a comparatively slight raising of the river surface by a weir or annicut gives a command of level which permits the water to be conveyed to any part of the district.

121. *Deltas.*—The name delta was originally given to the Δ-shaped portion of Lower Egypt, included between seven branches of the Nile. It is now given to the whole of the alluvial tracts round river mouths formed by deposition of sediment from the river, where its velocity is checked on its entrance to the sea. The characteristic feature of these alluvial deltas is that the river traverses them, not in a single channel, but in two or many bifurcating branches. Each branch

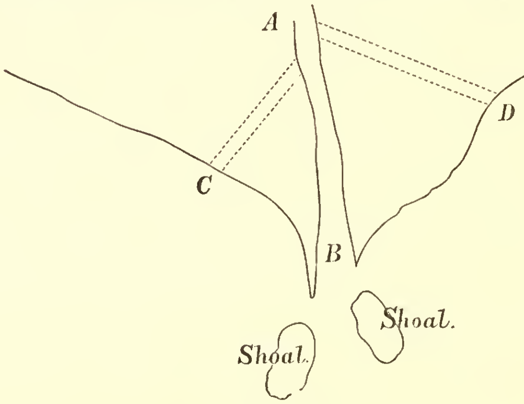


Fig. 135.

has a tract of the delta under its influence, and gradually raises the surface of that tract, and extends it seaward. As the delta extends itself seaward, the conditions of discharge through the different branches change. The water finds the passage through one of the branches less obstructed than through the others; the velocity and scouring action in that branch are increased; in the others they diminish. The one channel gradually absorbs the whole of the water supply, while the other branches silt up. But as the mouth of the new main channel extends seaward the resistance increases both from the greater length of the channel and the formation of shoals at its mouth, and the river tends to form new bifurcations AC or AD (fig. 135), and one of these may in time become the main channel of the river.

122. *Field Operations preliminary to a Study of River Improvement.*—There are required (1) a plan of the river, on which the positions of lines of levelling and cross sections are marked ; (2) a longitudinal section and numerous cross sections of the river ; (3) a series of gaugings of the discharge at different points and in different conditions of the river.

Longitudinal Section.—This requires to be carried out with great accuracy. A line of stakes is planted, following the sinuosities of the river and chained and levelled. The cross sections are referred to the line of stakes, both as to position and direction. To determine the slope of the water surface great care is necessary.

123. *Cross Sections.*—A stake is planted flush with the water, and its level relatively to some point on the line of levels is determined. Then the depth of the water is determined at a series of points (if possible at uniform distances) in a line starting from the stake and perpendicular to the thread of the stream. To obtain these, a wire may be stretched across with equal distances marked on it by hanging tags. The depth at each of these tags may be obtained by a light woollen staff, with a disk-shaped shoe 4 to 6 inches in diameter. If the depth is great, soundings may be taken by a chain and weight. To ensure the wire being perpendicular to the thread of the stream, it is desirable to stretch two other wires similarly graduated, one above and the other below, at a distance of 20 to 40 yards. A number of floats being then thrown in, it is observed whether they pass the same graduation on each wire.

For large and rapid rivers the cross section is obtained by sounding in the following way. Let AC (fig. 136) be the line on which soundings are required. A base line AB is measured out at right angles to AC, and ranging staves are set up at AB and at D in line with AC. A boat is allowed to drop down stream, and, at the moment it comes in line with AD, the lead is dropped and an observer in the boat takes, with a box sextant, the angle AEB subtended by AB. The sounding line may have a weight of 14 lb of lead, and, if the boat drops down stream slowly, it may hang near the bottom, so that the observation is made instantly. In extensive surveys of the Mississippi observers with theodolites were stationed at A and B. The theodolite at A was directed towards C, that at B was kept on the boat. When the boat came on the line AC, the observer at A signalled, the sounding line was dropped, and the observer at B read off the angle ABE. By repeating observations a number of soundings are obtained, which can be plotted in their proper position, and the form of the river bed drawn by connecting the extremities of the lines. From the section can be measured the sectional area of the stream Ω and its wetted perimeter χ ; and from these the hydraulic mean depth m can be calculated.

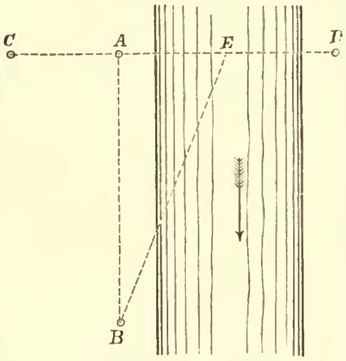


Fig. 136.

124. *Measurement of the Discharge of Rivers.*—The area of cross section multiplied by the mean velocity gives the discharge of the stream. The height of the river with reference to some fixed mark should be noted whenever the velocity is observed, as the velocity and area of cross section are different in different states of the river. To determine the mean velocity various methods may be adopted ; and, since no method is free from liability to error, either from the difficulty of the observations or from uncertainty as to the ratio of the mean velocity to the velocity observed, it is desirable that more than one method should be used.

Instruments for Measuring the Velocity of Water.

125. *Surface Floats* are convenient for determining the surface velocities of a stream, though their use is difficult near the banks. The floats may be small balls of wood, of wax, or of hollow metal, so loaded as to float nearly flush with the water surface. To render them visible they may have a vertical painted stem. In experiments on the Seine, cork balls $1\frac{3}{4}$ inches diameter were used, loaded to float flush with the water, and provided with a stem. In Captain Cunningham's observations at Roorkee, the floats were thin circular disks of English deal, 3 inches diameter and $\frac{1}{4}$ inch thick. For observations near the banks, floats 1 inch diameter and $\frac{1}{8}$ inch thick were used. To render them visible a tuft of cotton wool was used loosely fixed in a hole at the centre.

The velocity is obtained by allowing the float to be carried down, and noting the time of passage over a measured length of the stream. If v is the velocity of any float, t the time of passing over a length l, then $v=\frac{l}{t}$. To mark out distinctly the length of stream over which the floats pass, two ropes may be stretched across the stream at a distance apart, which varies usually from 50 to 250 feet, according to the size and rapidity of the river. In the Roorkee experiments a length of run of 50 feet was found best for the central two-fifths of the width, and 25 feet for the remainder, except very close to the banks, where the run was made $12\frac{1}{2}$ feet only. The longer the run the less is the proportionate error of the time observations, but on the other hand the greater the deviation of the floats from a straight course parallel to the axis of the stream. To mark the precise position at which the floats cross the ropes, Captain Cunningham used short white rope pendants, hanging so as nearly to touch the surface of the water. In this case the streams were 80 to 180 feet in width. In wider streams the use of ropes to mark the length of run is impossible, and recourse must be had to box sextants or theodolites to mark the path of the floats.

Let AB (fig. 137) be a measured base line strictly parallel to the thread of the stream, and AA_1, BB_1 lines at right angles to AB marked out by ranging rods at A_1 and B_1. Suppose observers stationed at A and B with sextants or theodolites, and let CD be the path of any float down stream. As the float approaches AA_1, the observer at B keeps it on the cross wire of his instrument. The observer at A observes the instant of the float reaching the line AA_1, and signals to B who then reads off the angle ABC. Similarly, as the float approaches BB_1, the observer at A keeps it in sight, and when signalled to by B reads the angle BAD. The data so obtained are sufficient for plotting the path of the float and determining the distances AC, BD.

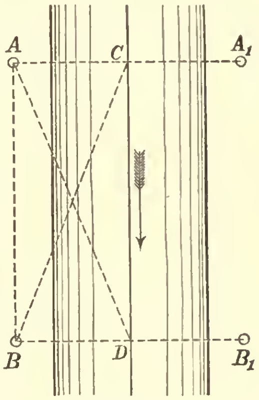


Fig. 137.

The time taken by the float in passing over the measured distance may be observed by a chronograph. started as the float passes the upper rope or line, and stopped when it passes the lower. In Captain Cunningham's observations two chronometers were sometimes used, the time of passing one end of the run being noted on one, and that of passing the other end of the run being noted on the other. The chronometers were compared immediately before the observations. In other cases a single chronometer was used placed midway of the run. The moment of the floats passing the ends of the run was signalled to a timekeeper at the chronometer by shouting. It was found quite possible to count the chronometer beats to the nearest half second, and in some cases to the nearest quarter second.

126. *Sub-surface Floats.*—The velocity at different depths below the surface of a stream may be obtained by sub-surface floats, used precisely in the same way as surface floats. The most usual arrangement is to have a large float, of slightly greater density than water, connected with a small and very light surface float. The motion of the combined arrangement is not sensibly different from that of the large float, and the small surface float enables an observer to note the path and velocity of the sub-surface float. The instrument is, however, not free from objection. If the large submerged float is made of very nearly the same density as water, then it is liable to be thrown upwards by very slight eddies in the water, and it does not maintain its position at the depth at which it is intended to float. On the other hand, if the large float is made sensibly heavier than water, the indicating or surface float must be made rather large, and then it to some extent influences the motion of the submerged float. Fig. 138 shows one form of sub-surface float. It consists of a couple of tin plates bent at a right angle and soldered together at the angle. This is connected with a wooden ball at the surface by a very thin wire or cord. As the tin alone makes a heavy submerged float, it is better to attach to the tin float some pieces of wood to diminish its weight in water. Fig. 139 shows the form of submerged float used by Captain Cunningham. It consists of a hollow metal ball connected to a slice of cork, which serves as the surface float.

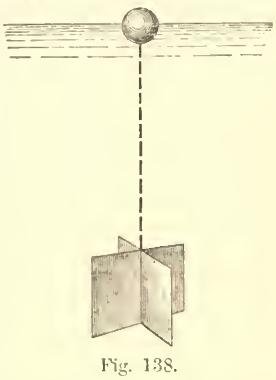


Fig. 138.

127. *Twin Floats.*—Suppose two equal and similar floats (fig. 140) connected by a wire. Let one float be a little lighter and the other a little heavier than water. Then the velocity of the combined floats will be the mean of the surface velocity and the velocity at the

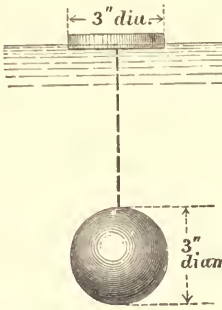


Fig. 139.

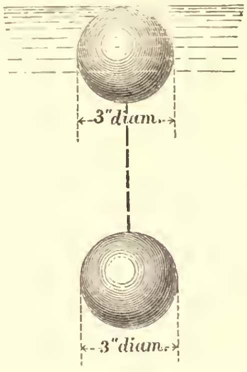


Fig. 140.

depth at which the heavier float swims, which is determined by the length of the connecting wire. Thus if v_s is the surface velocity and v_d the velocity at the depth to which the lower float is sunk, the velocity of the combined floats will be

$$v = \frac{v_s + v_d}{2} .$$

Consequently, if v is observed, and v_s determined by an experiment with a single float,

$$v_d = 2v - v_s .$$

According to Captain Cunningham, the twin float gives better results than the sub-surface float.

128. *Velocity Rods.*—Another form of float is shown in fig. 141. This consists of a cylindrical rod loaded at the lower end so as to float nearly vertical in water. A wooden rod, with a metal cap at the bottom in which shot can be placed, answers better than anything else, and sometimes the wooden rod is made in lengths which can be screwed together so as to suit streams of different depths. A tuft of cotton wool at the top serves to make the float more easily visible. Such a rod, so adjusted in length that it sinks nearly to the bed of the stream, gives directly the mean velocity of the whole vertical section in which it floats.

Fig. 141.

129. *Revy's Current Meter.*—No instrument has been so much used in directly determining the velocity of a stream at a given point as the screw current meter. Of this there are a dozen varieties at least. As an example of the instrument in its simplest form, Mr Revy's meter may be selected. This is an ordinary screw meter of a larger size than usual, more carefully made, and with its details carefully studied (figs. 142, 143). It was designed after experience in gauging the great South American rivers. The screw, which is actuated by the water, is 6 inches in diameter, and is of the type of the Griffiths screw used in ships. The hollow spherical boss serves to make the weight of the screw sensibly equal to its displacement, so that friction is much reduced. On the axis *aa* of the screw is a worm which drives the counter. This consists of two worm wheels *g* and *h* fixed on a common axis. The worm wheels are carried on a frame attached to the pin *l*. By means of a string attached to *l* they can be pulled into gear with the worm, or dropped out of gear and stopped at any instant. A nut *m* can be screwed up, if necessary, to keep the counter permanently in gear. The worm is two-threaded, and the worm wheel *g* has 200 teeth. Consequently it makes one rotation for 100 rotations of the screw, and the number of rotations up to 100 is marked by the passage of the graduations on its edge in front of a fixed index. The second worm wheel has 196 teeth, and its edge is divided into 49 divisions. Hence it falls behind the first wheel one division for a complete rotation of the latter. The number of hundreds of rotations of the screw are therefore shown by the number of divisions on *h* passed over by an index fixed to *g*. One difficulty in the use of the ordinary screw meter is that particles of grit, getting into the working parts, very sensibly alter the friction, and therefore the speed of the meter. Mr Revy obviates this by enclosing the counter in a brass box with a glass face. This box is filled with pure water, which ensures a constant coefficient of friction for the rubbing parts, and prevents any mud or grit finding its way in. In order

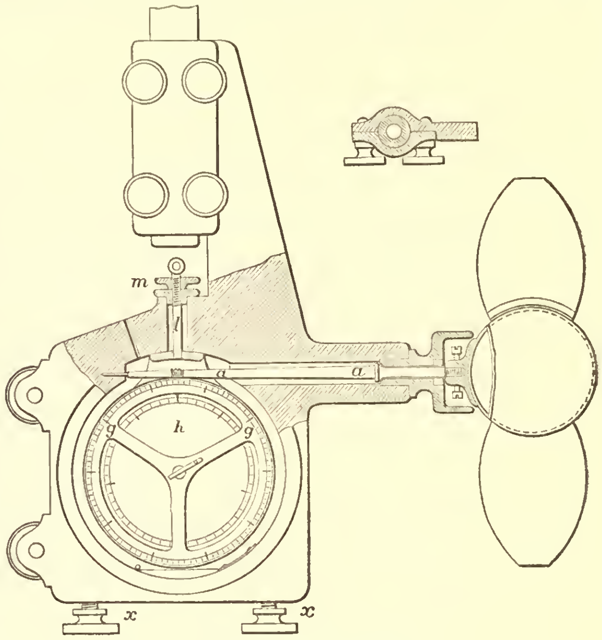


Fig. 142.—Scale ½ full size.

that the meter may place itself with the axis parallel to the current, it is pivoted on a vertical axis and directed by a large vane shown in fig. 143. To give the vane more directing power the vertical axis is nearer the screw than in ordinary meters, and the vane is larger. A second horizontal vane is attached by the screws *x*,*x*, the object of which is to allow the meter to rest on the ground without the motion of the screw being interfered with. The string or wire for starting and stopping the meter is carried through the centre of the vertical axis, so that the strain on it may not tend to pull the meter oblique to the current. The pitch of the screw is about 9 inches. The screws at *x* serve for filling the meter with water. The whole apparatus is fixed to a rod (fig. 143), of a length proportionate to the depth, or for very great depths it is fixed to a weighted bar lowered by ropes, a plan invented by Mr Revy. The instrument is generally used thus. The reading of the counter is noted, and it is put out of gear. The meter is then lowered into the water to the required position from a platform between two boats, or better from a temporary bridge. Then the counter is put into gear for one, two, or five minutes. Lastly, the instrument is raised and the counter again read. The velocity is deduced from the number of rotations in unit time by the formulæ given below. For surface velocities the counter may be kept permanently in gear, the screw being started and stopped by hand.

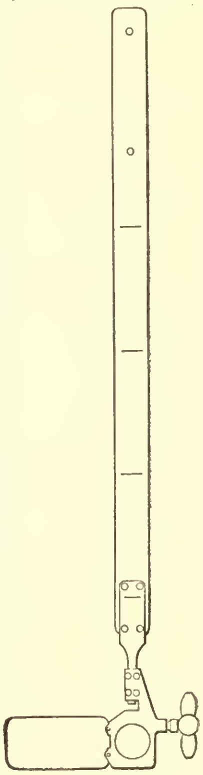


Fig. 143.

130. *The Harlacher Current Meter.*—A very interesting modification of the current meter is that made by Amsler Laffon of Schaffhausen, which is described in Heusinger von Waldegg (*Handb. der Ingenieurwissenschaften*, iii. p. 284). In this the ordinary counting apparatus is abandoned. A worm drives a worm wheel, which makes an electrical contact once for each 100 rotations of the worm. This contact gives a signal above water. With this arrangement, a series of velocity observations can be made, without removing the instrument from the water, and a number of practical difficulties attending the accurate starting and stopping of the ordinary counter are entirely got rid of. Fig 144 shows the meter. The worm wheel *z* makes one rotation for 100 of the screw. A pin moving the lever *x* makes the electrical contact. The wires *b*, *c* are led through a gas pipe B; this also serves to adjust the meter to any required position on the wooden rod *dd*. The rudder or

vane is shown at WH. The galvanic current acts on the electro-magnet m, which is fixed in a small metal box containing also the battery. The magnet exposes and withdraws a coloured disk at an opening in the cover of the box.

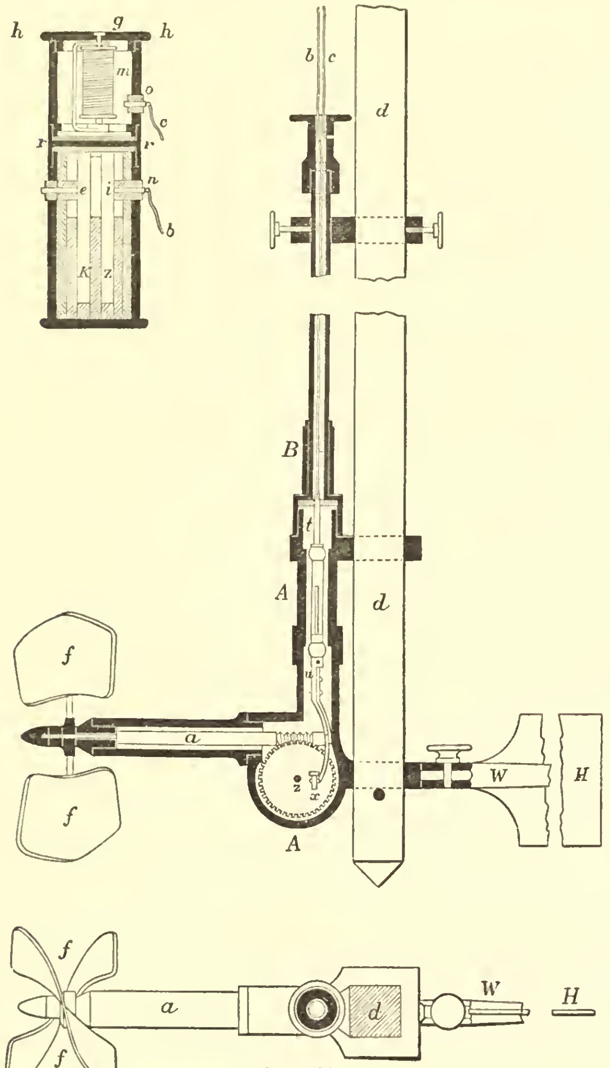
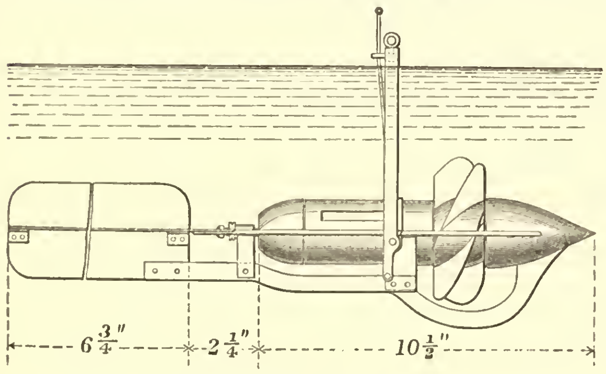


Fig. 144.

Moore's Current Meter.—The difficulties in using the ordinary current meter have been overcome to a great extent by an arrangement of another kind, invented by Mr B. T. Moore (*Proc. Inst.*



Scale $\frac{1}{6}$ *Full Size.*

Fig. 145.

Civil Eng., xlv. 220). This instrument (fig. 145) can be lowered into the water to any required depth by a light cord or chain. The counting arrangement inside the meter can be started or stopped at any instant. The instrument consists of a light brass frame carrying an ogival head, and long rudder, cross-shaped in section. The frame is suspended in a stirrup, and if necessary a lead weight can be suspended below the meter. A rotating cylinder with screw blades is placed behind the ogival head. The centre of gravity of the instrument is accurately in the intersection of the axis of the stirrup-bearings and the longitudinal axis of the instrument. The rotating cylinder is started by releasing a spring by a cord. The recording mechanism is inside the rotating cylinder. The instrument is put in motion by a very small force. Some experiments made by towing it in still water gave the following equations:—

For speeds giving more than sixty rotations per minute,

$$v = 1{\cdot}2\mathrm{R},$$

where v is the velocity of the water relatively to the instrument in feet per minute, and R the number of rotations per minute. For lower speeds,

$$v = \mathrm{R} + 12.$$

It would appear therefore that the instrument will record velocities down to 12 feet per minute. Mr Moore states that a velocity at any depth down to 20 feet can be taken in five minutes, the meter being raised and lowered much more easily than when it is attached to a rod.

Determination of the Coefficients of the Current Meter.—Suppose a series of observations have been made, by towing the meter in still water, at different speeds, and it is required from these to ascertain the coefficients of the meter. A formula must be assumed to connect the observed velocities v with the number of rotations per second n. Then, in determining the coefficients of the formula from the given observations, the condition to be fulfilled is that the sum of the squares of the differences between the observed results and those given by the formula should be a minimum.

Let the formula assumed be of the form

$$v = \alpha n + \beta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Then the difference in any case between the observed and calculated quantity is $v - \alpha n - \beta$; and therefore $\Sigma(v - \alpha n - \beta)^2$ is to be a minimum.

The coefficients being independent, we must equate separately to zero the differential coefficients of the expression with respect to the two coefficients.

$$\Sigma\Big[\,(v - \alpha n - \beta)n\,\Big] = 0\,;$$

$$\Sigma\Big[\,(v - \alpha n - \beta)\,\Big] = 0\,;$$

whence

$$\Sigma\,(n^2)\,\alpha + \Sigma(n)\beta = \Sigma(vn)\,;$$
$$\Sigma(n)\alpha + \Sigma(n)\beta = \Sigma(v)\,;$$

from which α and β are easily determined.

Exner has shown (*Zeitschrift für Bauwesen*, 1875) that the relation between the velocity of the water and the number of rotations of the meter is better expressed by the formula

$$v = \sqrt{(a^2 r^2 + v_0{}^2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

than by that generally used. v_0 is sensibly equal to the velocity at which the meter just ceases to revolve; and a is a constant determined by experiments at different speeds. Other expressions have been given, but they are more complicated and not more accurate than (1) and (2).

131. *Darcy Gauge or Modified Pitot Tube.*—A very old instrument for measuring velocities, invented or used by Pitot, consisted simply of a vertical glass tube with a right-angled bend, placed so that its mouth was normal to the direction of flow (fig. 146).

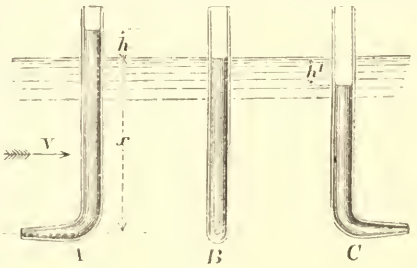


Fig. 146.

The impact of the stream on the mouth of the tube balances a column in the tube, the height of which is approximately $h = \frac{v^2}{2g}$, where v is the velocity at the depth x. Placed with its mouth parallel to the stream the water inside the tube is nearly at the same level as the surface of the stream, and turned with the mouth down stream, the fluid sinks a depth $h' = \frac{v^2}{2g}$ nearly, though the tube in that case interferes with the free flow of the liquid and somewhat modifies the result. Pitot expanded the mouth of the tube so as to form a funnel or bell mouth. In that case he found by experiment

$$h = 1{\cdot}5\,\frac{v^2}{2g}\,.$$

The objection to this is that the motion of the stream is interfered with, and it is no longer certain that the velocity in front of the orifice is exactly the velocity of the unobstructed stream. Darcy preferred to make the mouth of the tube very small, partly to avoid interference with the stream, partly to check oscillations of the column. In that case he found the difference of level of two tubes, such as A and B, to be almost exactly

$$h=\frac{v^2}{2g}.$$

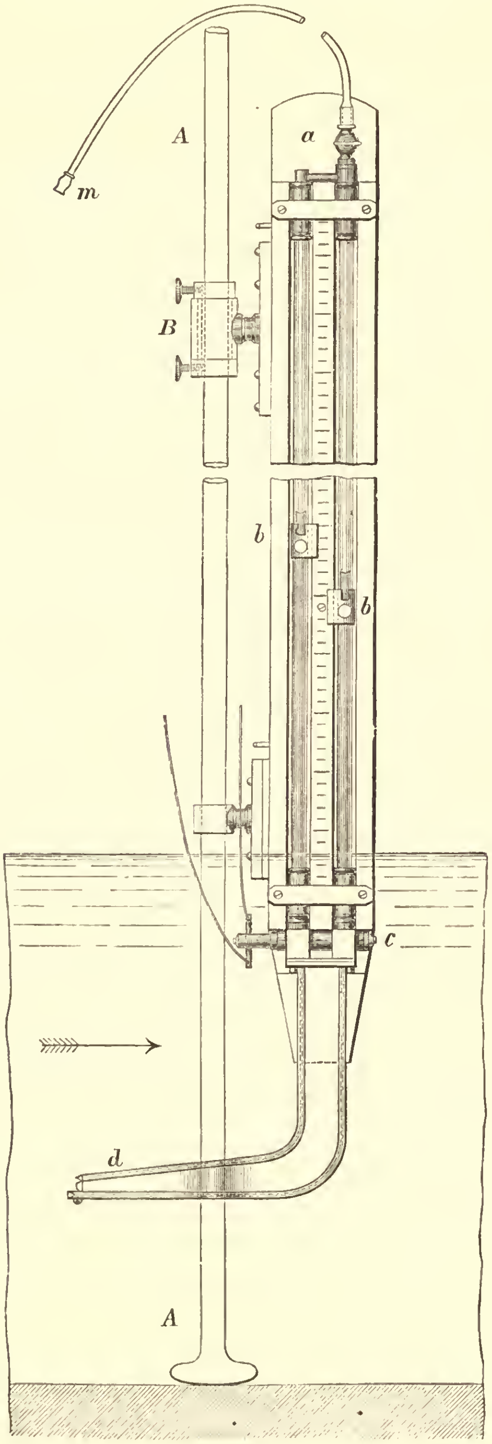


Fig. 147.

One objection to the Pitot tube in its original form was the great difficulty and inconvenience of reading the height h in the immediate neighbourhood of the stream surface. This is obviated in the Darcy gauge, which can be removed from the stream to be read.

Fig. 147 shows a Darcy gauge. It consists of two Pitot tubes having their mouths at right angles. In the instrument shown, the two tubes, formed of copper in the lower part, are united into one for strength, and the mouths of the tubes open vertically and horizontally. The upper part of the tubes is of glass, and they are provided with a brass scale and two verniers b, b. The whole instrument is supported on a vertical rod or small pile AA, the fixing at B permitting the instrument to be adjusted to any height on the rod, and at the same time allowing free rotation, so that it can be held parallel to the current. At c is a two-way cock, which can be opened or closed by cords. If this is shut, the instrument can be lifted out of the stream for reading. The glass tubes are connected at top by a brass fixing, with a stop cock a, and a flexible tube and mouthpiece m. The use of this is as follows. If the velocity is required at a point near the surface of the stream, one at least of the water columns would be below the level at which it could be read. It would be in the copper part of the instrument. Suppose then a little air is sucked out by the tube m, and the cock a closed, the two columns will be forced up an amount corresponding to the difference between atmospheric pressure and that in the tubes. But the difference of level will remain unaltered.

When the velocities to be measured are not very small, this instrument is an admirable one. It requires observation only of a single linear quantity, and does not require any time observation. The law connecting the velocity and the observed height is a rational one, and it is not absolutely necessary to make any experiments on the coefficient of the instrument. If we take

$$v=k\sqrt{2gh},$$

then it appears from Darcy's experiments that for a well-formed instrument k does not sensibly differ from unity. It gives the velocity at a definite point in the stream. The chief difficulty arises from the fact that at any given point in a stream the velocity is not absolutely constant, but varies a little from moment to moment. Darcy in some of his experiments took several readings, and deduced the velocity from the mean of the highest and lowest.

132. *Hydrodynamometer of M. Perrodil.*—This consists of a frame *abcd* (fig. 148) placed vertically in the stream, and of a height not less than the stream's depth. The two vertical members of this frame are connected by cross bars, and united above water by a circular bar, situated in the vertical plane and carrying a horizontal graduated circle *ef*. This whole system is movable round its axis, being suspended on a pivot at g connected with the fixed support *mn*. Other horizontal arms serve as guides. The central vertical rod *gr* forms a torsion rod, being fixed at r to the frame *abcd*, and, passing freely upwards through the guides, it carries a horizontal needle moving over the graduated circle *ef*. The support g, which carries the apparatus, also receives in a tubular guide the end of the torsion rod *gr* and a set screw for fixing the upper end of the torsion rod when necessary. The impulse of the stream of water is received on a circular disk x, in the plane of the torsion rod and the frame *abcd*. To raise and lower the apparatus easily, it is not fixed directly to the rod *mn*, but to a tube *kl* sliding on *mn*.

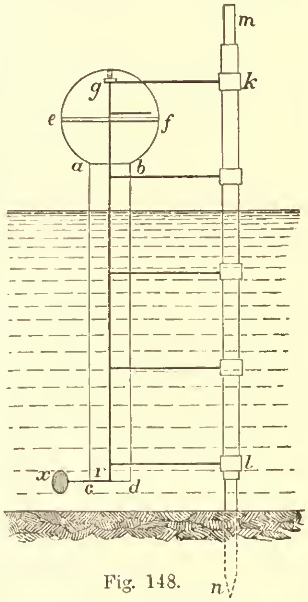


Fig. 148.

Suppose the apparatus arranged so that the disk x is at that level in the stream where the velocity is to be determined. The plane *abcd* is placed parallel to the direction of motion of the water. Then the disk x (acting as a rudder) will place itself parallel to the stream on the down stream side of the frame. The torsion rod will be unstrained, and the needle will be at zero on the graduated circle. If then the instrument is turned by pressing the needle, till the plane *abcd* of the disk and the zero of the graduated circle is at right angles to the stream, the torsion rod will be twisted through an angle which measures the normal impulse of the stream on the disk x. That angle will be given by the distance of the needle from zero. Observation shows that the velocity of the water at a given point is not constant. It varies between limits more or less wide. When the apparatus is nearly in its right position, the set screw at g is made to clamp the torsion spring. Then the needle is fixed, and the apparatus carrying the graduated circle oscillates. It is not then difficult to note the mean angle marked by the needle.

Let r be the radius of the torsion rod, l its length from the needle over *ef* to r, and α the observed torsion angle. Then the moment of the couple due to the molecular forces in the torsion rod is

$$M = E_t I \frac{a}{l};$$

where E_t is the modulus of elasticity for torsion, and I the polar moment of inertia of the section of the rod. If the rod is of circular section, $I = \frac{1}{2}\pi r^4$. Let R be the radius of the disk, and b its leverage, or the distance of its centre from the axis of the torsion rod. The moment of the pressure of the water on the disk is

$$Fb = kb\frac{G}{2g}\pi R^2 v^2,$$

where G is the heaviness of water and k an experimental coefficient. Then

$$E_t I \frac{a}{l} = kb\frac{G}{2g}\pi R^2 v^2.$$

For any given instrument,

$$v = c\sqrt{a};$$

where c is a constant coefficient for the instrument.

The instrument as constructed had three disks which could be used at will. Their radii and leverages were in feet

	R=	b=
1st disk	0·052	0·16
2d ,,	0·105	0·32
3d ,,	0·210	0·66

For a thin circular plate, the coefficient $k = 1·12$. In the actual instrument the torsion rod was a brass wire 0·06 inch diameter and $6\frac{1}{2}$ feet long. Supposing a measured in degrees, we get by calculation

$$v = 0·335\sqrt{a}\ ;\ 0·115\sqrt{a}\ ;\ 0·042\sqrt{a}$$

for the three disks.

Very careful experiments were made with the instrument. It was fixed to a wooden turning bridge, revolving over a circular channel of 2 feet width, and about 76 feet circumferential length. An allowance was made for the slight current produced in the channel. These experiments gave for the coefficient c, in the formula $v = c\sqrt{a}$,

1st disk,	$c = 0·3126$	for velocities of	3 to 16 feet
2d ,,	0·1177	,, ,,	$1\frac{1}{4}$ to $3\frac{1}{4}$,,
3d ,,	0·0349	,, ,,	less than $1\frac{1}{4}$,,

or values little different from the values calculated from the torsion.

The instrument is preferable to the current meter in giving the velocity in terms of a single observed quantity, the angle of torsion, while the current meter involves the observation of two quantities, the number of rotations and the time. The current meter, except in some improved forms, must be withdrawn from the water to read the result of each experiment, and the law connecting the velocity and number of rotations of a current meter is less well-determined than that connecting the pressure on a disk and the torsion of the wire of a hydrodynamometer. At very low velocities the current meter fails altogether.

The Pitot tube, like the hydrodynamometer, does not require a time observation. But, where the velocity is a varying one, and consequently the columns of water in the Pitot tube are oscillating, there is room for doubt as to whether, at any given moment of closing the cock, the difference of level exactly measures the impulse of the stream at the moment. The Pitot tube also fails to give measurable indications of very low velocities.

Processes for Gauging Streams.

133. *Gauging by Observation of the Maximum Surface Velocity.*—The method of gauging which involves the least trouble is to determine the surface velocity at the thread of the stream, and to deduce from it the mean velocity of the whole cross section. The maximum surface velocity may be determined by floats or by a current meter. Unfortunately, however, the ratio of the maximum surface to the mean velocity is extremely variable. Thus putting v_0 for the surface velocity at the thread of the stream, and v_m for the mean velocity of the whole cross section, $\frac{v_m}{v_0}$ has been found to have the following values:—

	$\frac{v_m}{v_0}$
De Prony, experiments on small wooden channels,	0·8164
Experiments on the Seine, ...	0·62
Destrem and De Prony, experiments on the Neva,	0·78
Boileau, experiments on canals, ...	0·82
Baumgartner, experiments on the Garonne, ...	0·80
Brünings (mean), ...	0·85
Cunningham, Solani aqueduct, ...	0·823

Various formulæ, either empirical or based on some theory of the vertical and horizontal velocity curves, have been proposed for determining the ratio $\frac{v_m}{v_0}$. Bazin found from his experiments the empirical expression

$$v_m = v_0 - 25·4\sqrt{mi};$$

where m is the hydraulic mean depth and i the slope of the stream. In article 101, it has already been shown how from this formula the ratio $\frac{v_m}{v_0}$ can be obtained for different kinds of channels.

In the case of irrigation canals and rivers, it is often important to determine the discharge either daily or at other intervals of time, while the depth and consequently the mean velocity is varying. Captain Cunningham, R.E. (*Roorkee Prof. Papers*, vol. iv. p. 47), has shown that, for a given part of such a stream, where the bed is regular and of permanent section, a simple formula may be found for the variation of the central surface velocity with the depth. When once the constants of this formula have been determined by measuring the central surface velocity and depth, in different conditions of the stream, the surface velocity can be obtained by simply observing the depth of the stream, and from this the mean velocity and discharge can be calculated. Let z be the depth of the stream, and v_0 the surface velocity, both measured at the thread of the stream. Then

$$v_0^2 = cz;$$

where c is a constant which for the Solani aqueduct had the values 1·9 to 2, the depths being 6 to 10 feet, and the velocities $3\frac{1}{2}$ to $4\frac{1}{2}$ feet. Without any assumption of a formula, however, the surface velocities, or still better the mean velocities, for different conditions of the stream may be plotted on a diagram in which the abscissæ are depths and the ordinates velocities. The continuous curve through points so found would then always give the velocity for any observed depth of the stream, without the need of making any new float or current meter observations.

134. *Mean Velocity determined by observing a Series of Surface Velocities.*—The ratio of the mean velocity to the surface velocity in one longitudinal section is better ascertained than the ratio of the central surface velocity to the mean velocity of the whole cross section. Suppose the river divided into a number of compartments by equidistant longitudinal planes, and the surface velocity observed in each compartment. From this the mean velocity in each compartment and the discharge can be calculated. The sum of the partial discharges will be the total discharge of the stream. When wires or ropes can be stretched across the stream, the compartments can be marked out by tags attached to them. Suppose two such ropes stretched across the stream, and floats dropped in above the upper rope. By observing within which compartment the path of the float lies, and noting the time of transit between the ropes, the surface velocity in each compartment can be ascertained. The mean velocity in each compartment is 0·85 to 0·91 of the surface velocity in that compartment. Putting k for this ratio, and $v_1, v_2 \ldots$ for the observed velocities, in compartments of area $\Omega_1, \Omega_2 \ldots$ then the total discharge is

$$Q = k(\Omega_1 v_1 + \Omega_2 v_2 + \ldots).$$

If several floats are allowed to pass over each compartment, the mean of all those corresponding to one compartment is to be taken as the surface velocity of that compartment.

This method is very applicable in the case of large streams or rivers too wide to stretch a rope across. The paths of the floats are then ascertained in this way. Let fig. 149 represent a portion of the river, which should be straight and free from obstructions. Suppose a base line AB measured parallel to the thread of the stream, and let the mean cross section of the stream be ascertained either by sounding the terminal cross sections AE, BF, or by sounding a series of equidistant cross sections. The cross sections are taken at right angles to the base line. Observers are placed at A and B with theodolites or box sextants. The floats are dropped in from a boat above AE, and picked up by another boat below BF. An observer with a chronograph or watch notes the time in which each float passes from AE to BF. The method of proceeding is this. The observer A sets his theodolite in the direction AE, and gives a signal to drop a float. B keeps his instrument on the float as it comes down. At the moment the float arrives at C in the line AE, the observer at A calls out. B clamps his instrument and reads off the angle ABC, and the time observer begins to note the time of transit. B now points his instrument in the direction BF, and A keeps the float on the cross wire of his instrument. At the moment the float arrives at D in the line BF, the observer B calls out, A clamps his instrument and reads off the angle BAD, and the time observer notes the time of transit from C to D. Thus all

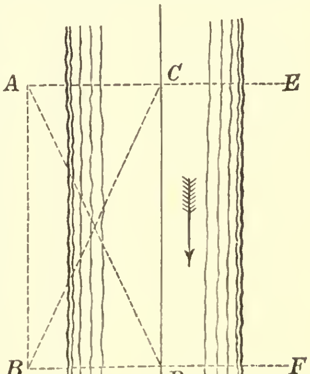


Fig. 149.

the data are determined for plotting the path CΓ of the float and determining its velocity. By dropping in a series of floats, a number of surface velocities can be determined. When all these have been plotted, the river can be divided into convenient compartments. The observations belonging to each compartment are then averaged, and the mean velocity and discharge calculated. It is obvious that, as the surface velocity is greatly altered by wind, experiments of this kind should be made in very calm weather.

The ratio of the surface velocity to the mean velocity in the same vertical can be ascertained from the formulæ for the vertical velocity curve already given (§ 101). Exner, in *Erbkam's Zeitschrift* for 1875, has given the following convenient formula. Let v be the mean and V the surface velocity in any given vertical longitudinal section, the depth of which is h

$$\frac{v}{V}=\frac{1+0{\cdot}1478\sqrt{h}}{1+0{\cdot}2216\sqrt{h}}$$

If vertical velocity rods are used instead of common floats, the mean velocity is directly determined for the vertical section in which the rod floats. No formula of reduction is then necessary. The observed velocity has simply to be multiplied by the area of the compartment to which it belongs.

135. *Mean Velocity of the Stream from a Series of Mid Depth Velocities.*—In the gaugings of the Mississippi it was found that the mid depth velocity differed by only a very small quantity from the mean velocity in the vertical section, and it was uninfluenced by wind. If therefore a series of mid depth velocities are determined by double floats or by a current meter, they may be taken to be the mean velocities of the compartments in which they occur, and no formula of reduction is necessary. If floats are used, the method is precisely the same as that described in the last paragraph for surface floats. The paths of the double floats are observed and plotted, and the mean taken of those corresponding to each of the compartments into which the river is divided. The discharge is the sum of the products of the observed mean mid depth velocities and the areas of the compartments.

136. *Boileau's Process for Gauging Streams.*—Let U be the mean velocity at a given section of a stream, V the maximum velocity, or that of the principal filament, which is generally a little below the surface, W and w the greatest and least velocities at the surface. The distance of the principal filament from the surface is generally less than one-fourth of the depth of the stream; W is a little less than V; and U lies between W and w. As the surface velocities change continuously from the centre towards the sides, there are at the surface two filaments having a velocity equal to U. The determination of the position of these filaments, which Boileau terms the gauging filaments, cannot be effected entirely by theory. But, for sections of a stream in which there are no abrupt changes of depth, their position can be very approximately assigned. Let Δ and l be the horizontal distances of the surface filament, having the velocity W, from the gauging filament, which has the velocity U, and from the bank on one side. Then

$$\frac{\Delta}{l}=c\sqrt[4]{\frac{W+2w}{7(W-w)}},$$

c being a numerical constant. From gaugings by Humphreys and Abbot, Bazin, and Baumgarten, the values $c=0{\cdot}919$, $0{\cdot}922$, and $0{\cdot}925$ are obtained. Boileau adopts as a mean value $0{\cdot}922$. Hence, if W and w are determined by float gauging or otherwise, Δ can be found, and then a single velocity observation at Δ feet from the filament of maximum velocity gives, without need of any reduction, the mean velocity of the stream. More conveniently W, w, and U can be measured from a horizontal surface velocity curve, obtained from a series of float observations.

137. *Direct Determination of the Mean Velocity by a Current Meter or Darcy Gauge.*—The only method of determining the mean velocity at a cross section of a stream which involves no assumption of the ratio of the mean velocity to other quantities is this—a plank bridge is fixed across the stream near its surface. From this, velocities are observed at a sufficient number of points in the cross section of the stream, evenly distributed over its area. The mean of these is the true mean velocity of the stream. In Darcy and Bazin's experiments on small streams, the velocity was thus observed at 36 points in the cross section.

When the stream is too large to fix a bridge across it, the observations may be taken from a boat, or from a couple of boats with a gangway between them, anchored successively at a series of points across the width of the stream. The position of the boat for each series of observations is fixed by angular observations to a base line on shore.

138. *Harlacher's Graphic Method of determining the Discharge from a Series of Current Meter Observations.*—Let ABC (fig. 150) be the cross section of a river at which a complete series of current meter observations have been taken. Let I., II., III. . . . be the verticals at different points of which the velocities were measured. Suppose the depths at I., II., III., . . . (fig. 150), set off as vertical ordinates in fig. 151, and on these vertical ordinates suppose the velocities set off horizontally at their proper depths. Thus, if v is the measured velocity at the depth h from the surface in fig. 150, on vertical marked III., then at III. in fig. 151 take $cd=h$ and $ac=v$.

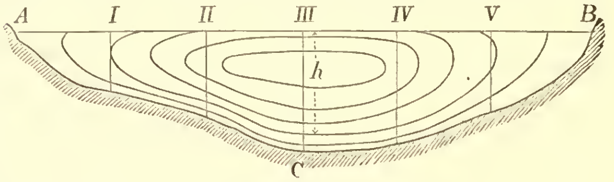


Fig. 150.

Then d is a point in the vertical velocity curve for the vertical III., and, all the velocities for that ordinate being similarly set off, the curve can be drawn. Suppose all the vertical velocity curves I. . . . V. (fig. 151), thus drawn. On each of these figures draw verticals corresponding to velocities of x, $2x$, $3x$ . . . feet per second. Then for instance cd at III. (fig. 151) is the depth at which a velocity of $2x$ feet per second existed on the vertical III. in fig. 150, and if cd is set off at III. in fig. 150 it gives a point in a curve passing through points of the section where the velocity was $2x$ feet per second. Set off on each of the verticals in fig. 150 all the depths thus found in the corresponding diagram in fig. 151. Curves drawn through the corresponding points on the verticals are curves of equal velocity.

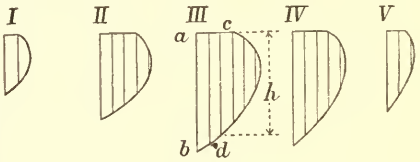


Fig. 151.

The discharge of the stream per second may be regarded as a solid having the cross section of the river (fig. 150), as a base, and cross sections normal to the plane of fig. 150 given by the diagrams in fig. 151. The curves of equal velocity may therefore be considered as contour lines of the solid whose volume is the discharge of the stream per second. Let Ω_0 be the area of the cross section of the river, Ω_1, Ω_2 . . . . the areas contained by the successive curves of equal velocity, or, if these cut the surface of the stream, by the curves and that surface. Let x be the difference of velocity for which the successive curves are drawn, assumed above for simplicity at 1 foot per second. Then the volume of the successive layers of the solid body whose volume represents the discharge, limited by successive planes passing through the contour curves, will be

$$\tfrac{1}{2}x(\Omega_0+\Omega_1),\qquad \tfrac{1}{2}x(\Omega_1+\Omega_2),\qquad \text{and so on.}$$

Consequently the discharge is

$$Q=x\left\{\frac{\Omega_0+\Omega_n}{2}+\Omega_1+\Omega_2+\ .\ .\ .\ +\Omega_{n-1}\right\}.$$

The areas Ω_0, Ω_1 . . . . are easily ascertained by means of the polar planimeter. A slight difficulty arises in the part of the solid lying above the last contour curve. This will have generally a height which is not exactly x, and a form more rounded than the other layers and less like a conical frustum. The volume of this may be estimated separately, and taken to be the area of its base (the area Ω_n) multiplied by $\frac{1}{3}$ to $\frac{1}{2}$ its height.

Fig. 152 shows the results of one of Professor Harlacher's gaugings worked out in this way. The upper figure shows the section of the river and the positions of the verticals at which the soundings and gaugings were taken. The lower gives the curves of equal velocity, worked out from the current meter observations, by the aid of vertical velocity curves. The vertical scale in this figure is ten times as great as in the other. The discharge calculated from the contour curves is 14·1087 cubic metres per second. In the lower figure some other interesting curves are drawn. Thus, the uppermost dotted curve is the curve through points at which the maximum velocity was found; it shows that the maximum velocity was always a little below the surface, and at a greater depth at the centre than at the sides. The next curve shows the depth at which the mean velocity for each vertical was found. The next is the curve of equal velocity corresponding to the mean velocity of the stream; that is, it passes through points in the cross section where the velocity was identical with the mean velocity of the stream.

XII. IMPACT AND REACTION OF WATER.

When a stream of fluid impinges on a solid surface, it presses on the surface with a force equal and opposite to that by which the velocity and direction of motion of the fluid are changed. Generally, in problems on the impact of fluids, it is necessary to neglect the effect of friction between the fluid and the surface on which it moves.

139. *During Impact the Velocity of the Fluid relatively to the Surface on which it impinges remains unchanged in Magnitude.*—Con-

sider a mass of fluid flowing in contact with a solid surface also in motion, the motion of both fluid and solid being estimated relatively to the earth. Then the motion of the fluid may be resolved into two parts, one a motion equal to that of the solid, and in the same direction, the other a motion relatively to the solid. The motion which the fluid has in common with the solid cannot at all be influenced by the contact. The relative component of the motion of the fluid can only be altered in direction, but not in magnitude. The fluid moving in contact with the surface can only have a relative motion parallel to the surface, while the pressure between the fluid and

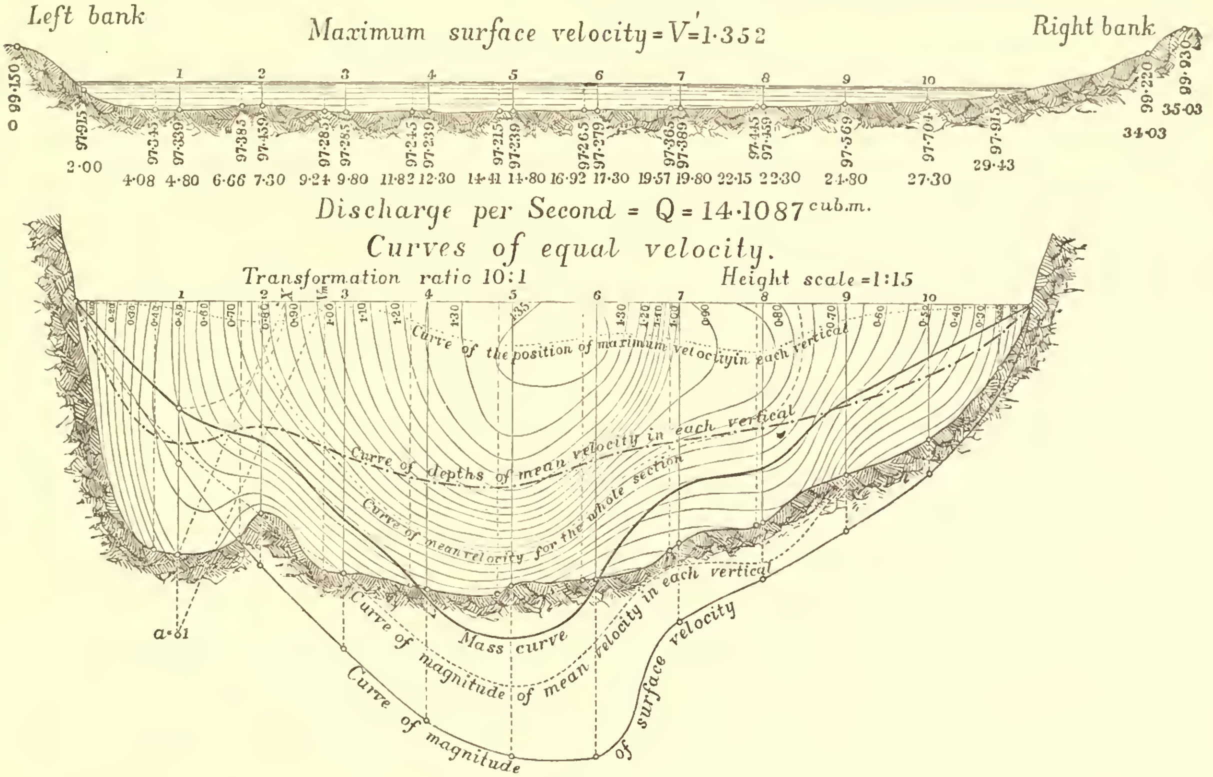


Fig. 152.

solid, if friction is neglected, is normal to the surface. The pressure therefore can only deviate the fluid, without altering the magnitude of the relative velocity. The unchanged common component and, combined with it, the deviated relative component give the resultant final velocity, which may differ greatly in magnitude and direction from the initial velocity.

From the principle of momentum the impulse of any mass of fluid reaching the surface in any given time is equal to the change of momentum estimated in the same direction. The pressure between the fluid and surface, in any direction, is equal to the change of momentum in that direction of so much fluid as reaches the surface in one second. If P_a is the pressure in any direction, m the mass of fluid impinging per second, v_a the change of velocity in the direction of P_a due to impact, then

$$P_a = mv_a .$$

If v_1 (fig. 153) is the velocity and direction of motion before impact, v_2 that after impact, then v is the total change of motion due to impact. The resultant pressure of the fluid on the surface is in the direction of v, and is equal to v multiplied by the mass impinging per second. That is, putting P for the resultant pressure,

$$P = mv .$$

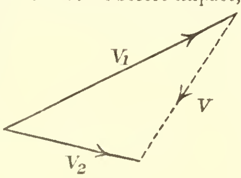


Fig. 153.

Let P be resolved into two components, N and T, normal and tangential to the direction of motion of the solid on which the fluid impinges. Then N is a lateral force producing a pressure on the supports of the solid, T is an effort which does work on the solid. If u is the velocity of the solid, Tu is the work done per second by the fluid in moving the solid surface.

Let Q be the volume, and GQ the weight of the fluid impinging per second, and let v_1 be the initial velocity of the fluid before striking the surface. Then $\frac{1}{2}\frac{G}{g}Qv_1^2$ is the original kinetic energy of Q cubic feet of fluid, and the efficiency of the stream considered as an arrangement for moving the solid surface is

$$\eta = \frac{Tu}{\frac{1}{2}\frac{G}{g}Qv_1^2} .$$

140. *Jet deviated entirely in one Direction—Geometrical Solution* (fig. 154).—Suppose a jet of water impinges on a surface ac with a velocity ab, and let it be wholly deviated in planes parallel to the

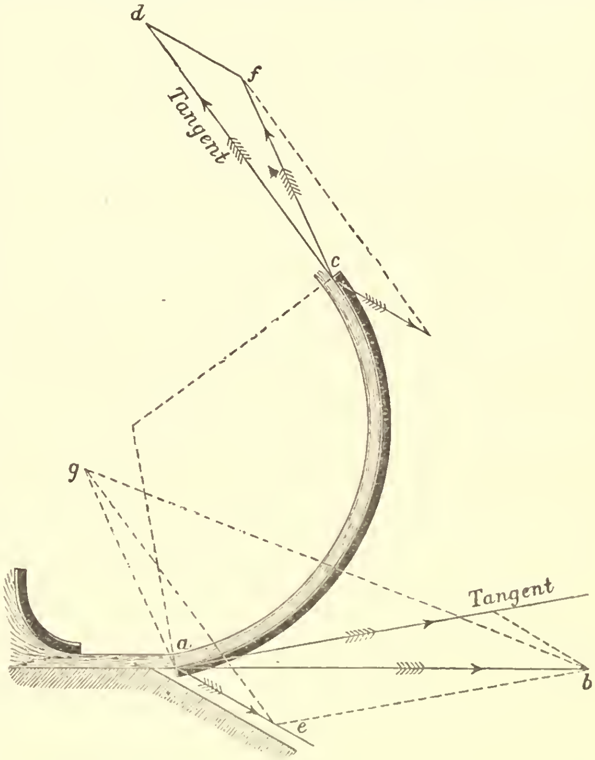


Fig. 154.

figure. Also let ac be the velocity and direction of motion of the surface. Join eb; then the water moves with respect to the surface in the direction and with the velocity eb. As this relative velocity is unaltered by contact with the surface, take $cd=eb$, then cd is the relative motion of the water with respect to the surface at c. Take df equal and parallel to ac. Then fc (obtained by compounding the relative motion of water to surface and common velocity of water and surface) is the absolute velocity and direction of the water leaving the surface. Take ag equal and parallel to fc. Then, since ab is the initial and ag the final velocity and direction of motion, gb is the total change of motion of the water. The resultant pressure on the plane is in the direction gb. Join eg. In the triangle gae, ae is equal and parallel to df, and ag to fc. Hence eg is equal and parallel to cd. But $cd=eb$ = relative motion of water and surface. Hence the change of motion of the water is represented in magnitude and direction by the third side of an isosceles triangle, of which the other sides are equal to the relative velocity of the water and surface, and parallel to the initial and final directions of relative motion.

Special Cases.

141. (1) *A Jet impinges on a plane surface at rest, in a direction normal to the plane* (fig. 155).—Let a jet whose section is ω impinge with a velocity v on a plane surface at rest, in a direction normal to the plane. The particles approach the plane, are gradually deviated, and finally flow away parallel to the plane, having then no velocity in the original direction of the jet. The quantity of water impinging per second is ωv. The pressure on the plane, which is equal to the change of momentum per second, is $\frac{G}{g}\omega v^2$.

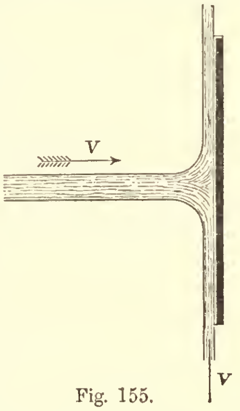


Fig. 155.

(2) *If the plane is moving in the direction of the jet with the velocity* $\pm u$, the quantity impinging per second is $\omega(v\mp u)$. The momentum of this quantity before impact is $\frac{G}{g}\omega(v\mp u)v$. After impact, the water still possesses the velocity $\pm u$ in the direction of the jet; and the momentum, in that direction, of so much water as impinges in one second, after impact, is $\pm\frac{G}{g}\omega(v\mp u)u$. The pressure on the plane, which is the change of momentum per second, is the difference of these quantities or $\frac{G}{g}\omega(v\mp u)^2$. This differs from the expression obtained in the previous case, in that the relative velocity of the water and plane $v\mp u$ is substituted for v. The expression may be written $P=2\times G\times\omega\left(\frac{v\mp u}{2g}\right)^2$, where the last term is the volume of a prism of water whose section is the area of the jet and whose length is the head due to the relative velocity. The pressure on the plane is twice the weight of that prism of water. The work done on the plane in this case is $Pu=\frac{G}{g}\omega(v\mp u)^2$ foot-pounds per second. There issue from the jet ωv cubic feet per second, and the energy of this quantity before impact is $\frac{G}{2g}\omega v^3$. The efficiency of the jet is therefore $\eta=2\frac{(v\mp u)^2}{v^3}u$. The value of u which makes this a maximum is found by differentiating and equating the differential coefficient to zero:—

$$\frac{d\eta}{du}=2\left(\frac{v^2\mp 4vu+3u^2}{v^3}\right)=0\,;$$

$$\therefore\quad u=v \text{ or } \tfrac{1}{3}v.$$

The former gives a minimum, the latter a maximum efficiency.

Putting $u=\frac{1}{3}v$ in the expression above,

$$\eta \text{ max.} = \tfrac{8}{27}\,.$$

(3) If, instead of one plane moving before the jet, a series of planes are introduced at short intervals at the same point, the quantity of water impinging on the series will be ωv instead of $\omega(v-u)$, and the whole pressure $=\frac{G}{g}\omega v(v-u)$. The work done is $\frac{G}{g}\omega vu(v-u)$. The efficiency $\eta=\frac{G}{g}\omega vu(v-u)\div\frac{G}{2g}\omega v^3=2u\left(\frac{v-u}{v^2}\right)$. This becomes a maximum for $\frac{d\eta}{du}=2(v-2u)=0$, or $u=\frac{1}{2}v$. This result is often used as an approximate expression for the velocity of greatest efficiency when a jet of water strikes the floats of a water wheel. The work wasted in this case is half the whole energy of the jet when the floats run at the best speed.

142. (4) *Case of a Concave Cup Vane*, velocity of water v, velocity of vane in the same direction u (fig. 156).

If the cup is hemispherical, the water leaves the cup in a direction parallel to the jet. Its relative velocity is $v-u$ when approaching the cup, and $-(v-u)$ when leaving it. Hence its absolute velocity when leaving the cup is $u-(v-u)=2u-v$. The change of momentum per second $=\frac{G}{g}\omega(v-u)v-\frac{G}{g}\omega(v-u)(2u-v)=2\frac{G}{g}\omega(v-u)^2$.

Comparing this with case 2, it is seen that the pressure on a hemispherical cup is double that on a flat plane. The work done on the cup $=2\frac{G}{g}\omega(v-u)^2u$ foot-pounds per second. The efficiency of the jet is greatest when $v=2u$; in that case the efficiency $=\frac{1}{2}$.

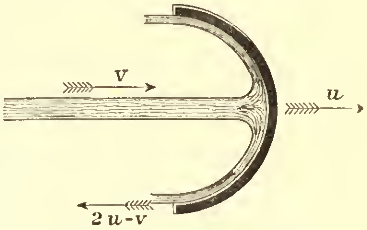


Fig. 156.

If a series of cup vanes are introduced in front of the jet, so that the quantity of water acted upon is ωv instead of $\omega(v-u)$, then the whole pressure on the chain of cups is $\frac{G}{g}\omega v^2-\frac{G}{g}\omega v(2u-v)=2\frac{G}{g}\omega v(v-u)$. In this case the efficiency is greatest when $v=2u$, and the maximum efficiency is unity, or all the energy of the water is expended on the cups.

143. (5) *Case of a Flat Vane oblique to the Jet* (fig. 157).—This case presents some difficulty. The water spreading on the plane in all directions from the point of impact, different particles leave the plane with different absolute velocities. Let $AB=v=$ velocity of water, $AC=u=$ velocity of plane. Then, completing the parallelogram, AD represents in magnitude and direction the relative velocity of water and plane. Draw AE normal to the plane and DE parallel to

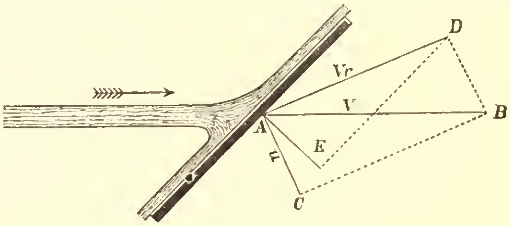


Fig. 157.

the plane. Then the relative velocity AD may be regarded as consisting of two components, one AE normal, the other DE parallel to the plane. On the assumption that friction is insensible, DE is unaffected by impact, but AE is destroyed. Hence AE represents the entire change of velocity due to impact and the direction of that change. The pressure on the plane is in the direction AE, and its amount is = mass of water impinging per second × AE.

Let $DAE=\theta$, and let $AD=v_r$. Then $AE=v_r\cos\theta$; $DE=v_r\sin\theta$. If Q is the volume of water impinging on the plane per second, the change of momentum is $\frac{G}{g}Qv_r\cos\theta$. Let $AC=u=$ velocity of the plane, and let AC make the angle $CAE=\delta$ with the normal to the plane. The velocity of the plane in the direction $AE=u\cos\delta$. The work of the jet on the plane $=\frac{G}{g}Qv_r\cos\theta\, u\cos\delta$. The same problem may be thus treated algebraically (fig. 158). Let $BAF=\alpha$, and $CAF=\delta$. The velocity v of the water may be decom-

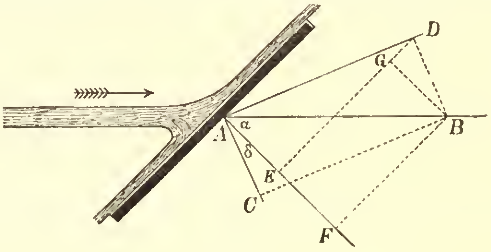


Fig 158.

posed into $AF=v\cos\alpha$ normal to the plane, and $FB=v\sin\alpha$ parallel to the plane. Similarly the velocity of the plane $=u=AC=BD$ can be decomposed into $BG=FE=u\cos\delta$ normal to the plane, and $DG=u\sin\delta$ parallel to the plane. As friction is neglected, the velocity of the water parallel to the plane is unaffected by the impact, but its component $v\cos\alpha$ normal to the plane becomes after impact the same as that of the plane, that is, $u\cos\delta$. Hence the change of velocity during impact $=AE=v\cos\alpha-u\cos\delta$. The change of momentum per second, and consequently the normal pressure on the plane is $N=\frac{G}{g}Q(v\cos\alpha-u\cos\delta)$. The pressure in the direction in which the plane is moving is $P = N\cos\delta = \frac{G}{g}Q(v\cos\alpha - u\cos\delta)\cos\delta$, and the work done on the plane is

$Pu = \frac{G}{g}Q(v\cos\alpha - u\cos\delta)$ $u\cos\delta$, which is the same expression as before, since $AE = v_r\cos\theta = v\cos\alpha - u\cos\delta$.

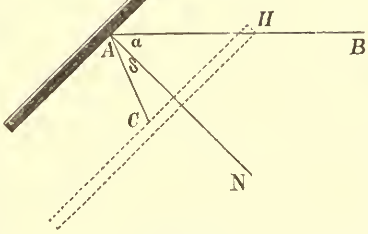


Fig. 159.

In one second the plane moves so that the point A (fig. 159) comes to C, or from the position shown in full lines to the position shown in dotted lines. If the plane remained stationary, a length $AB = v$ of the jet would impinge on the plane, but, since the plane moves in the same direction as the jet, only the length $HB = AB - AH$ impinges on the plane.

But $AH = AC\frac{\cos\delta}{\cos\alpha} = u\frac{\cos\delta}{\cos\alpha}$, and therefore $HB = v - u\frac{\cos\delta}{\cos\alpha}$. Let ω = sectional area of jet; volume impinging on plane per second $= Q = \omega\left(v - u\frac{\cos\delta}{\cos\alpha}\right) = \omega\frac{v\cos\alpha - u\cos\delta}{\cos\alpha}$. Inserting this in the formulæ above, we get

$$N = \frac{G}{g}\frac{\omega}{\cos\alpha}(v\cos\alpha - u\cos\delta)^2 \quad \ldots \quad (1);$$

$$P = \frac{G}{g}\frac{\omega\cos\delta}{\cos\alpha}(v\cos\alpha - u\cos\delta)^2 \quad \ldots \quad (2);$$

$$Pu = \frac{G}{g}\omega u\frac{\cos\delta}{\cos\alpha}(v\cos\alpha - u\cos\delta)^2 \quad \ldots \quad (3).$$

Three cases may be distinguished:—

(*a*) The plane is at rest. Then $u = 0$, $N = \frac{G}{g}\omega v^2\cos\alpha$; and the work done on the plane and the efficiency of the jet are zero.

(*b*) The plane moves parallel to the jet. Then $\delta = \alpha$, and $Pu = \frac{G}{g}\omega u\cos^2\alpha\,(v-u)^2$, which is a maximum when $u = \frac{1}{3}v$.

When $u = \frac{1}{3}v$ then Pu max. $= \frac{4}{27}\frac{G}{g}\omega v^3\cos^2\alpha$, and the efficiency $= \eta = \frac{4}{9}\cos^2\alpha$.

(*c*) The plane moves perpendicularly to the jet. Then $\delta = 90° - \alpha$; $\cos\delta = \sin\alpha$; and $Pu = \frac{G}{g}\omega u\frac{\sin\alpha}{\cos\alpha}(v\cos\alpha - u\sin\alpha)^2$. This is a maximum when $u = \frac{1}{3}v\cos\alpha$.

When $u = \frac{1}{3}v\cos\alpha$, the maximum work and the efficiency are the same as in the last case.

144. *Best Form of Vane to receive Water.*—When water impinges normally or obliquely on a plane, it is scattered in all directions after impact, and the work carried away by the water is then generally lost, from the impossibility of dealing afterwards with streams of water deviated in so many directions. By suitably forming the vane, however, the water may be entirely deviated in one direction, and the loss of energy from agitation of the water is entirely avoided.

Let AB (fig. 160) be a vane, on which a jet of water impinges at the point A and in the direction AC. Take $AC = v$ = velocity of water, and let AD represent in magnitude and direction the velocity of the vane. Completing the parallelogram, DC or AE repre-

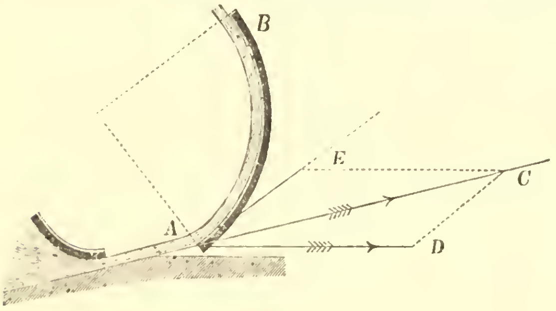


Fig. 160.

sents the direction in which the water is moving relatively to the vane. If the lip of the vane at A is tangential to AE, the water will not have its direction suddenly changed when it impinges on the vane, and will therefore have no tendency to spread laterally. On the contrary it will be so gradually deviated that it will *glide* up the vane in the direction AB. This is sometimes expressed by saying that the vane *receives the water without shock.*

145. *Floats of Poncelet Water Wheels.*—Let AC (fig. 161) represent the direction of a thin horizontal stream of water having the

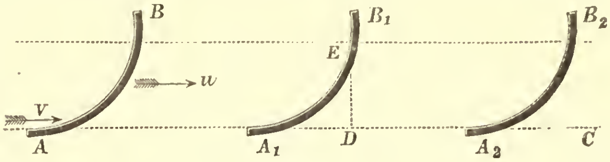


Fig. 161.

velocity v. Let AB be a curved float moving horizontally with velocity u. The relative motion of water and float is then initially horizontal, and equal to $v - u$.

In order that the float may receive the water without shock, it is necessary and sufficient that the lip of the float at A should be tangential to the direction AC of relative motion. At the end of $\frac{v-u}{g}$ seconds the float moving with the velocity u comes to the position A_1B_1, and during this time a particle of water received at A and gliding up the float with the relative velocity $v - u$, attains a height $DE = \frac{(v-u)^2}{2g}$. At E the water comes to relative rest. It then descends along the float, and when after $\frac{2(v-u)}{g}$ seconds the float has come to A_2B_2 the water will again have reached the lip at A_2 and will quit it tangentially, that is, in the direction CA_2, with a relative velocity $-(v-u) = -\sqrt{2gDE}$ acquired under the influence of gravity. The absolute velocity of the water leaving the float is therefore $u - (v - u) = 2u - v$. If $u = \frac{1}{2}v$, the water will drop off the bucket deprived of all energy of motion. The whole of the work of the jet must therefore have been expended in driving the float. The water will have been received without shock and discharged without velocity. This is the principle of the Poncelet wheel, but in that case the floats move over an arc of a large circle; the stream of water has considerable thickness (about 8 inches); in order to get the water into and out of the wheel, it is then necessary that the lip of the float should make a small angle (about 15°) with the direction of its motion. The water quits the wheel with a little of its energy of motion remaining.

146. *Pressure on a Curved Surface when the Water is deviated wholly in one Direction.*—When a jet of water impinges on a curved surface in such a direction that it is received without shock, the pressure on the surface is due to its gradual deviation from its first direction. On any portion of the area the pressure is equal and opposite to the force required to cause the deviation of so much water as rests on that surface. In common language, it is equal to the centrifugal force of that quantity of water.

Case 1. *Surface Cylindrical and Stationary.*—Let AB (fig. 162) be the surface, having its axis at O and its radius $= r$. Let the water impinge at A tangentially, and quit the surface tangentially at B. Since the surface is at rest, v is both the absolute velocity of the water and the velocity relatively to the surface, and this remains unchanged during contact with the surface, because the deviating force is at each point perpendicular to the direction of motion. The water is deviated through an angle $BCD = AOB = \phi$. Each particle of water of weight p exerts radially a centrifugal force $\frac{pv^2}{rg}$. Let the thickness of

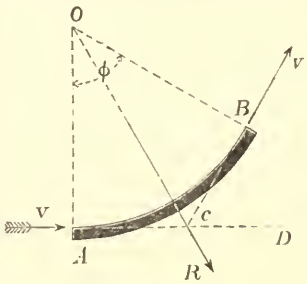


Fig. 162.

the stream $= t$ feet. Then the weight of water resting on unit of surface $= Gt$ lb; and the normal pressure per unit of surface $= n = \frac{Gt}{g}\cdot\frac{v^2}{r}$. The resultant of the radial pressures uniformly distributed from A to B will be a force acting in the direction OC bisecting AOB, and its magnitude will equal that of a force of intensity $= n$, acting on the projection of AB on a plane perpendicular to the direction OC. The length of the chord $AB = 2r\sin\frac{\phi}{2}$; let b = breadth of the surface perpendicular to the plane of the figure. The resultant pressure on surface

$$= R = 2rb\sin\frac{\phi}{2}\times\frac{Gt}{g}\cdot\frac{v^2}{r} = 2\frac{G}{g}btv^2\sin\frac{\phi}{2},$$

which is independent of the radius of curvature. It may be inferred that the resultant pressure is the same for any curved surface of the same projected area, which deviates the water through the same angle.

Case 2. Cylindrical Surface moving in the Direction AC *with Velocity* u.—The relative velocity $=v-u$. The final velocity BF (fig. 163) is found by combining the relative velocity $BD=v-u$

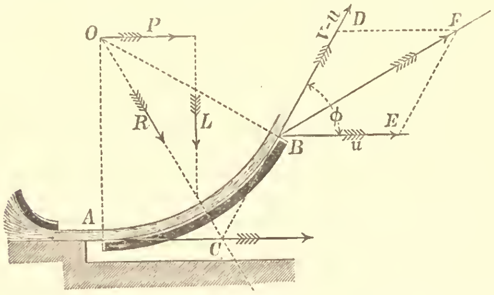


Fig. 163.

tangential to the surface with the velocity $BE=u$ of the surface. The intensity of normal pressure, as in the last case, is $\frac{Gt}{g}\frac{(v-u)^2}{r}$.

The resultant normal pressure $R=2\frac{G}{g}bt\,(v-u)^2\sin\frac{\phi}{2}$. This resultant pressure may be resolved into two components P and L, one parallel and the other perpendicular to the direction of the vane's motion. The former is an effort doing work on the vane. The latter is a lateral force which does no work.

$$P=R\sin\frac{\phi}{2}=\frac{G}{g}\,bt(v-u)^2\,(1-\cos\phi)\;;$$

$$L=R\cos\frac{\phi}{2}=\frac{G}{g}\,bt(v-u)^2\sin\phi.$$

The work done by the jet on the vane is $Pu=\frac{G}{g}btu(v-u)^2(1-\cos\phi)$, which is a maximum when $u=\frac{1}{3}v$. This result can also be obtained by considering that the work done on the plane must be equal to the energy lost by the water, when friction is neglected.

If $\phi=180°$, $\cos\phi=-1$, $1-\cos\phi=2$; then $P=2\frac{G}{g}bt(v-u)^2$, the same result as for a concave cup.

147. *Position which a Movable Plane takes in Flowing Water.*—When a rectangular plane, movable about an axis parallel to one of its sides, is placed in an indefinite current of fluid, it takes a position such that the resultant of the normal pressures on the two sides of the axis passes through the axis. If, therefore, planes pivoted so that the ratio $\frac{a}{b}$ (fig. 164) is varied are placed in water, and the angle they make with the direction of the stream is observed, the position of the resultant of the pressures on the plane is determined for different angular positions. Experiments of this kind have been made by Herr Hagen. Some of his results are given in the following table:—

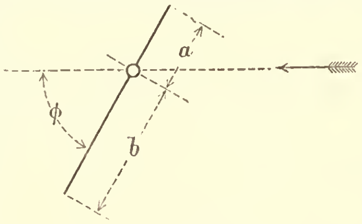


Fig. 164.

	Larger Plane.	Smaller Plane.
$\frac{a}{b}=1{\cdot}0$	$\phi=\ldots$	$\phi=90°$
0·9	75°	$72\frac{1}{2}°$
0·8	60°	57°
0·7	48°	43°
0·6	25°	29°
0·5	13°	13°
0·4	8°	$6\frac{1}{2}°$
0·3	$6\frac{1}{2}°$	...
0·2	4°	...

148. *Effect of Friction during Impulse.*—Thus far the effect of the friction between the water and the surface which deviates it has been neglected. Nothing precise is known of its mode of action, and the following investigation is in part conjectural (Rankine, *Steam Engine*, p. 171, § 146).

Let it be assumed that the friction causes a loss of energy per second proportional to the height due to the velocity of the water relatively to the surface; that is, the head due to the relative velocity being $\frac{v^2}{2g}$, the loss of head due to friction will be $f\frac{v^2}{2g}$; the whole energy due to the relative head being $GQ\frac{v^2}{2g}$, the loss of energy due to friction will be $GQf\frac{v^2}{2g}$.

Cylindrical Surface with Water deviated wholly in one Direction, Friction taken into account.—In Case 2, discussed in § 146, the velocity of the water relatively to the surface is $v-u$. The quantity of water impinging per second is $bt(v-u)$. The loss of head due to friction is $f\frac{(v-u)^2}{2g}$. The loss of energy due to friction is $Gbtf\frac{(v-u)^3}{2g}$. The energy exerted on the surface, after deducting the loss due to friction, is

$$Pu=\frac{G}{g}\,bt(v-u)^2u(1-\cos\phi)-Gbtf\frac{(v-u)^3}{2g}$$
$$=\frac{G}{g}\,bt(v-u)^2\left\{u(1-\cos\phi)-f\frac{v-u}{2}\right\}.$$

The efficiency when friction is taken into account becomes

$$\eta=\frac{Pu}{Gbt(v-u)\frac{v^2}{2g}}=\frac{(v-u)\left\{2u(1-\cos\phi)-f(v-u)\right\}}{v^2}\;;$$

and this becomes a maximum if

$$u=\frac{1-\cos\phi+f}{2-2\cos\phi+f}v,$$

being greater than the speed when friction is neglected in the ratio

$$2(1-\cos\phi)+f:\;3(1-\cos\phi+f).$$

Suppose that the speed of greatest efficiency u has been found by experiment;

$$f=\frac{(2u-v)(1-\cos\phi)}{v-u}.$$

149. *Direct Action distinguished from Reaction* (Rankine, *Steam Engine*, § 147).

The pressure which a jet exerts on a vane can be distinguished into two parts, viz:—

(1) The pressure arising from changing the direct component of the velocity of the water into the velocity of the vane. In fig. 154, § 140, $ab\cos bac$ is the direct component of the water's velocity, or component in the direction of motion of vane. This is changed into the velocity ae of the vane. The pressure due to direct impulse is then

$$P_1=GQ\,\frac{ab\cos bac-ae}{g}.$$

For a flat vane moving normally, this direct action is the only action producing pressure on the vane.

(2) The term reaction is applied to the additional action due to the direction and velocity with which the water glances off the vane. It is this which is diminished by the friction between the water and the vane. In Case 2, § 146, the direct pressure is

$$P_1=Gbt\,\frac{(v-u)^2}{g}.$$

That due to reaction is

$$P_2=-Gbt\,\frac{(v-u)^2}{g}\cos\phi.$$

If $\phi<90°$, the direct component of the water's motion is not wholly converted into the velocity of the vane, and the whole pressure due to direct impulse is not obtained. If $\phi>90°$, $\cos\phi$ is negative and an additional pressure due to reaction is obtained.

150. *Reaction of a Jet issuing from a Vessel.*—Suppose a vessel filled with water (fig. 165), having an orifice of area ω, from which water issues horizontally with a velocity $v=\sqrt{2gh}$. The volume discharged per second, neglecting contraction, $=\omega v$. The momentum generated per second in a horizontal direction $=\frac{G}{g}\omega v^2$; and this is equal to the force producing the change of momentum.

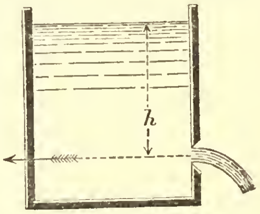


Fig. 165.

Hence the horizontal force or reaction R, acting on the side of the vessel, opposite to the orifice, and equal and opposite to the force producing the momentum, is

$$R=\frac{G}{g}\,\omega v^2=2G\omega h\;;$$

this is the weight of a column of water the section of which is the area of the orifice, and the height is twice the head.

If the vessel moves in a direction opposite to that of the jet, with the velocity u, the absolute velocity of the water leaving the vessel is $v-u$. The momentum generated per second is $\frac{G}{g}\,\omega v(v-u)=R$.

Jet Propeller.—In the case of vessels propelled by a jet of water (fig. 166), driven sternwards from orifices at the side of the vessel, the water, originally at rest outside the vessel, is drawn into the ship and caused to move with the forward velocity V of the ship. Afterwards it is projected sternwards from the jets with a velocity v relatively to the ship, or $v - \mathrm{V}$ relatively to the earth. If Ω is the total sectional area of the jets, Ωv is the quantity of water discharged per second. The momentum generated per second in a sternward direction is $\frac{\mathrm{G}}{g}\,\Omega v(v-\mathrm{V})$, and this is equal to the forward acting reaction P which propels the ship.

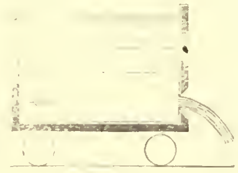


Fig. 166.

The energy carried away by the water

$$=\tfrac{1}{2}\frac{\mathrm{G}}{g}\,.\,\Omega v(v-\mathrm{V})^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

The useful work done on the ship

$$\mathrm{PV}=\frac{\mathrm{G}}{g}\,\Omega v(v-\mathrm{V})\mathrm{V} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Adding (1) and (2), we get the whole work expended on the water, neglecting friction:—

$$\mathrm{W}=\frac{\mathrm{G}}{g}\,\Omega v\,\frac{v^2-\mathrm{V}^2}{2}\,.$$

Hence the efficiency of the jet propeller is

$$\frac{\mathrm{PV}}{\mathrm{W}}=\frac{2\mathrm{V}}{v+\mathrm{V}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

This increases towards unity as v approaches V. In other words, the less the velocity of the jets exceeds that of the ship, and therefore the greater the area of the orifice of discharge, the greater is the efficiency of the propeller.

In the "Waterwitch" v was about twice V. Hence in this case the theoretical efficiency of the propeller, friction neglected, was about $\frac{2}{3}$.

151. *Pressure of a Steady Stream in a Uniform Pipe on a Plane normal to the Direction of Motion.*—Let CD (fig. 167) be a plane

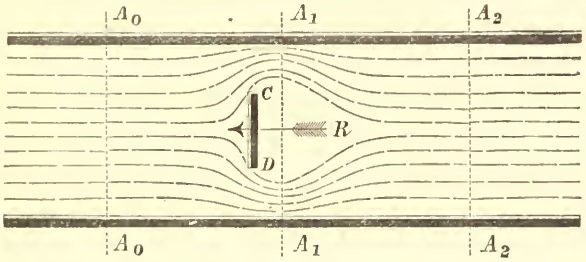


Fig. 167.

placed normally to the stream which, for simplicity, may be supposed to flow horizontally. The fluid filaments are deviated in front of the plane, form a contraction at $\mathrm{A}_1\mathrm{A}_1$, and converge again, leaving a mass of eddying water behind the plane. Suppose the section $\mathrm{A}_0\mathrm{A}_0$ taken at a point where the parallel motion has not begun to be disturbed, and $\mathrm{A}_2\mathrm{A}_2$ where the parallel motion is re-established. Then, since the same quantity of water with the same velocity passes $\mathrm{A}_0\mathrm{A}_0$, $\mathrm{A}_2\mathrm{A}_2$ in any given time, the external forces produce no change of momentum on the mass $\mathrm{A}_0\mathrm{A}_0\mathrm{A}_2\mathrm{A}_2$, and must therefore be in equilibrium. If Ω is the section of the stream at $\mathrm{A}_0\mathrm{A}_0$ or $\mathrm{A}_2\mathrm{A}_2$, and ω the area of the plate CD, the area of the contracted section of the stream at $\mathrm{A}_1\mathrm{A}_1$ will be $c_c\,(\Omega-\omega)$, where c_c is the coefficient of contraction. Hence, if v is the velocity at $\mathrm{A}_0\mathrm{A}_0$ or $\mathrm{A}_2\mathrm{A}_2$, and v_1 the velocity at $\mathrm{A}_1\mathrm{A}_1$,

$$v\Omega=c_c v_1(\Omega-\omega)\,;$$

$$\therefore\quad v_1=v\frac{\Omega}{c_c(\Omega-\omega)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Let p_0, p_1, p_2 be the pressures at the three sections. Applying Bernoulli's theorem to the sections $\mathrm{A}_0\mathrm{A}_0$ and $\mathrm{A}_1\mathrm{A}_1$,

$$\frac{p_0}{\mathrm{G}}+\frac{v^2}{2g}=\frac{p_1}{\mathrm{G}}+\frac{v_1^2}{2g}\,.$$

Also, for the sections $\mathrm{A}_1\mathrm{A}_1$ and $\mathrm{A}_2\mathrm{A}_2$, allowing that the head due to the relative velocity v_1-v is lost in shock:—

$$\frac{p_1}{\mathrm{G}}+\frac{v_1^2}{2g}=\frac{p_2}{\mathrm{G}}+\frac{v^2}{2g}+\frac{(v_1-v)^2}{2g}\,;$$

$$\therefore\quad p_0-p_2=\mathrm{G}\,\frac{(v_1-v)^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2);$$

or, introducing the value in (1),

$$p_0-p_2=\frac{\mathrm{G}}{2g}\left(\frac{\Omega}{c_c(\Omega-\omega)}-1\right)^2 v^2 \quad . \quad . \quad . \quad . \quad (3).$$

Now the external forces in the direction of motion acting on the mass $\mathrm{A}_0\mathrm{A}_0\mathrm{A}_2\mathrm{A}_2$ are the pressures $p_0\Omega$, $-p_2\Omega$ at the ends, and the reaction $-\mathrm{R}$ of the plane on the water, which is equal and opposite to the pressure of the water on the plane. As these are in equilibrium,

$$(p_0-p_2)\Omega-\mathrm{R}=0\,;$$

$$\therefore\quad \mathrm{R}=\mathrm{G}\Omega\left(\frac{\Omega}{c_c(\Omega-\omega)}-1\right)^2\frac{v^2}{2g} \quad . \quad . \quad . \quad . \quad (4);$$

an expression like that for the pressure of an isolated jet on an indefinitely extended plane, with the addition of the term in brackets, which depends only on the areas of the stream and the plane. For a given plane, the expression in brackets diminishes as Ω increases. If $\frac{\Omega}{\omega}=\rho$, the equation (4) becomes

$$\mathrm{R}=\mathrm{G}\omega\,\frac{v^2}{2g}\left\{\rho\left(\frac{\rho}{c_c(\rho-1)}-1\right)^2\right\} \quad . \quad . \quad . \quad . \quad (4a),$$

which is of the form

$$\mathrm{R}=\mathrm{G}\omega\,\frac{v^2}{2g}\times\mathrm{K}\,,$$

where K depends only on the ratio of the sections of the stream and plane.

For example, let $c_c=0{\cdot}85$, a value which is probable, if we allow that the sides of the pipe act as internal borders to an orifice. Then

$$\mathrm{K}=\rho\left(1{\cdot}176\frac{\rho}{\rho-1}-1\right)^2.$$

$\rho=$	K=
1	∞
2	3·66
3	1·75
4	1·29
5	1·10
10	·94
50	2·00
100	3·50

The assumption that the coefficient of contraction c_c is constant for different values of ρ is probably only true when ρ is not very large. Further, the increase of K for large values of ρ is contrary to experience, and hence it may be inferred that the assumption that all the filaments have a common velocity v_1 at the section $\mathrm{A}_1\mathrm{A}_1$ and a common velocity v at the section $\mathrm{A}_2\mathrm{A}_2$ is not true when the stream is very much larger than the plane. Hence, in the expression

$$\mathrm{R}=\mathrm{KG}\omega\frac{v^2}{2g}\,,$$

K must be determined by experiment in each special case.

152. *Pressure on a Cylindrical Body of a Length about three times its Diameter.*—A contraction of the stream is formed at $\mathrm{A}_1\mathrm{A}_1$

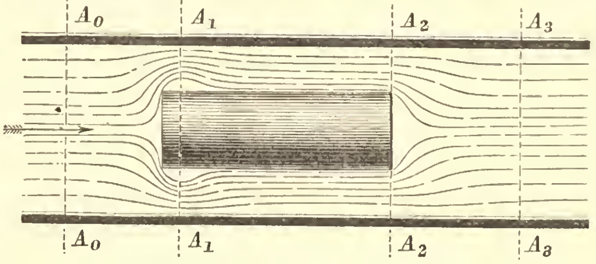


Fig. 168.

(fig. 168). Let the same notation be used, the subscript figures indicating the section to which the quantities belong.

For sections $\mathrm{A}_0\mathrm{A}_0$, $\mathrm{A}_1\mathrm{A}_1$,

$$\frac{p_0}{\mathrm{G}}+\frac{v^2}{2g}=\frac{p_1}{\mathrm{G}}+\frac{v_1^2}{2g}\,;$$

for sections $\mathrm{A}_1\mathrm{A}_1$ and $\mathrm{A}_2\mathrm{A}_2$, allowing for the abrupt enlargement of the stream,

$$\frac{p_1}{\mathrm{G}}+\frac{v_1^2}{2g}=\frac{p_2}{\mathrm{G}}+\frac{v_2^2}{2g}+\frac{(v_1-v_2)^2}{2g}\,;$$

and for sections $\mathrm{A}_2\mathrm{A}_2$, $\mathrm{A}_3\mathrm{A}_3$, allowing for another abrupt enlargement,

$$\frac{p_2}{\mathrm{G}}+\frac{v_2^2}{2g}=\frac{p_3}{\mathrm{G}}+\frac{v^2}{2g}+\frac{(v_2-v)^2}{2g}\,.$$

Adding the three equations,

$$p_0-p_3=\mathrm{G}\left\{\frac{(v_1-v_2)^2}{2g}+\frac{(v_2-v)^2}{2g}\right\}.$$

From the principle of momentum,

$$(p_0-p_3)\Omega-\mathrm{R}=0\,;$$

$$\mathrm{R}=\mathrm{G}\Omega\left\{\frac{(v_1-v_2)^2}{2g}+\frac{(v_2-v)^2}{2g}\right\}.$$

Putting ω for the section of the body, c_c for the coefficient of contraction, $c_c(\Omega-\omega)$ for the area of the stream at A_1A_1,

$$v_1 = v\frac{\Omega}{c_c(\Omega-\omega)}\ ;\ v_2 = v\frac{\Omega}{\Omega-\omega}\ ;$$

or, putting $\rho = \frac{\Omega}{\omega}$,

$$v_1 = v\frac{\rho}{c_c(\rho-1)}\ ,\ v_2 = v\frac{\rho}{\rho-1}\ .$$

Then

$$R = K_1 G\omega\frac{v^2}{2g}\ ,$$

where

$$K_1 = \rho\left\{\left(\frac{\rho}{\rho-1}\right)^2\left(\frac{1}{c_c}-1\right)^2+\left(\frac{\rho}{\rho-1}-1\right)^2\right\}.$$

Taking $c_c = 0{\cdot}85$ and $\rho = 4$, $K_1 = 0{\cdot}467$, a value less than before. Hence there is less pressure on the cylinder than on the thin plane.

153. *Distribution of Pressure on a Surface on which a Jet impinges normally.*—The principle of momentum gives readily enough the total or resultant pressure of a jet impinging on a plane surface, but in some cases it is useful to know the distribution of the pressure. The problem in the case in which the plane is struck normally, and the jet spreads in all directions, is one of great complexity, but even in that case the maximum intensity of the pressure is easily assigned. Each layer of water flowing from an orifice is gradually deviated (fig. 169) by contact with the surface, and during deviation exercises a centrifugal pressure towards the axis of the jet. The force exerted by each small mass of water is normal to its path, and inversely as the radius of curvature of the path. Hence the greatest pressure on the plane must be at the axis of the jet, and the pressure must decrease from the axis outwards, in some such way as is shown by the curve of pressure in fig. 170, the branches of the curve being probably asymptotic to the plane.

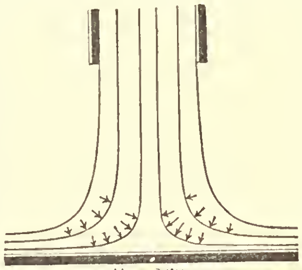


Fig. 169.

For simplicity suppose the jet is a vertical one. Let h_1 be the depth of the orifice from the free surface, and v_1 the velocity of discharge. Then, if ω is the area of the orifice, the quantity of water impinging on the plane is obviously

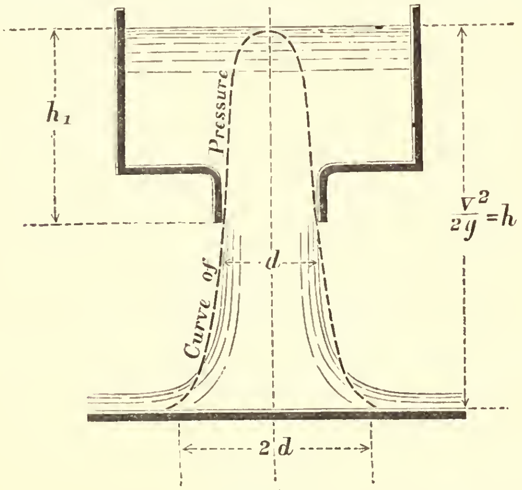


Fig. 170.

$$Q = \omega v_1 = \omega\sqrt{2gh_1}\ ;$$

that is, supposing the orifice rounded, and neglecting the coefficient of discharge.

The velocity with which the fluid reaches the plane is, however, greater than this, and may reach the value

$$v = \sqrt{2gh}\ ;$$

where h is the depth of the plane below the free surface. The external layers of fluid subjected throughout, after leaving the orifice, to the atmospheric pressure will attain the velocity v, and will flow away with this velocity unchanged except by friction. The layers towards the interior of the jet, being subjected to a pressure greater than atmospheric pressure, will attain a less velocity, and so much less as they are nearer the centre of the jet. But the pressure can in no case exceed the pressure $\frac{v^2}{2g}$ or h measured in feet of water, or the direction of motion of the water would be reversed, and there would be reflux. Hence the maximum intensity of the pressure of the jet on the plane is h feet of water. If the pressure curve is drawn with pressures represented by feet of water, it will touch the free water surface at the centre of the jet.

Suppose the pressure curve rotated so as to form a solid of revolution. The weight of water contained in that solid is the total pressure of the jet on the surface, which has already been determined. Let V = volume of this solid, then GV is its weight in pounds. Consequently

$$GV = \frac{G}{g}\omega v_1 v\ ;$$

$$V = 2\omega\sqrt{hh_1}\ .$$

We have already, therefore, two conditions to be satisfied by the pressure curve.

Some very interesting experiments on the distribution of pressure on a surface struck by a jet have been made by Mr J. S. Beresford (*Prof. Papers on Indian Engineering*, No. cccxxii.), with a view to afford information as to the forces acting on the aprons of weirs. Cylindrical jets ½ inch to 2 inches diameter, issuing from a vessel in which the water level was constant, were allowed to fall vertically on a brass plate 9 inches in diameter. A small hole in the brass plate communicated by a flexible tube with a vertical pressure column. Arrangements were made by which this aperture could be moved $\frac{1}{20}$ inch at a time across the area struck by the jet. The height of the pressure column, for each position of the aperture, gave the pressure at that point of the area struck by the jet. When the aperture was exactly in the axis of the jet, the pressure column was very nearly level with the free surface in the reservoir supplying the jet; that is, the pressure was very nearly $\frac{v^2}{2g}$. As the aperture moved away from the axis of the jet, the pressure diminished, and it became insensibly small at a distance from the axis of the jet about equal to the diameter of the jet. Hence, roughly, the pressure due to the jet extends over an area about four times the area of section of the jet.

Fig 171 shows the pressure curves obtained in three experiments with three jets of the sizes shown, and with the free surface level in the reservoir at the heights marked.

Experiment 1. Jet ·475 in. diameter.			Experiment 2. Jet ·988 in. diameter.			Experiment 3. Jet 1·95 in. diameter.		
Height from Free Surface to Brass Plate in inches.	Distance from Axis of Jet in inches.	Pressure in inches of Water.	Height from Free Surface to Brass Plate in inches.	Distance from Axis of Jet in inches.	Pressure in inches of Water.	Height from Free Surface to Brass Plate in inches.	Distance from Axis of Jet in inches.	Pressure in inches of Water.
43	0	40·5	42·15	0	42	27·15	0	26·9
,,	·05	39–40	,,	·05	41·9	,,	·08	26·9
,,	·1	37·5–39·5	,,	·1	41·5–41·8	,,	·13	26·8
,,	·15	35	,,	·15	41	,,	·18	26·5–26·6
,,	·2	33·5–37	,,	·2	40·3	,,	·23	26·4–26·5
,,	·25	31	,,	·25	39·2	,,	·28	26·3–26·6
,,	·3	21–27	,,	·3	37·5	27	·33	26·2
,,	·35	21	,,	·35	34·8	,,	·38	25·9
,,	·4	14	,,	·45	27	,,	·43	25·5
,,	·45	8	42·25	·5	23	,,	·48	25
,,	·5	3·5	,,	·55	18·5	,,	·53	24·5
,,	·55	1	,,	·6	13	,,	·58	24
,,	·6	0·5	,,	·65	8·3	,,	·63	23·3
,,	·65	0	,,	·7	5	,,	·68	22·5
			,,	·75	3	,,	·73	21·8
			,,	·8	2·2	,,	·78	21
			42·15	·85	1·6	,,	·83	20·3
			,,	·95	1	,,	·88	19·3
						,,	·93	18
						,,	·98	17
						26·5	1·13	13·5
						,,	1·18	12·5
						,,	1·23	10·8
						,,	1·28	9·5
						,,	1·33	8
						,,	1·38	7
						,,	1·43	6·3
						,,	1·48	5
						,,	1·53	4·3
						,,	1·58	3·5
						,,	1·9	2

As the general form of the pressure curve has been already indicated, it may be assumed that its equation is of the form

$$y = ab^{-x^2}\quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

But it has already been shown that for $x=0$, $y=h$, hence $a=h$.

To determine the remaining constant, the other condition may be used, that the solid formed by rotating the pressure curve represents the total pressure on the plane. The volume of the solid is

$$V = \int_0^\infty 2\pi xy dx$$

$$= 2\pi h \int_0^\infty b^{-x^2} x dx$$

$$= \frac{\pi h}{\log_\epsilon b}\Big[-b^{-x^2} \Big]_0^\infty$$

$$= \frac{\pi h}{\log_\epsilon b} .$$

Using the condition already stated,

$$2\omega\sqrt{hh_1} = \frac{\pi h}{\log_\epsilon b} ;$$

$$\log_\epsilon b = \frac{\pi}{2\omega}\sqrt{\frac{h}{h_1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Putting the value of b in (2) in eq. (1), and also r for the radius of the jet at the orifice, so that $\omega = \pi r^2$, the equation to the pressure curve is

$$y = h\epsilon^{-\frac{1}{2}\sqrt{\frac{h}{h_1}}\frac{x^2}{r^2}} .$$

154. *Resistance of a Plane moving through a Fluid, or Pressure of a Current on a Plane.*—When a thin plate moves through the air, or through an indefinitely large mass of still water, in a direction normal to its surface, there is an excess of pressure on the anterior face and a diminution of pressure on the posterior face. Let v be the relative velocity of the plate and fluid, Ω the area of the plate, G the density of the fluid, h the height due to the velocity, then the total resistance is expressed by the equation

$$R = f G\Omega \frac{v^2}{2g} \text{ pounds} = f G\Omega h ;$$

where f is a coefficient having about the value 1·3 for a plate moving in still fluid, and 1·8 for a current impinging on a fixed plane, whether the fluid is air or water. The difference in the value of the coefficient in the two cases is perhaps due to errors of experiment. There is a similar resistance to motion in the case of all bodies of "*unfair*" form, that is, in which the surfaces over which the water slides are not of gradual and continuous curvature.

The stress between the fluid and plate arises chiefly in this way. The streams of fluid deviated in front of the plate, supposed for definiteness to be moving through the fluid, receive from it forward momentum. Portions of this forward moving water are thrown off laterally at the edges of the plate, and diffused through the surrounding fluid, instead of falling to their original position behind the plate. Other portions of comparatively still water are dragged into motion to fill the space left behind the plate; and there is thus a pressure less than hydrostatic pressure at the back of the plate. The whole resistance to the motion of the plate is the sum of the excess of pressure in front and deficiency of pressure behind. This resistance is independent of any friction or viscosity in the fluid, and is due simply to its inertia resisting a sudden change of direction at the edge of the plate.

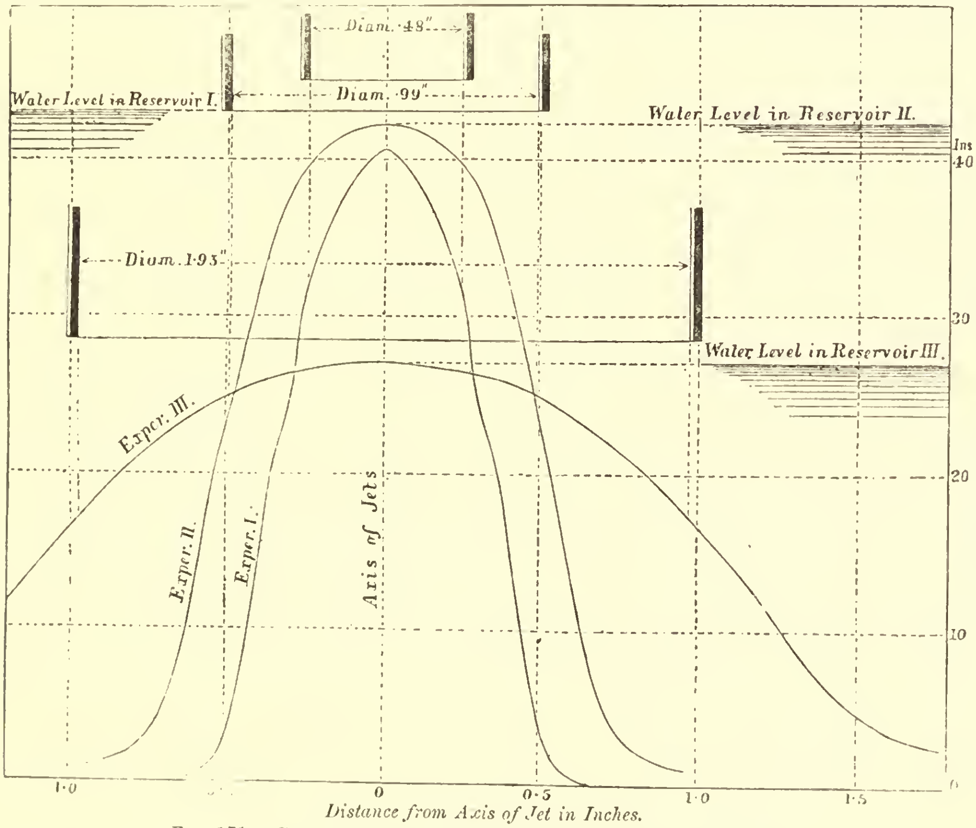


Fig. 171.—Curves of Pressure of Jets impinging normally on a Plane.

Experiments made by a whirling machine, in which the plate is fixed on a long arm and moved circularly, gave the following values of the coefficient f. The method is not free from objection, as the centrifugal force causes a flow outwards across the plate.

Approximate Area of Plate in sq. ft.	Values of f.		
	Borda.	Hutton.	Thibault.
0·13	1·39	1·24	...
0·25	1·49	1·43	1·525
0·63	1·64	...	...
1·11	...	...	1·784

There is a steady increase of resistance with the size of the plate, in part or wholly due to centrifugal action.

Dubuat made experiments on a plane one foot square, moved in a straight line in water at 3 to 6½ feet per second. Calling m the coefficient of excess of pressure in front, and n the coefficient of deficiency of pressure behind, so that $f = m + n$, he found the following values:—

$$m = 1 ; \; n = 0{\cdot}433 ; \; f = 1{\cdot}433.$$

The pressures were measured by pressure columns. Experiments by Morin, Piobert, and Didion on plates of 0·3 to 2·7 square feet area, drawn vertically through water, gave $f = 2{\cdot}18$; but the experiments were made in a reservoir of comparatively small depth. For similar plates moved through air they found $f = 1{\cdot}36$, a result more in accordance with those which precede.

For a fixed plane in a moving current of water Mariotte found $f = 1{\cdot}25$. Dubuat, in experiments in a current of water like those mentioned above, obtained the values $m = 1{\cdot}186$; $n = 0{\cdot}670$; $f = 1{\cdot}856$. Thibault exposed to wind pressure planes of 1·17 and 2·5 square feet area, and found f to vary from 1·568 to 2·125, the mean value being $f = 1{\cdot}834$, a result agreeing well with Dubuat.

155. *Case when the Direction of Motion is oblique to the Plane.*—The determination of the pressure between a fluid and surface in this case is of importance in many practical questions, for instance, in assigning the load due to wind pressure on sloping and curved roofs, and experiments have been made by Hutton, Vince, and Thibault on planes moved circularly through air and water on a whirling machine.

Let AB (fig. 172) be a plane moving in the direction R making an angle ϕ with the plane. The resultant pressure between the fluid and the plane will be a normal pressure N. The component R of this normal pressure is the resistance to the motion of the plane and the other component L is a lateral force resisted by the guides which support the plane. Obviously

$$R = N \sin \phi ;$$
$$L = N \cos \phi .$$

In the case of wind pressure on a sloping roof surface, R is the horizontal and L the vertical component of the normal pressure.

In experiments with the whirling machine it is the resistance to motion, R, which is directly measured. Let P be the pressure on a plane moved normally through a fluid. Then, for the same plane inclined at an angle ϕ to its direction of motion, the resistance was found by Hutton to be

$$R = P(\sin \phi)^{1 \cdot 842 \cos \phi}.$$

A simpler and more convenient expression given by Colonel Duchemin is

$$R = P \frac{2 \sin^2\phi}{1 + \sin^2\phi}.$$

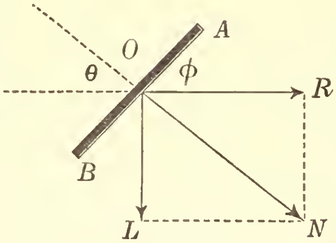


Fig. 172.

Consequently, the total pressure between the fluid and plane is

$$N = P \frac{2 \sin \phi}{1 + \sin^2\phi} = \frac{2P}{\operatorname{cosec} \phi + \sin \phi},$$

and the lateral force is

$$L = P \frac{2 \sin \phi \cos \phi}{1 + \sin^2\phi}.$$

In 1872 some experiments were made for the Aeronautical Society on the pressure of air on oblique planes. These plates, of 1 to 2 feet square, were balanced by ingenious mechanism designed by Mr Wenham and Mr Spencer Browning, in such a manner that both the pressure in the direction of the air current and the lateral force were separately measured. These planes were placed opposite a blast from a fan issuing from a wooden pipe 18 inches square. The pressure of the blast varied from $\frac{6}{10}$ to 1 inch of water pressure. The following are the results given in pounds per square foot of the plane, and a comparison of the experimental results with the pressures given by Duchemin's rule. These last values are obtained by taking $P = 3 \cdot 31$, the observed pressure on a normal surface:—

Angle between Plane and Direction of Blast.	15°	20°	60°	90°
Horizontal pressure R	0·4	0·61	2·73	3·31
Lateral pressure L	1·6	1·96	1·26	...
Normal pressure $\sqrt{L^2 + R^2}$	1·65	2·05	3·01	3·31
Normal pressure by Duchemin's rule	1·605	2·027	3·276	3·31

Resistance of Ships.

156. Down to a recent period the resistance of ships was supposed to be due to a difference between the pressure on the bow and stern, caused by the pushing aside of the water, precisely as in the case of the "unfair" bodies whose resistance has just been discussed. Hence the resistance was supposed to be proportional to the immersed midship sectional area of the vessel. It will be shown immediately, however, that in a "fair" body, completely immersed, there is no resistance of this kind, the pressure of the water closing in behind exactly balancing the excess of pressure on the bow. In such a body, therefore, the resistance is almost entirely due to the frictional drag of the water on the surface of the body, and is proportional to its skin area. In a ship, which is only partially immersed, a further resistance, which in some cases becomes very large, is due to the alteration of the surface level of the water causing a dissipation of energy in producing waves.

157. *Stream Line Motion of a Fluid past a submerged Body.*—Consider a shipshape body, or body of *fair* form, that is, bounded by surfaces of continuous curvature, moving below the surface of a fluid, and for the moment let the friction of the fluid against the

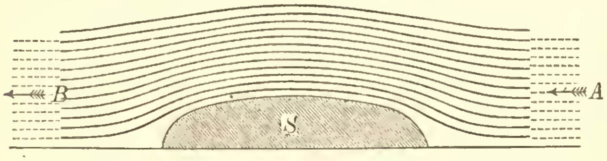


Fig. 173.

surface of the body be supposed absent. In such conditions, the particles of fluid are gradually deviated sideways as the body passes, and gradually close together again behind it. They are left after the operation in their original position with momentum unchanged; there is, therefore, in this case no resistance due to the direct action of the inertia of the water.

The nature of the action is more conveniently studied by supposing the body at rest and the fluid flowing past it. Let S, fig 173, represent the immersed body surrounded by fluid which is flowing past it. The fluid particles, arriving at A in the direction shown by the arrow, are gradually deviated as they approach S, gradually unite again after passing it; and, if the body is of fair form, that is, if it presents no abrupt changes of section or discontinuity of curvature, the stream lines or paths of the particles will be continuous lines, which take, at a sufficient distance B sternwards of S, their original direction of motion. The fluid surrounding S may then be conceived to be divided into an infinite number of elementary streams of continuous curvature. Suppose, for simplicity, S is a solid of revolution. Then, from the similarity of conditions in all directions, the elementary streams will be in planes drawn through the axis of S.

Each elementary stream may be conceived as a mass of fluid flowing steadily in an infinitely thin frictionless pipe. But it has already been shown that in a tortuous pipe, the ends of which are in the same direction, there is no resultant force due to the motion of the fluid which tends to displace the pipe, either due to its curvature or its changes of section. Consequently the whole mass of fluid exerts no resultant pressure on the body S past which it is flowing. Nor, if the fluid is at rest, will there be any resistance to the uniform motion of the body S through it. The resistance of the ship therefore cannot be due, like that of an unshipshape body, to the forward momentum impressed directly on the fluid. In a frictionless fluid, and for a uniformly moving and wholly immersed body of fair form, the resistance would be *nil*.

With a fluid which is not perfectly frictionless, however, a resistance may be generated in this way. The particles of water exert a drag on the surface of the body over which they slide. They receive, either in consequence of their adhesion to the surface, or in consequence of impact on the roughnesses which project from it, a forward momentum, and the velocity at B is no longer, as in a frictionless fluid, the same as the velocity at A.

In the case of a ship which is only in part immersed there is another source of resistance. Considering the elementary streams already defined as flowing along indefinitely thin frictionless pipes, it is obvious that there would be greater pressure in those parts where the cross section was large and the velocity small, and less pressure where the section was small and the velocity high. It will be seen from the diagram that the streams are large in cross section in the neighbourhood of the bow and stern, and small along the sides. There will therefore be an excess of pressure at bow and stern, and a diminution at the sides. But the free surface of the water in which the ship floats is a surface of uniform pressure. Hence the water will be forced up at the bow and stern, and sink down in the space between, the variation of the hydrostatic pressure due to depth balancing the variation of pressure in the stream lines. There are thus formed waves accompanying the ship. So far as the ship in its passage through the water has to supply the waste of energy due to the diffusion of this wave motion in the surrounding liquid, it suffers a resistance which may be termed the wave-making resistance. This resistance would arise even in a frictionless fluid.

It will be seen from the foregoing that the two principal causes of the resistance to the motion of a ship are the skin friction and the production of waves. The frictional resistance depends on the immersed surface of the ship, its roughness, and the velocity of the water relatively to the surface. Mr Froude concludes that no sensible error is committed if the frictional resistance is taken to be equivalent to that of a rectangular surface of equal area and of length (in the line of motion) equal to that of the ship and moving at the same speed. For such a rectangular surface Mr Froude's experiments already described furnish the means of calculating the resistance.

Experiments made on H.M. ship "Greyhound" appear to show that in well-formed, clean-bottomed ships, at speeds not exceeding 8 knots per hour, the frictional resistance is from 80 to 90 per cent. of the whole resistance, and that at the greatest speeds of the quickest ships the frictional resistance is from 60 to 70 per cent. of the whole resistance. For ships with foul bottoms the frictional resistance is a still larger fraction of the whole resistance.

The wave-making resistance is not yet fully understood, and involves considerations beyond the scope of the present article. For any given length of ship, with given proportions of entrance, middle body, and run, there is a limit of speed beyond which the resistance due to dissipation of energy in waves rapidly increases. Below that limit the resistance, being chiefly due to friction, increases nearly as the square of the speed. Above that limit the resistance increases as a higher power of the speed. In the trials of the "Greyhound" the resistance varied nearly as the square of the speed up to 8 knots per hour, as the cube of the speed at 10 knots, and as the fourth power of the speed at 12 knots.

158. *Ratio of the Resistance of Models and of Actual Ships.*—It will be understood from the foregoing explanations that the laws of the resistance of ships are complicated and at present imperfectly

known. Mr Froude has, however, indicated a way in which experiments, on comparatively small models, may be made so as to furnish very useful data as to the resistance of ships. In order that experiments on models may be serviceable, it is necessary that their resistance should be measured at speeds for which the different resistances bear the same proportion to each other as in the actual ship. Let d be the ratio of the dimensions of the model to that of the ship. Let R_1, R_2, R_3 . . . be the resistances of the model at speeds v_1, v_2, v_3 . . . Then it may be expected that the actual ship at speeds $v_1\sqrt{d}$, $v_2\sqrt{d}$, $v_3\sqrt{d}$ . . . will have resistances d^3R_1, d^3R_2, d^3R_3.

This law, however, is not strictly applicable to that part of the resistance which is due to friction, because of the diminution of the coefficient of friction for a given surface as the length increases. Hence, when the resistance of the model has been ascertained, a correction must be made to allow for the different coefficient of friction of the ship. The frictional resistances of the model and of the ship are calculated from their immersed surfaces, using the coefficients of friction suitable for their respective lengths. Deducting the former and adding the latter to the observed resistance at the corresponding speeds, the total resistance of the ship is ascertained.

XIII. HYDRAULIC MACHINERY.

159. Hydraulic machinery may be broadly divided into hydraulic motor machines and pumps. In the former class, a quantity of water descending from a higher to a lower level, or from a higher to a lower pressure, drives a machine which receives energy from the water, and applies it to overcoming the resistances of other machines doing useful work. In the latter class, work done on the machine by a steam engine or other source of energy is employed in lifting water from a lower to a higher level. A few machines such as the ram and jet pump combine the functions of motors and pumps.

Water Motors.

In every system of machinery deriving energy from a natural water fall there exist the following parts :—

(1) A supply channel or head race, leading the water from the highest accessible level to the site of the machine. This may be an open channel of earth, masonry, or wood, laid at as small a slope as is consistent with the delivery of the necessary supply of water, or it may be a closed cast or wrought-iron pipe, laid at the natural slope of the ground, and about 3 feet below the surface. In some cases part of the head race is an open channel, part a closed pipe. The channel often starts from a small storage reservoir, constructed near the stream supplying the water motor, in which the water accumulates when the motor is not working. There are sluices or penstocks by which the supply can be cut off when necessary.

(2) Leading from the motor there is a tail race, culvert, or discharge pipe delivering the water after it has done its work at the lowest convenient level.

(3) A waste channel, weir, or bye-wash is placed on or at the origin of the head race, by which surplus water, in floods, escapes.

(4) The motor itself, of one of the kinds to be described presently, which either overcomes a useful resistance directly, as in the case of a ram acting on a lift or crane chain, or indirectly by actuating transmissive machinery, as when a turbine drives the shafting, belting, and gearing of a mill. With the motor is usually combined regulating machinery for adjusting the power and speed to the work done. This may be controlled in some cases by automatic governing machinery.

Water Motors with Artificial Sources of Energy.—The great convenience and simplicity of water motors has led to their adoption in certain cases, where no natural source of water power is available. In these cases, an artificial source of water power is created by using a steam engine to pump water to a reservoir at a great elevation, or to pump water into a closed reservoir in which there is great pressure. The water flowing from the reservoir through hydraulic engines gives back the energy expended, less so much as has been wasted in friction. Such arrangements are most useful where a continuously acting steam engine stores up energy by pumping the water, while the work done by the hydraulic engines is done intermittently.

160. *Energy of a Water Fall.*—Let H_t be the total fall of level from the point where the water is taken from a natural stream to the point where it is discharged into it again. Of this total fall a portion, which can be estimated independently, is expended in overcoming the resistances of the head and tail races or the supply and discharge pipes. Let this portion of head wasted be $\mathfrak{h}_r$. Then the available head to work the motor is $H = H_t - \mathfrak{h}_r$. It is this available head which should be used in all calculations of the proportions of the motor. Let Q be the supply of water per second. Then

$$GQH \text{ foot-pounds per second}$$

is the gross available work of the fall. The power of the fall may be rendered available in three ways. The GQ pounds of water may be placed on a machine at the highest level, and descending in contact with it a distance of H feet, the work done will be (neglecting losses from friction or leakage)

$$GQH \text{ foot-pounds per second.}$$

Or the water may descend in a closed pipe from the higher to the lower level, in which case, with the same reservation as before, the pressure at the foot of the pipe will be $p = GH$ pounds per square foot. If the water with this pressure acts on a movable piston like that of a steam engine, it will drive the piston so that the volume described is Q cubic feet per second. Then the work done will be

$$pQ = GHQ \text{ foot-pounds per second}$$

as before. Or lastly, the water may be allowed to acquire the velocity $v = \sqrt{2gH}$ by its descent. The kinetic energy of Q cubic feet will then be $\frac{G}{g}Q\frac{v^2}{2} = GQH$, and if the water is allowed to impinge on surfaces suitably curved which bring it finally to rest, it will impart to these the same energy as in the previous cases. Generally, if Q feet per second of water act by weight through a distance h_1, at a pressure p due to h_2 feet of fall, and with a velocity v due to h_3 feet of fall, so that

$$h_1 + h_2 + h_3 = H,$$

then, apart from energy wasted by friction or leakage or imperfection of the machine, the work done will be

$$GQh_1 + pQ + \frac{G}{g}\cdot Q\frac{v^2}{2g} = GQH \text{ foot pounds,}$$

the same as if the water acted simply by its weight while descending H feet.

161. *Site for Water Motor.*—Wherever a stream flows from a higher to a lower level it is possible to erect a water motor. The amount of power obtainable depends on the available head and the supply of water. In choosing a site the engineer will select a portion of the stream where there is an abrupt natural fall, or at least a considerable slope of the bed. He will have regard to the facility of constructing the channels which are to convey the water, and will take advantage of any bend in the river which enables him to shorten them. He will have accurate measurements made of the quantity of water flowing in the stream, and he will endeavour to ascertain the average quantity available throughout the year, the minimum quantity in dry seasons, and the maximum for which bye-wash channels must be provided. In many cases the natural fall can be increased by a dam or weir thrown across the stream. The engineer will also examine to what extent the head will vary in different seasons, and whether it is necessary to sacrifice part of the fall and give a steep slope to the tail race to prevent the motor being drowned by backwater in floods.

In designing or selecting a water motor it is not sufficient to consider only its efficiency in normal conditions of working. It is generally quite as important to know how it will act with a scanty water supply or a diminished head. The greatest difference in water motors is in their adaptability to varying conditions of working.

162. *Action of Water in a Water Motor.*—Water motors may be divided into water-pressure engines, water wheels, and turbines.

Water-pressure engines are machines with a cylinder and piston or ram, in principle identical with the corresponding part of a steam engine. The water is alternately admitted to and discharged from the cylinder, causing a reciprocating action of the piston or ram. It is admitted at a high pressure and discharged at a low one, and consequently work is done on the piston. The water in these machines never acquires a high velocity, and for the most part the kinetic energy of the water is wasted. The useful work is due to the difference of the pressure of admission and discharge, whether that pressure is due to the weight of a column of water of more or less considerable height, or is artificially produced in ways to be described presently.

Water wheels are large vertical wheels driven by water falling from a higher to a lower level. In most water wheels, the water acts directly by its weight loading one side of the wheel and so causing rotation. But in all water wheels a portion and in some a considerable portion of the work due to gravity is first employed to generate kinetic energy in the water; during its action on the water wheel the velocity of the water diminishes, and the wheel is therefore in part driven by the impulse due to the change of the water's momentum. Water wheels are therefore motors on which the water acts, partly by weight, partly by impulse.

Turbines are wheels, generally of small size compared with water wheels, driven chiefly by the impulse of the water. Before entering the moving part of the turbine, the water is allowed to acquire a considerable velocity; during its action on the turbine this velocity is diminished, and the impulse due to the change of momentum drives the turbine.

Roughly speaking, the fluid acts in a water-pressure engine directly by its pressure, in a water wheel chiefly by its weight causing a pressure, but in part by its kinetic energy, and in a turbine chiefly by its kinetic energy, which again causes a pressure.

Water-Pressure Engines.

163. In these water acts by simple pressure due to the height of the column in the supply pipe or the pressure in the supply reservoir. The water acts on a piston or ram which it displaces. When the height of the column exceeds 100 or 200 feet, or there is a pressure equivalent to this, water wheels are inapplicable, and turbines have the disadvantage that in such circumstances their speed is very great. Then water-pressure engines maybe very conveniently adopted. In other cases they are generally too cumbrous.

When an incompressible fluid such as water is used to actuate piston engines, two special difficulties arise. One is that the waste of work in friction is very great, if the water attains considerable velocity; another is that there is great straining action on the machinery. The violent straining action due to the more or less sudden arrest of the motion of water in machinery is termed hydraulic shock. For these reasons the maximum velocity of flow of water in hydraulic machines should generally not exceed 5 to 10 feet per second. Under very high pressure, where there is less object in economizing energy, and it is very important to keep the dimensions of the machinery small, Mr Anderson gives 24 feet per second as the limiting velocity. In large water-pressure engines used for pumping mines the average piston speed does not exceed ½ to 2 feet per second.

Direct-Acting Hydraulic Lift (fig. 174).—This is the simplest of all kinds of hydraulic motor. A cage W is lifted directly by water pressure acting in a cylinder C, the length of which is a little greater than the lift. A ram or plunger R of the same length is attached to the cage. The water pressure admitted by a cock to the cylinder forces up the ram, and when the supply valve is closed and the discharge valve opened, the ram descends. In this case the ram is 9 inches diameter, with a stroke of 49 feet. It consists of lengths of wrought-iron pipe screwed together perfectly water-tight, the lower end being closed by a cast-iron plug. The ram works in a cylinder 11 inches diameter, of 9 feet lengths of flanged cast-iron pipe. The ram passes water-tight through the cylinder cover, which is provided with double hat leathers to prevent leakage outwards or inwards. As the weight of the ram and cage is much more than sufficient to cause a descent of the cage, part of the weight is balanced. A chain attached to the cage passes over a pulley at the top of the lift, and carries at its free end a balance weight B, working in T iron guides. Water is admitted to the cylinder from a 4-inch supply pipe through a two-way slide, worked by a rack, spindle, and endless rope. The lift works under 73 feet of head, and lifts 1350 ℔ at 2 feet per second. The efficiency is given by Mr Anderson at 75 to 80 per cent.[1]

The principal prejudicial resistance to the motion of a ram of this kind is the friction of the cup leathers, which make the joint between the cylinder and ram. Some experiments by Mr John Hick give for the friction of these leathers the following formula. Let F= the total friction in pounds; d= diameter of ram in feet; p= water pressure in pounds per square foot; k a coefficient.

$F = k\,p\,d$

$k = 0{\cdot}00393$ if the leathers are new or badly lubricated;

$= 0{\cdot}00262$ if the leathers are in good condition and well lubricated.

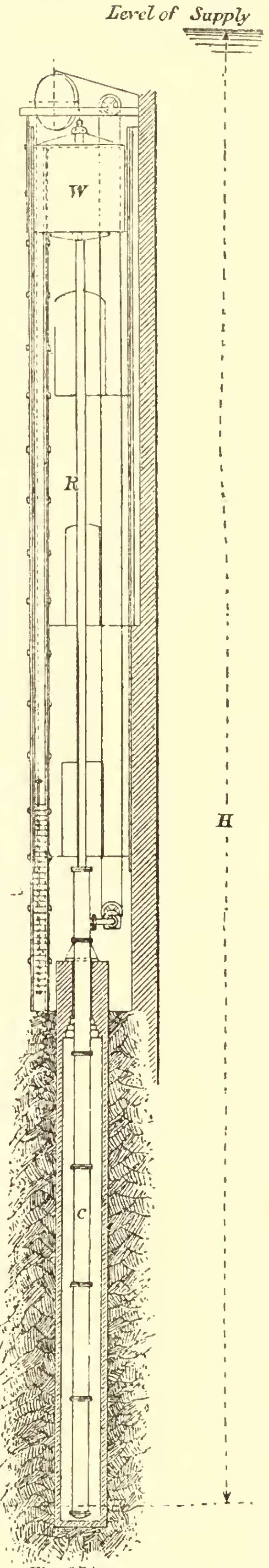


Fig. 174.

[1] The drawing and description of this ram are taken from Mr Anderson's *Chatham Lectures on Hydraulic Machinery*.

Since the total pressure on the ram is $\frac{\pi}{4}d^2p$, the fraction of the total pressure expended in overcoming the friction of the leathers is $\frac{\cdot 005}{d}$ to $\frac{\cdot 0033}{d}$, d being in feet.

Let H be the height of the pressure column measured from the free surface of the supply reservoir to the bottom of the ram in its lowest position, H_b the height from the discharge reservoir to the same point, h the height of the ram above its lowest point at any moment, S the length of stroke, Ω the area of the ram, W the weight of cage, R the weight of ram, B the weight of balance weight, w the weight of balance chain per foot run, F the friction of the cup leather and slides. Then, neglecting fluid friction, if the ram is rising the accelerating force is

$$P_1 = G(H-h)\Omega - R - W + B - w(S-h) + wh - F,$$

and if the ram is descending

$$P_2 = -G(H_b - h)\Omega + W + R - B + w(S-h) - wh - F.$$

If $w = \frac{1}{2}G\Omega$, P_1 and P_2 are constant throughout the stroke; and the moving force in ascending and descending is the same, if

$$B = W + R + wS - G\Omega\frac{H+H_b}{2}.$$

Using the values just found for w and B,

$$P_1 = P_2 = \tfrac{1}{2}G\Omega(H - H_b) - F.$$

Let $W + R + wS + B = U$, and let P be the constant accelerating force acting on the system, then the acceleration is

$$\frac{P}{U}g.$$

The velocity at the end of the stroke is (assuming the friction to be constant)

$$v = \sqrt{\left(2\frac{P}{U}gS\right)};$$

and the mean velocity of ascent is

$$\tfrac{1}{2}v.$$

164. *Self-Acting Hydraulic Engines.*—The admission and discharge valve in the lift just described is worked by hand at the required times. It is easy to see that mechanism like that used in steam engines can be applied to actuate the admission and discharge valves periodically, and the lift is then converted into a continuously acting engine.

Let H be the available fall to work the engine after deducting the loss of head in the supply and discharge pipes, Q the supply of water in cubic feet per second, and η the efficiency of the engine. Then the horse-power of the engine is

$$H.P. = \frac{\eta GQH}{550}.$$

The efficiency of large slow-moving pressure engines is $\eta = \cdot 66$ to $\cdot 8$. In small motors of this kind probably η is not greater than $\cdot 5$. Let v be the mean velocity of the piston, then its diameter d is given by the relation

$$Q = \frac{\pi}{4}d^2v \text{ in double-acting engines,}$$

$$= \frac{\pi}{8}d^2v \text{ in single-acting engines.}$$

If there are n cylinders put $\frac{Q}{n}$ for Q in these equations.

The mean velocity v is from $\frac{1}{2}$ to 2 feet per second in large engines. Smaller engines working on high lifts may be run at a greater speed, but with a sacrifice of efficiency. The usual piston speed of Messrs Hastie's engines described below is 100 feet per minute. For pressures of less than 200 feet of head, the speed is less. The velocity of the water in the supply pipes may be 3 to 6 feet per second.

In large engines the admission and discharge valves are of very large size, and require very considerable force to move them. It is also desirable that they should open and close more rapidly than the eccentric-moved valves used in steam engines. In these engines the valves are made cylindrical, so that the water pressure causes no friction of the valve on its seating. They are moved by a weight which is released at the proper moment, or by a subsidiary water-pressure engine, the valves of which being small can be actuated automatically. Tolerably full details of engines with mechanism of this kind are to be found in Weisbach's *Mechanics of Engineering*.

Small pressure engines form extremely convenient motors for hoists, capstans, or winches, and for driving small machinery. They are usually rotative engines, and may be single or double acting. The single-acting engine has the advantage that the pressure of the piston on the crank pin is always in one direction; there is then no knocking as the dead centres are passed. Generally three single-acting cylinders are used, so that the engine will readily start in all positions, and the driving effort on the crank pin is very uniform.

Mr Brotherhood's well-known three-cylinder steam engine has been modified so as to be used as a water-pressure engine. The three cylinders are formed in one casting. The valve is a circular revolving disc with segmental ports, which pass over corresponding apertures in the valve seating during rotation. The valve seating is of lignum vitæ.

Fig. 175 shows a similar engine made by Messrs Hastie of Greenock. G, G, G are the three plungers which pass out of the cylinders through cup leathers, and act on the same crank pin. A is the inlet pipe which communicates with the cock B. This cock controls the action of the engine, being so constructed that it acts as a reversing valve when the handle C is in its extreme positions and as a brake when in its middle position. With the

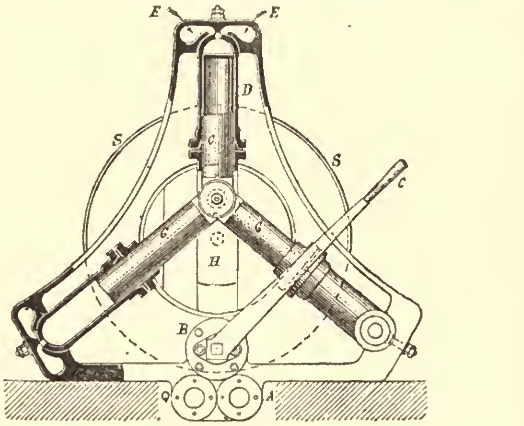


Fig. 175.

handle in its middle position, the ports of the cylinders are in communication with the exhaust. Two passages are formed in the framing leading from the cock B to the ends of the cylinders, one being in communication with the supply pipe A, the other with the discharge pipe Q. These passages end as shown at E. The oscillation of the cylinders puts them alternately in communication with each of these passages, and thus the water is alternately admitted and exhausted.

In any ordinary rotative engine the length of stroke is invariable. Consequently the consumption of water depends simply on the speed of the engine, irrespective of the effort overcome. If the power of the engine must be varied without altering the number of rotations, then the stroke must be made variable. Messrs Hastie have contrived an exceedingly ingenious method of varying the stroke automatically, in proportion to the amount of work to be done (fig. 176). The crank pin I is carried in a slide H moving in a disk M. In this is a double cam K acting on two small steel rollers J, L attached to the slide H. If the cam rotates it moves the slide and increases or decreases the radius of the circle in which the crank pin I rotates. The disk M is keyed on a hollow shaft surrounding the driving shaft P, to which the cams are attached. The hollow shaft N has two snugs to which the chains RR are attached (fig. 177). The shaft P carries the spring case SS to which also are attached the other ends of the chains. When the engine is at rest the springs extend themselves, rotating the hollow shaft N and the frame M, so as to place the crank pin I at its nearest position to the axis of rotation. When

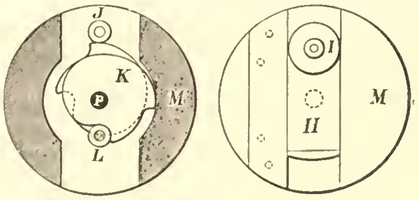


Fig. 176.

a resistance has to be overcome, the shaft N rotates relatively to P, compressing the springs, till their resistance balances the pressure due to the resistance to the rotation of P. The engine then commences to work, the crank pin being in the position in which the turning effort just overcomes the resistance. If the resistance diminishes, the springs force out the chains and shorten the stroke of the plungers, and *vice versa.* The following experiments, on an engine of this kind working a hoist, show how the automatic arrangement adjusted the water used to the work done. The lift was 22 feet and the water pressure in the cylinders 80 lb per square inch.

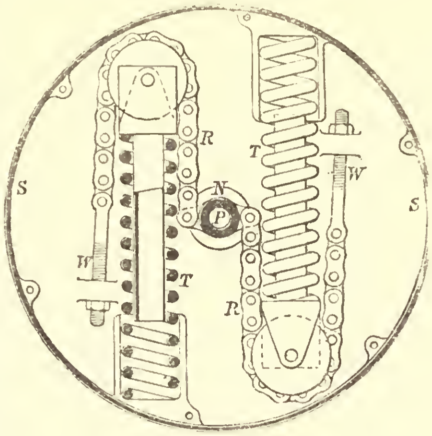


Fig. 177.

Weight lifted, in pounds	Chain only	427	633	745	857	969	1081	1193
Water used, in gallons.....	$7\frac{1}{2}$	10	14	16	17	20	21	22

165. *Accumulator Machinery.*—It has already been pointed out that it is in some cases convenient to use a steam engine to create an artificial head of water, which is afterwards employed in driving water-pressure machinery. Where power is required intermittently, for short periods, at a number of different points, as, for instance, in moving the cranes, lock gates, &c., of a dockyard, a separate steam engine and boiler at each point is very inconvenient; nor can engines worked from a common boiler be used, because of the great loss of heat and the difficulties which arise out of condensation in the pipes. If a tank, into which water is continuously pumped, can be placed at a great elevation, the water can then be used in hydraulic machinery in a very convenient way. Each hydraulic machine is put in communication with the tank by a pipe, and on opening a valve it commences work, using a quantity of water directly proportional to the work done. No attendance is required when the machine is not working.

A site for such an elevated tank is, however, seldom available, and in place of it a beautiful arrangement termed the accumulator, invented by Sir W. Armstrong, is used. This consists of a tall vertical cylinder; into this works a solid ram through cup leathers or hemp packing, and the ram is loaded by fixed weights, so that the pressure in the cylinder is 700 lb or 800 lb per square inch. The pumping engines which supply the energy that is stored in the accumulator should be a pair coupled at right angles, so as to start in any position. The engines pump into the accumulator cylinder till the ram is at the top of its stroke, when by a catch arrangement the engines are stopped. If the accumulator ram descends, in consequence of water being taken to work machinery, the engines immediately recommence working. Pipes lead from the accumulator to each of the machines requiring to be driven. These pipes do not require to be of large size, as the pressure is so great. They are generally flanged pipes about $1\frac{1}{4}$ inches bore, the joints being made by a gutta-percha ring.

Fig. 178 shows in a diagrammatic way the scheme of a system of accumulator machinery. A is the accumulator, with its ram carrying a cylindrical wrought-iron tank W, in which weights are placed to load the accumulator. At R is one of the pressure engines worked from the accumulator, discharging the water after use into the tank T. In this case the pressure engine is shown working a set of blocks, the fixed block being on the ram cylinder, the running block on the ram. The chain running over these blocks works a lift cage C, the speed of which is as many times greater than that of the ram as there are plies of chain on the block tackle. B is the balance weight of the cage.

In the use of accumulators on shipboard for working gun gear or steering gear, the accumulator ram is loaded by springs, or by steam pressure acting on a piston much larger than the ram.

Mr Tweddell has used accumulators with a pressure of 2000 lb per square inch to work hydraulic riveting machinery.

The amount of energy stored in the accumulator, having a ram d inches in diameter, a stroke of S feet, and working at p pounds pressure per square inch, is

$$\frac{\pi}{4} p d^2 S \text{ foot-pounds.}$$

Thus, if the ram is 9 inches, the stroke 20 feet, and the pressure 800 lb per square inch, the work stored in the accumulator when the ram is at the top of the stroke is 1,017,600 foot-pounds, that is, enough to drive a machine requiring one horse power for about half an hour. As, however, the pumping engine replaces water as soon as it is drawn off, the working capacity of the accumulator is very much greater than this.

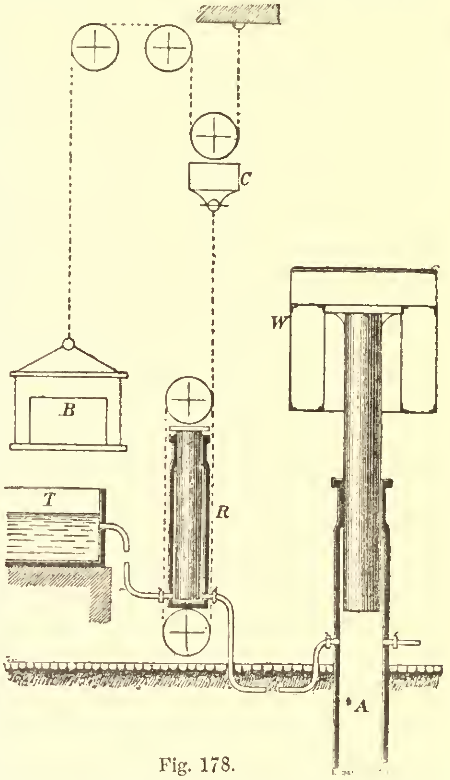


Fig. 178.

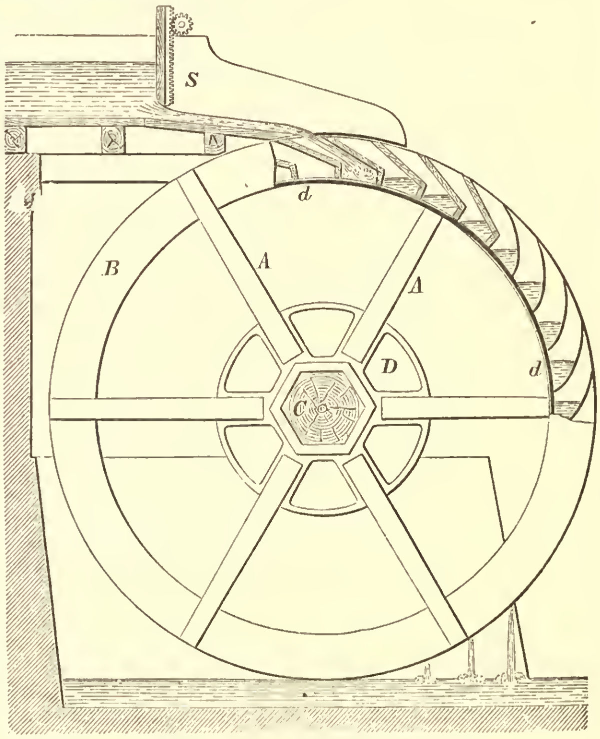


Fig. 179.

Water Wheels.

166. *Overshot and High Breast Wheels.*—When a water fall ranges between 10 and 70 feet, and the water supply

is from 3 to 25 cubic feet per second, it is possible to construct a bucket wheel on which the water acts chiefly by its weight. If the variation of the head-water level does not exceed 2 feet, an overshot wheel may be used (fig. 179). The water is then projected over the summit of the wheel, and falls in a parabolic path into the buckets. With greater variation of head-water level, a pitch-back or high breast wheel is better. The water falls over the top of a sliding sluice into the wheel, on the same side as the head race channel. By adjusting the height of the sluice, the requisite supply is given to the wheel in all positions of the head-water level.

The wheel consists of a cast-iron or wrought-iron axle C supporting the weight of the wheel. To this are attached two sets of arms A of wood or iron, which support circular segmental plates termed shrouds B. A cylindrical sole plate *dd* extends between the shrouds on the inner side. The buckets are formed by wood planks or curved wrought-iron plates extending from shroud to shroud, the back of the buckets being formed by the sole plate.

The efficiency may be taken at 0·75. Hence, if *h.p.* is the effective horse power, H the available fall, and Q the available water supply per second,

$$h.p. = 0{\cdot}75\ \frac{GQH}{550} = 0{\cdot}085\ QH.$$

If the peripheral velocity of the water wheel is too great, water is thrown out of the buckets before reaching the bottom of the fall. In practice, the circumferential velocity of water wheels of the kind now described is from $4\frac{1}{2}$ to 10 feet per second, about 6 feet being the usual velocity of good iron wheels not of very small size. In order that the water may enter the buckets easily, it must have a greater velocity than the wheel. Usually the velocity of the water at the point where it enters the wheel is from 9 to 12 feet per second, and to produce this it must enter the wheel at a point 16 to 27 inches below the head-water level. Hence the diameter of an overshot wheel may be

$$D = H - 1\tfrac{1}{3} \text{ to } H - 2\tfrac{1}{4} \text{ feet.}$$

Overshot and high breast wheels work badly in back-water, and hence if the tail-water level varies, it is better to reduce the diameter of the wheel so that its greatest immersion in flood is not more than 1 foot. The depth *d* of the shrouds is about 10 to 16 inches. The number of buckets may be about

$$N = \frac{\pi D}{d}.$$

Let *v* be the peripheral velocity of the wheel. Then the capacity of that portion of the wheel which passes the sluice in one second is

$$Q_1 = \frac{vb}{D}(Dd - d^2)$$
$$= v\,b\,d \text{ nearly,}$$

b being the breadth of the wheel between the shrouds. If, however, this quantity of water were allowed to pass on to the wheel the buckets would begin to spill their contents almost at the top of the fall. To diminish the loss from spilling, it is not only necessary to give the buckets a suitable form, but to restrict the water supply to one-fourth or one-third of the gross bucket capacity. Let *m* be the value of this ratio; then, Q being the supply of water per second,

$$Q = mQ_1 = mbdv.$$

This gives the breadth of the wheel if the water supply is known. The form of the buckets should be determined thus. The outer element of the bucket should be in the direction of motion of the water entering relatively to the wheel, so that the water may enter without splashing or shock. The buckets should retain the water as long as possible, and the width of opening of the buckets should be 2 or 3 inches greater than the thickness of the sheet of water entering.

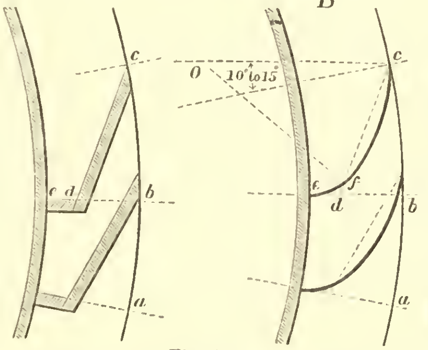


Fig. 180.

For a wooden bucket (fig. 180, A), take *ab* = distance between two buckets on periphery of wheel. Make $cd = \frac{1}{2}\,cb$, and $bc = \frac{5}{8}$ to $\frac{3}{4}\,ab$. Join *cd*. For an iron bucket (fig. 180, B), take $cd = \frac{1}{3}\,cb$; $bc = \frac{5}{6}\,ab$. Draw *c*O making an angle of 10° to 15° with the radius at *c*. On O*c* take a centre giving a circular arc passing near *d*, and round the curve into the radial part of the bucket *de*.

There are two ways in which the power of a water wheel is given off to the machinery driven. In wooden wheels and wheels with rigid arms, a spur or bevil wheel keyed on the axle of the turbine will transmit the power to the shafting. It is obvious that the whole turning moment due to the weight of the water is then transmitted through the arms and axle of the water wheel. When the water wheel is an iron one, it usually has light iron suspension arms incapable of resisting the bending action due to the transmission of the turning effort to the axle. In that case spur segments are bolted to one of the shrouds, and the pinion to which the power is transmitted is placed so that the teeth in gear are, as nearly as may be, on the line of action of the resultant of the weight of the water in the loaded arc of the wheel.

167. *The Poncelet Water Wheel.*—When the fall does not exceed 6 feet, the best water motor to adopt in many cases is the Poncelet undershot water wheel. In this the water acts very nearly in the same way as in a turbine, and the Poncelet wheel, although slightly less efficient than the best turbines, in normal conditions of working, is superior to most of them when working with a reduced supply of water. A general notion of the action of the water on a Poncelet wheel has already been given in § 145. Fig. 181 shows its construction. The water penned back

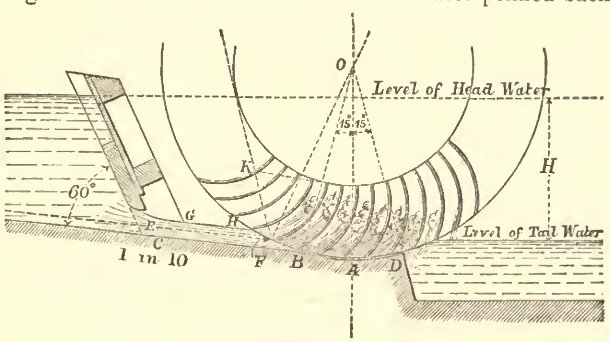


Fig. 181.

between the side walls of the wheel pit is allowed to flow to the wheel under a movable sluice, at a velocity nearly equal to the velocity due to the whole fall. The water is guided down a slope of 1 in 10, or a curved race, and enters the wheel without shock. Gliding up the curved floats it comes to rest, falls back, and acquires at the point of discharge a backward velocity relative to the wheel nearly equal to the forward velocity of the wheel. Consequently it leaves the wheel deprived of nearly the whole of its original kinetic energy.

Taking the efficiency at 0·60, and putting H for the available fall, *h.p.* for the horse-power, and Q for the water supply per second,

$$h.p. = 0{\cdot}068\ QH.$$

The diameter D of the wheel does not depend on the fall. With a straight channel of approach the smallest convenient diameter is about 14 feet, with a curved channel 10 feet. The diameter is often taken at four times the fall.

Let H′ be the fall measured from the free surface of the head-water to the point F where the mean layer enters the wheel; then the velocity at which the water enters is $v = \sqrt{2gH'}$, and the best circumferential velocity of the wheel is $V = 0{\cdot}55v$ to $0{\cdot}6v$. The number of rotations of the wheel per second is $N = \dfrac{V}{\pi D}$.

The thickness of the sheet of water entering the wheel is very important. The best thickness according to experiment is 8 to 10 inches. The maximum thickness should not exceed 12 to 15 inches, when there is a surplus water supply. Let *e* be the thickness of the sheet of water entering the wheel, and *b* its width; then

$$bev = Q;\quad \text{or } b = \frac{Q}{ev}.$$

Grashof takes $e=\frac{1}{6}H$, and then

$$b=6\frac{Q}{H\sqrt{2gH}}.$$

Allowing for the contraction of the stream, the area of opening through the sluice may be 1·25 be to 1·3 be. The inside width of the wheel is made about 4 inches greater than b.

Several constructions have been given for the floats of Poncelet wheels. One of the simplest is that shown in figs. 181, 182.

Let OA (fig. 181) be the vertical radius of the wheel. Set off OB, OD making angles of 15° with OA. Then BD may be the length of

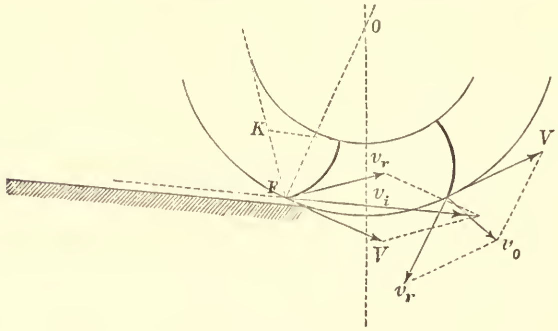


Fig. 182.

the close breasting fitted to the wheel. Draw the bottom of the head race BC at a slope of 1 in 10. Parallel to this, at distances $\frac{1}{2}e$ and e, draw EF and GH. Then EF is the mean layer and GH the surface layer entering the wheel. Join OF, and make OFK = 23°. Take FK = 0·5 to 0·7 H. Then K is the centre from which the bucket curve is struck and KF is the radius. The depth of the shrouds must be sufficient to prevent the water from rising over the top of the float. It is $\frac{1}{2}$H to $\frac{2}{3}$H. The number of buckets is not very important. They are usually 1 foot apart on the circumference of the wheel.

The efficiency of a Poncelet wheel has been found in experiments to reach 0·68. It is better to take it at 0·6 in estimating the power of the wheel, so as to allow some margin.

In fig. 182 v_i is the initial and v_o the final velocity of the water, v_r parallel to the vane the relative velocity of the water and wheel, and V the velocity of the wheel.

Turbines.

168. The name turbine was originally given in France to any water motor which revolved in a horizontal plane, the axis being vertical. The rapid development of this class of motors dates from 1827, when a prize was offered by the Societé d'Encouragement for a motor of this kind, which should be an improvement on certain wheels then in use. The prize was ultimately awarded to M. Fourneyron, whose turbine, but little modified, is still constructed.

Classification of Turbines.—In some turbines the whole available energy of the water is converted into kinetic energy before the water acts on the moving part of the turbine. Such turbines are termed *Impulse Turbines*, and they are distinguished by this that the wheel passages are never entirely filled by the water. To ensure this condition they must be placed a little above the tail water and discharge into free air.

Turbines in which part only of the available energy is converted into kinetic energy, before the water enters the turbine wheel, may be termed *Reaction Turbines*. In these the pressure is greater at the inlet than at the outlet ends of the wheel passages. The wheel passages must therefore be entirely filled, and the wheel may be and generally is placed below the tail-water level.

Next there is a difference of constructive arrangement of turbines, which does not very essentially alter the mode of action of the water. In axial flow or so called parallel flow turbines, the water enters and leaves the turbine in a direction parallel to the axis of rotation, and the paths of the molecules lie on cylindrical surfaces concentric with that axis. In radial outward and inward flow turbines, the water enters and leaves the turbine in directions normal to the axis of rotation, and the paths of the molecules lie exactly or nearly in planes normal to the axis of rotation. In outward flow turbines the general direction of flow is away from the axis, and in inward flow turbines towards the axis. There are also mixed flow turbines in which the water enters normally and is discharged parallel to the axis of rotation.

Another difference of construction is this, that the water may be admitted equally to every part of the circumference of the turbine wheel or to a portion of the circumference only. In the former case, the condition of the wheel passages is always the same; they receive water equally in all positions during rotation. In the latter case, they receive water during a part of the rotation only. The former may be termed turbines with complete admission, the latter turbines with partial admission. A reaction turbine should always have complete admission. An impulse turbine may have complete or partial admission.

When two turbine wheels similarly constructed are placed on the same axis, in order to balance the pressures and diminish journal friction, the arrangement may be termed a twin turbine.

If the water, having acted on one turbine wheel, is then passed through a second on the same axis, the arrangement may be termed a compound turbine. The object of such an arrangement would be to diminish the speed of rotation.

Many forms of reaction turbine may be placed at any height not exceeding 30 feet above the tail water. They then discharge into an air-tight suction pipe. The weight of the column of water in this pipe balances part of the atmospheric pressure, and the difference of pressure, producing the flow through the turbine, is the same as if the turbine were placed at the bottom of the fall.

I. *Impulse Turbines.*	II. *Reaction Turbines.*
(Wheel passages not filled, and discharging above the tail water.)	(Wheel passages filled, discharging above or below the tail water or into a suction-pipe.)
(*a.*) Complete admission. (Rare.) (*b.*) Partial admission. (Usual.)	Always with complete admission.

Axial flow, outward flow, inward flow, or mixed flow.

Simple turbines; twin turbines; compound turbines.

169. *The Simple Reaction Wheel.*—It has been shown, in § 151, that, when water issues from a vessel, there is a reaction on the vessel tending to cause motion in a direction opposite to that of the jet. This principle was applied in a rotating water motor at a very early period, and the Scotch turbine, at one time much used, differs in no essential respect from the older form of reaction wheel.

The old reaction wheel consisted of a vertical pipe balanced on a vertical axis, and supplied with water (fig. 183). From the bottom of the vertical pipe two or more hollow horizontal arms extended, at the ends of which were orifices from which the water was discharged. The reaction of the jets caused the rotation of the machine.

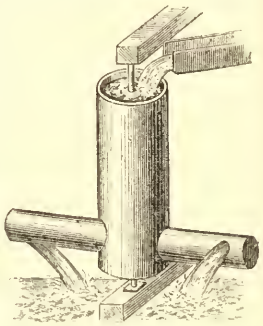


Fig. 183.

Let H be the available fall measured from the level of the water in the vertical pipe to the centres of the orifices, r the radius from the axis of rotation to the centres of the orifices, v the velocity of discharge through the jets, α the angular velocity of the machine. When the machine is at rest the water issues from the orifices with the velocity $\sqrt{2gH}$ (friction being neglected). But when the machine rotates the water in the arms rotates also, and is in the condition of a forced vortex, all the particles having the same angular velocity. Consequently the pressure in the arms at the orifices is

$$H+\frac{\alpha^2r^2}{2g}$$

feet of water, and the velocity of discharge through the orifices is

$$v=\sqrt{2gH+\alpha^2r^2}.$$

If the total area of the orifices is ω, the quantity discharged from the wheel per second is

$$Q=\omega v=\omega\sqrt{2gH+a^2r^2}.$$

While the water passes through the orifices with the velocity v, the orifices are moving in the opposite direction with the velocity ar. The absolute velocity of the water is therefore

$$v-ar=\sqrt{2gH+a^2r^2}-ar.$$

The momentum generated per second is $\frac{GQ}{g}(v-ar)$, which is numerically equal to the force driving the motor at the radius r. The work done by the water in rotating the wheel is therefore, per second,

$$\frac{GQ}{g}(v-ar)ar \text{ foot-pounds.}$$

The work expended by the water fall is GQH foot-pounds per second. Consequently the efficiency of the motor is

$$\eta=\frac{(v-ar)ar}{gH}=\frac{\left\{\sqrt{2gH+a^2r^2}-ar\right\}ar}{gH}$$

Let $\sqrt{2gH+a^2r^2}=ar+\frac{gH}{ar}-\frac{g^2H^2}{2a^3r^3}\;.\;.\;.\;.\;.$

then $\eta=1-\frac{gH}{2ar}+\;.\;.\;.\;.\;.$

which increases towards the limit 1 as ar increases towards infinity. Neglecting friction, therefore, the maximum efficiency is reached when the wheel has an infinitely great velocity of rotation. But this condition is impracticable to realize, and even, at practicable but high velocities of rotation, the friction would considerably reduce the efficiency. Experiment seems to show that the best efficiency is reached when $ar=\sqrt{2gH}$. Then the efficiency apart from friction is

$$\eta=\frac{(\sqrt{2a^2r^2}-ar)ar}{gH}$$
$$=\frac{0\cdot414a^2r^2}{gH}=0\cdot828,$$

about 17 per cent. of the energy of the fall being carried away by the water discharged. The actual efficiency realized appears to be about 60 per cent., so that about 21 per cent. of the energy of the fall is lost in friction, in addition to the energy carried away by the water.

170. *General Statement of Hydrodynamical Principles necessary for the Theory of Turbines.*

1. When water flows through any pipe-shaped passage, such as the passage between the vanes of a turbine wheel, the relation between the changes of pressure and velocity is given by Bernoulli's theorem (§ 26). Suppose that, at a section A of such a passage, h_1 is the pressure measured in feet of water, v_1 the velocity, and z_1 the elevation above any horizontal datum plane, and that at a section B the same quantities are denoted by h_2, v_2, z_2. Then

$$h_1-h_2=\frac{v_2^2-v_1^2}{2g}+z_2-z_1\;.\;.\;.\;.\;.\;.\;.\;(1).$$

If the flow is horizontal, $z_2=z_1$; and

$$h_1-h_2=\frac{v_2^2-v_1^2}{2g}\;.\;.\;.\;.\;.\;.\;.\;(1a).$$

2. When there is an abrupt change of section of the passage, or an abrupt change of section of the stream due to a contraction, then, in applying Bernoulli's equation allowance must be made for the loss of head in shock (§ 32). Let v_1, v_2 be the velocities before and after the abrupt change, then a stream of velocity v_1 impinges on a stream at a velocity v_2 and the relative velocity is v_1-v_2. The head lost is $\frac{(v_1-v_2)^2}{2g}$. Then equation $(1a)$ becomes

$$h_2-h_1=\frac{v_1^2-v_2^2}{2g}-\frac{(v_1-v_2)^2}{2g}=\frac{v_2(v_1-v_2)}{g}\;.\;.\;.\;(2).$$

To diminish as much as possible the loss of energy from irregular eddying motions, the change of section in the turbine passages must be very gradual, and the curvature without discontinuity.

3. *Equality of Angular Impulse and Change of Angular Momentum.*—Suppose that a couple, the moment of which is M, acts on a body of weight W for t seconds, during which it moves from A_1 to A_2 (fig. 184). Let v_1 be the velocity of the body at A_1, v_2 its velocity at A_2, and let p_1, p_2 be the perpendiculars from C on v_1 and v_2. Then Mt is termed the angular impulse of the couple, and the quantity

$$\frac{W}{g}(v_2p_2-v_1p_1)$$

is the change of angular momentum relatively to C. Then, from the equality of angular impulse and change of angular momentum

$$Mt=\frac{W}{g}(v_2p_2-v_1p_1),$$

or, if the change of momentum is estimated for one second,

$$M=\frac{W}{g}(v_2p_2-v_1p_1).$$

Let r_1, r_2 be the radii drawn from C to A_1, A_2, and let w_1, w_2 be the components of v_1, v_2, perpendicular to these radii, making angles β and a with v_1, v_2. Then

$$v_1=w_1\sec\beta\;;\;v_2=w_2\sec a;$$
$$p_1=r_1\cos\beta\;;\;p_2=r_2\cos a.$$
$$\therefore\;M=\frac{W}{g}(w_2r_2-w_1r_1)\cdot\;(3),$$

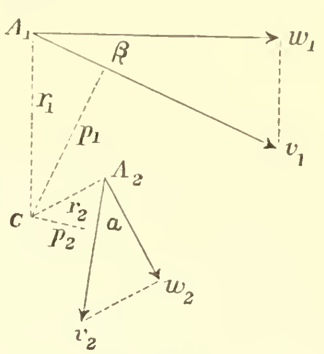


Fig. 184.

where the moment of the couple is expressed in terms of the radii drawn to the positions of the body at the beginning and end of a second, and the tangential components of its velocity at those points.

Now the water flowing through a turbine enters at the admission surface and leaves at the discharge surface of the wheel, with its angular momentum relatively to the axis of the wheel changed. It therefore exerts a couple $-M$ tending to rotate the wheel, equal and opposite to the couple M which the wheel exerts on the water. Let Q cubic feet enter and leave the wheel per second, and let w_1, w_2 be the tangential components of the velocity of the water at the receiving and discharging surfaces of the wheel, r_1, r_2 the radii of those surfaces. By the principle above,

$$-M=\frac{GQ}{g}(w_2r_2-w_1r_1)\;.\;.\;.\;.\;.\;(4).$$

If a is the angular velocity of the wheel, the work done by the water on the wheel is

$$T=Ma=\frac{GQ}{g}(w_1r_1-w_2r_2)a \text{ foot-pounds per second}\;.\;(5).$$

171. *Total and Available Fall.*—Let H_t be the total difference of level from the head-water to the tail-water surface. Of this total head a portion is expended in overcoming the resistances of the head race, tail race, supply pipe, or other channel conveying the water. Let $\mathfrak{h}_p$ be that loss of head, which varies with the local conditions in which the turbine is placed. Then

$$H=H_t-\mathfrak{h}_p$$

is the available head for working the turbine, and on this the calculations for the turbine should be based. In some cases it is necessary to place the turbine above the tail-water level, and there is then a fall $\mathfrak{h}$ from the centre of the outlet surface of the turbine to the tail-water level which is wasted, but which is properly one of the losses belonging to the turbine itself. In that case the velocities of the water in the turbine should be calculated for a head $H-\mathfrak{h}$, but the efficiency of the turbine for the head H.

172. *Gross Efficiency and Hydraulic Efficiency of a Turbine.*—Let T_d be the useful work done by the turbine, in foot-pounds per second, T_t the work expended in friction of the turbine shaft, gearing, &c., a quantity which varies with the local conditions in which the turbine is placed. Then the effective work done by the water in the turbine is

$$T=T_d+T_t.$$

The gross efficiency of the whole arrangement of turbine, races, and transmissive machinery is

$$\eta_t=\frac{T_d}{GQH_t}\;.\;.\;.\;.\;.\;.\;.\;(6).$$

And the hydraulic efficiency of the turbine alone is

$$\eta=\frac{T}{GQH}\;.\;.\;.\;.\;.\;.\;.\;.\;(7).$$

It is this last efficiency only with which the theory of turbines is concerned.

From equations (5) and (7) we get

$$\eta GQH=\frac{GQ}{g}(w_1r_1-w_2r_2)a\;;$$
$$\eta=\frac{(w_1r_1-w_2r_2)a}{gH}\;.\;.\;.\;.\;.\;.\;(8).$$

This is the fundamental equation in the theory of turbines. In general,[1] w_1 and w_2, the tangential components of the water's motion

[1] In general, because when the water leaves the turbine wheel it ceases to act on the machine. If deflecting vanes or a whirlpool are added to a turbine at the discharging side, then v_1 may in part depend on v_2, and the statement above is no longer true.

on entering and leaving the wheel, are completely independent. That the efficiency may be as great as possible, it is obviously necessary that $w_2 = 0$. In that case

$$\eta = \frac{w_1 r_1 a}{gH} \quad . \quad . \quad . \quad . \quad (9).$$

ar_1 is the circumferential velocity of the wheel at the inlet sur-

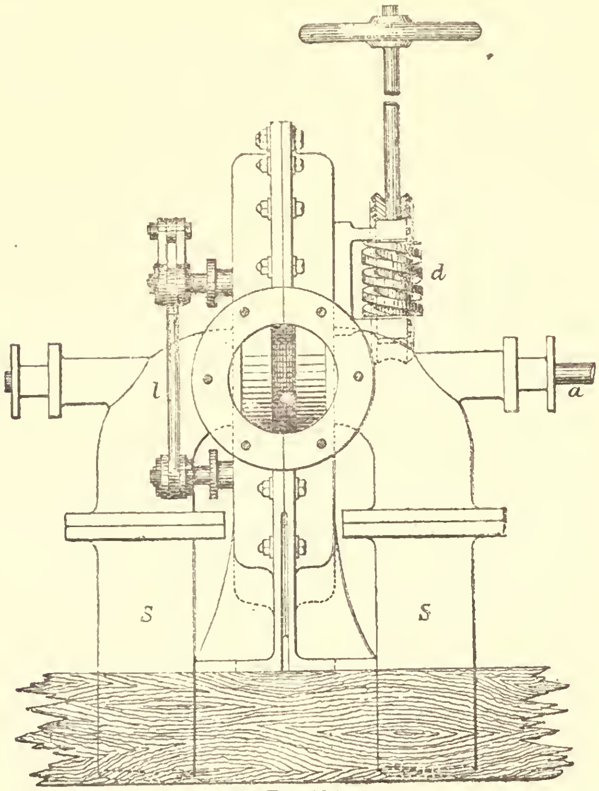


Fig. 185.

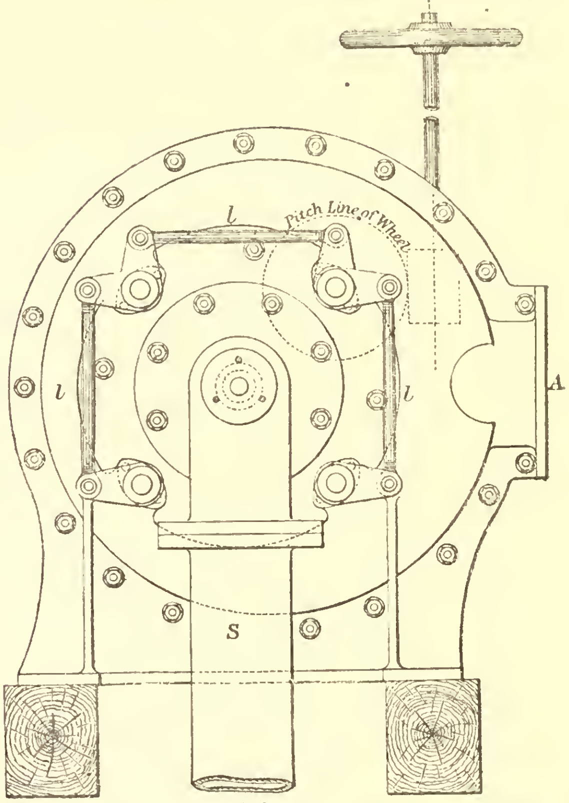


Fig. 186.

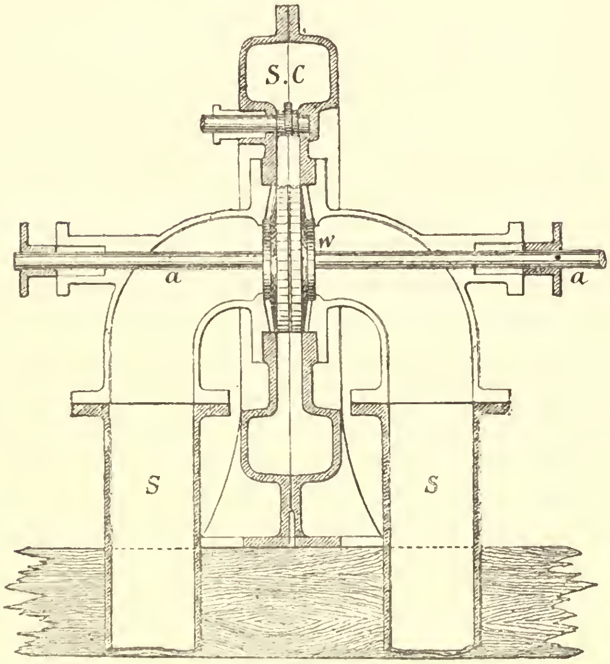


Fig. 187.

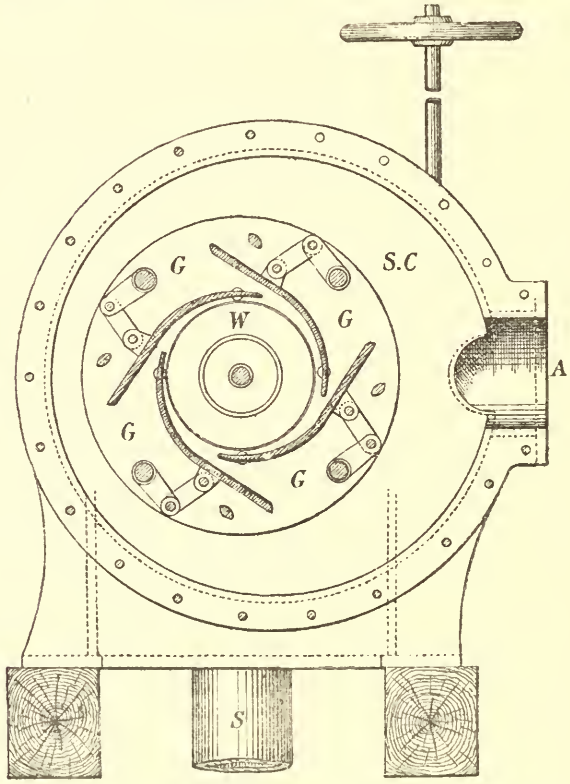


Fig. 188.

face. Calling this V_1, the equation becomes

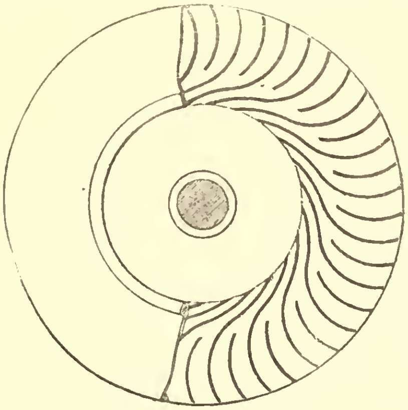
$$\eta = \frac{w_1 V_1}{gH} \quad . \quad . \quad . \quad . \quad (9a).$$

This remarkably simple equation is the fundamental equation in the theory of turbines. It was first given by Herr v. Reiche (*Turbinen-baues*, 1877).

173. *General Description of a Reaction Turbine.*—Professor James Thomson's inward flow or vortex turbine has been

selected as the type of reaction turbines. It is one of the best even in normal conditions of working, and the mode of regulation introduced is decidedly superior to that in most reaction turbines; it might almost be said to be the only mode of regulation which satisfies the conditions of efficient working, and it has been adopted in a modified form in the Leffel turbine, which is now largely used in America.

Figs. 185 and 186 are external views of the turbine case; figs. 187 and 188 are the corresponding sections; fig. 189 is



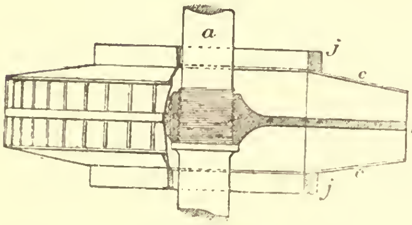


Fig. 189.

the turbine wheel. The example chosen for illustration has suction pipes, which permit the turbine to be placed at any height less than 30 feet above the tail-water level. The water enters the turbine by cast-iron supply pipes at A, and is discharged through two suction pipes S, S. The water on entering the case distributes itself through a rectangular supply chamber SC, from which it finds its way equally to the four guide-blade passages G, G, G, G. In these passages it acquires a velocity about equal to that due to half the fall, and is directed into the wheel at an angle of about 10° or 12° with the tangent to its circumference. The wheel W receives the water in equal proportions from each guide-blade passage. It consists of a centre plate p (fig. 189) keyed on the shaft aa, which passes through stuffing boxes on the suction pipes. On each side of the centre plate are the curved wheel vanes, on which the pressure of the water acts, and the vanes are bounded on each side by dished or conical coverplates c, c. Joint-rings j, j on the cover plates make a sufficiently water-tight joint with the casing, to prevent leakage from the guide-blade chamber into the suction pipes. The pressure near the joint rings is not very great, probably not one-fourth the total head. The wheel vanes receive the water without shock, and deliver it into central spaces, from which it flows on either side to the suction pipes. The mode of regulating the power of the turbine is very simple. The guide-blades are pivoted to the case at their inner ends, and they are connected by a linkwork, so that they all open and close simultaneously and equally. In this way the area of opening through the guide-blades is altered without materially altering the angle or the other conditions of the delivery into the wheel. The guide-blade gear may be variously arranged. In this example four spindles, passing through the case, are linked to the guide-blades inside the case, and connected together by the links l, l, l on the outside of the case. A worm wheel on one of the spindles is rotated by a worm d, the motion being thus slow enough to adjust the guide-blades very exactly. These turbines are made by Messrs Williamson Brothers of Kendal, who supplied the drawing of the turbine.

Fig. 190 shows another arrangement of the same turbine, with some adjuncts not shown in the other drawings. In this case the turbine rotates horizontally, and the turbine case is placed entirely below the tail water. The water is supplied to the turbine by a vertical pipe, over which is a wooden pentrough, containing a strainer, which prevents sticks and other solid bodies getting into the turbine.

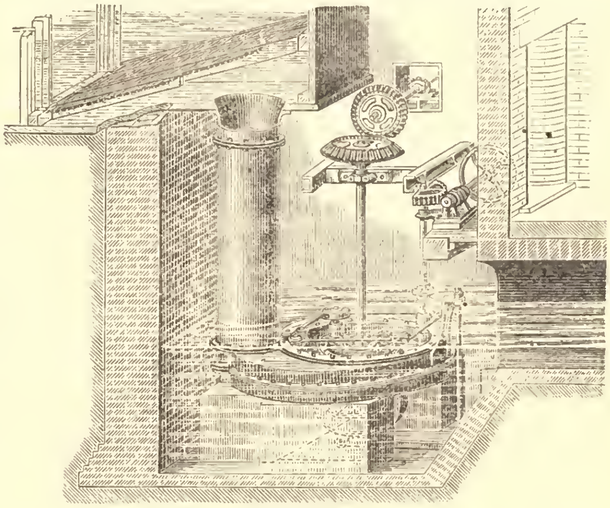


Fig. 190.

The turbine rests on three foundation stones, and, the pivot for the vertical shaft being under water, there is a screw and lever arrangement for adjusting it as it wears. The vertical shaft gives motion to the machinery driven by a pair of bevel wheels. On the right are the worm and wheel for working the guide-blade gear.

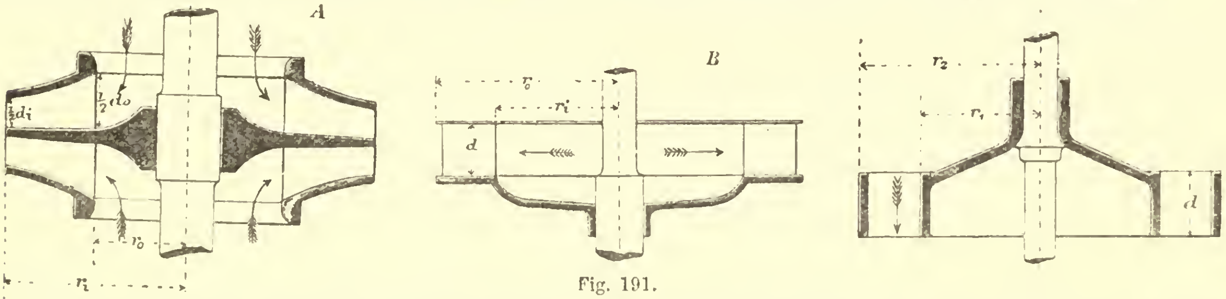


Fig. 191.

174. *Different Forms of Turbine Wheel.*—The wheel of a turbine or part of the machine on which the water acts is an annular space, furnished with curved vanes dividing it into passages exactly or roughly rectangular in cross section. For radial flow turbines the wheel may have the form A or B, fig. 191, A being most usual with inward, and B with outward flow turbines. In A the wheel vanes are fixed on each side of a centre plate keyed on the turbine shaft. The vanes are limited by slightly-coned annular cover plates. In B the vanes are fixed on one side of a disk, keyed on the shaft, and limited by a cover plate parallel to the disk. Parallel

flow or axial flow turbines have the wheel as in C. The vanes are limited by two concentric cylinders.

Reaction Turbines.

175. *Velocity of Whirl and Velocity of Flow.*—Let *acb* (fig. 192) be the path of the particles of water in a turbine wheel. That path will be in a plane normal to the axis of rotation in radial flow turbines, and on a cylindrical surface in axial flow turbines. At any point *c* of the path the water will have some velocity *v*, in the direction of a tangent to the path. That velocity may be resolved into two components, a whirling velocity *w* in the direction of the wheel's rotation at the point *c*, and a component *u* at right angles to this, radial in radial flow, and parallel to the axis in axial flow turbines. This second component is termed the velocity of flow. Let v_0, w_0, u_0 be the velocity of the water, the whirling velocity and velocity of flow at the outlet surface of the wheel, and v_i, w_i, u_i the same quantities at the inlet surface of the wheel. Let α and β be the angles which the water's direction of motion makes with the direction of motion of the wheel at those surfaces. Then

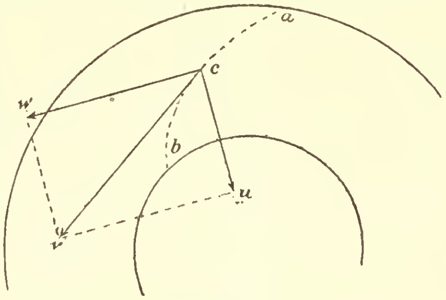


Fig. 192.

$$\left.\begin{aligned} w_0 &= v_0 \cos\beta\;;\; u_0 = v_0 \sin\beta \\ w_i &= v_0 \cos\alpha\;;\; u_i = v_i \sin\alpha \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (10).$$

The velocities of flow are easily ascertained independently from the dimensions of the wheel. The velocities of flow at the inlet and outlet surfaces of the wheel are normal to those surfaces. Let Ω_0, Ω_i be the areas of the outlet and inlet surfaces of the wheel, and Q the volume of water passing through the wheel per second; then

$$v_0 = \frac{Q}{\Omega_0}\;;\quad v_i = \frac{Q}{\Omega_i} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11).$$

Using the notation in fig. 191, we have, for an inward flow turbine (neglecting the space occupied by the vanes),

$$\Omega_0 = 2\pi r_0 d_0\;;\; \Omega_i = 2\pi r_i d_i \quad . \quad . \quad . \quad . \quad (12a).$$

Similarly, for an outward flow turbine,

$$\Omega_0 = 2\pi r_0 d\;;\; \Omega_i = 2\pi r_i d \quad . \quad . \quad . \quad . \quad . \quad (12b);$$

and, for an axial flow turbine,

$$\Omega_0 = \Omega_i = \pi\left(r_2^2 - r_1^2\right), \quad . \quad . \quad . \quad . \quad . \quad (12c).$$

Relative and Common Velocity of the Water and Wheel.—There is another way of resolving the velocity of the water. Let V be the velocity of the wheel at the point *c*, fig. 193. Then the velocity of the water may be resolved into a component V, which the water has in common with the wheel, and a component v_r, which is the velocity of the water relatively to the wheel.

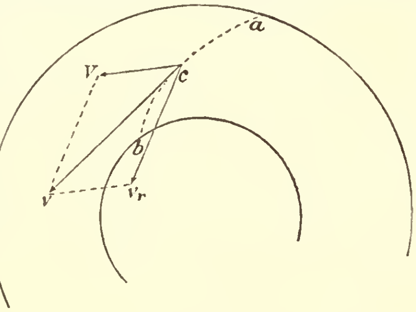


Fig. 193.

Velocity of Flow.—It is obvious that the frictional losses of head in the wheel passages will increase as the velocity of flow is greater, that is, the smaller the wheel is made. But if the wheel works under water, the skin friction of the wheel cover increases as the diameter of the wheel is made greater, and in any case the weight of the wheel and consequently the journal friction increase as the wheel is made larger. It is therefore desirable to choose, for the velocity of flow, as large a value as is consistent with the condition that the frictional losses in the wheel passages are a small fraction of the total head.

The values most commonly assumed in practice are these:—

In axial flow turbines, $u_0 = u_i = 0{\cdot}15$ to $0{\cdot}2\sqrt{2g\mathrm{H}}$;

In outward flow turbines, $u_i = 0{\cdot}25\sqrt{2g(\mathrm{H}-\mathfrak{h})}$,

$u_0 = 0{\cdot}21$ to $0{\cdot}17\sqrt{2g(\mathrm{H}-\mathfrak{h})}$;

In inward flow turbines, $u_0 = u_i = 0{\cdot}125\sqrt{2g\mathrm{H}}$.

176. *Speed of the Wheel.*—The best speed of the wheel depends partly on the frictional losses, which the ordinary theory of turbines disregards. It is best, therefore, to assume for V_0 and V_i values which experiment has shown to be most advantageous.

In axial flow turbines, the circumferential velocities at the mean radius of the wheel may be taken

$$\mathrm{V}_0 = \mathrm{V}_i = 0{\cdot}6\sqrt{2g\mathrm{H}} \text{ to } 0{\cdot}66\sqrt{2g\mathrm{H}}\ .$$

In a radial outward flow turbine,

$$\mathrm{V}_i = 0{\cdot}56\sqrt{2g(\mathrm{H}-\mathfrak{h})}$$

$$\mathrm{V}_0 = \mathrm{V}_i \frac{r_0}{r_i}\ ,$$

where r_0, r_i are the radii of the outlet and inlet surfaces.

In a radial inward flow turbine,

$$\mathrm{V}_i = 0{\cdot}66\sqrt{2g\mathrm{H}}\ ,$$

$$\mathrm{V}_0 = \frac{r_0}{r_i}\mathrm{V}_i\ .$$

If the wheel were stationary and the water flowed through it, the water would follow paths parallel to the wheel vane curves, at least when the vanes were so close that irregular motion was prevented. Similarly, when the wheel is in motion, the water follows paths relatively to the wheel, which are curves parallel to the wheel vanes. Hence the relative component, v_r, of the water's motion at *c* is tangential to a wheel vane curve drawn through the point *c*. Let v_0, V_0, v_{r0} be the velocity of the water and its common and relative components at the outlet surface of the wheel, and v_i, V_i, v_{ri} be the same quantities at the inlet surface; and let θ and ϕ be the angles the wheel vanes make with the inlet and outlet surfaces; then

$$\left.\begin{aligned} v_0^2 &= \surd(v_{r0}^2 + \mathrm{V}_0^2 - 2\mathrm{V}_0 v_{r0}\cos\phi) \\ v_i &= \surd(v_{ri}^2 + \mathrm{V}_i^2 - 2\mathrm{V}_i v_{ri}\cos\theta) \end{aligned}\right\} \quad . \quad . \quad . \quad (13),$$

equations which may be used to determine ϕ and θ.

177. *Condition determining the Angle of the Vanes at the Outlet Surface of the Wheel.* — It has been shown that, when the water leaves the wheel, it should have no tangential velocity, if the efficiency is to be as great as possible; that is, $w_0 = 0$. Hence, from (10), $\cos\beta = 0$, $\beta = 90°$, $u_0 = v_0$, and the direction of the water's motion is normal to the outlet surface of the wheel, radial in radial flow, and axial in axial flow turbines.

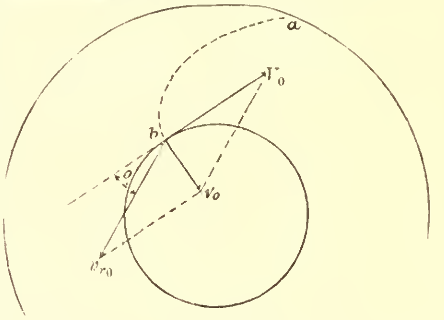


Fig. 194.

Drawing v_0 or u_0 radial or axial as the case may be, and V_0 tangential to the direction of motion, v_{r0} can be found by the parallelogram of velocities. From fig. 194,

$$\tan\phi = \frac{v_0}{\mathrm{V}_0} = \frac{u_0}{\mathrm{V}_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14);$$

but ϕ is the angle which the wheel vane makes with the outlet surface of the wheel, which is thus determined when the velocity of flow u_0 and velocity of the wheel V_0 are known. When ϕ is thus determined,

$$v_{r0} = u_0 \operatorname{cosec}\phi = \mathrm{V}_0\sqrt{1 + \frac{u_0^2}{\mathrm{V}_0^2}} \quad . \quad . \quad . \quad . \quad (14a).$$

Correction of the Angle ϕ to allow for Thickness of Vanes.—In determining ϕ, it is most convenient to calculate its value approximately at first, from a value of u_0 obtained by neglecting the thickness of the vanes. As, however, this angle is the most important angle in the turbine, the value should be afterwards corrected to allow for the vane thickness.

Let

$$\phi' = \tan^{-1}\frac{u_0}{\mathrm{V}_0} = \tan^{-1}\frac{\mathrm{Q}}{\Omega_0 \mathrm{V}_0}$$

be the first or approximate value of ϕ, and let t be the thickness, and n the number of wheel vanes which reach the outlet surface of the wheel. As the vanes cut the outlet surface approximately at the angle ϕ', their width measured on that surface is $t\operatorname{cosec}\phi'$. Hence the space occupied by the vanes on the outlet surface is

$$\left.\begin{aligned} &\text{For A, fig. 191, } ntd_0 \operatorname{cosec}\phi \\ &\text{B, fig. 191, } ntd \operatorname{cosec}\phi \\ &\text{C, fig. 191, } nt(r_2 - r_1)\operatorname{cosec}\phi \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (15).$$

Call this area occupied by the vanes ω. Then the true value of the clear discharging outlet of the wheel is $\Omega_0 - \omega$, and the true value of u_0 is $\frac{Q}{\Omega_0 - \omega}$. The corrected value of the angle of the vanes will be

$$\phi = \tan^{-1}\frac{Q}{(\Omega_0 - \omega)V_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16).$$

178. *Head producing Velocity with which the Water enters the Wheel.*—Consider the variation of pressure in a wheel passage, which satisfies the condition that the sections change so gradually that there is no loss of head in shock. When the flow is in a horizontal plane, there is no work done by gravity on the water passing through the wheel. In the case of an axial flow turbine, in which the flow is vertical, the fall d between the inlet and outlet surfaces should be taken into account.

Let V_i, V_0 be the velocities of the wheel at the inlet and outlet surfaces,
v_i, v_0 the velocities of the water,
u_i, u_0 the velocities of flow,
v_{ri}, v_{r0} the relative velocities,
h_i, h_0 the pressures, measured in feet of water,
r_i, r_0 the radii of the wheel,
a the angular velocity of the wheel.

At any point in the path of a portion of water, at radius r, the velocity v of the water may be resolved into a component $V = ar$ equal to the velocity at that point of the wheel, and a relative component v_r. Hence the motion of the water may be considered to consist of two parts:—(*a*) a motion identical with that in a forced vortex of constant angular velocity a; (*b*) a flow along curves parallel to the wheel vane curves. Taking the latter first, and using Bernoulli's theorem, the change of pressure due to flow through the wheel passages is given by the equation

$$h'_i + \frac{v_{ri}^2}{2g} = h'_0 + \frac{v_{r0}^2}{2g};$$

$$h'_i - h'_0 = \frac{v_{r0}^2 - v_{ri}^2}{2g}.$$

The variation of pressure due to rotation in a forced vortex is

$$h''_i - h''_0 = \frac{V_i^2 - V_0^2}{2g}.$$

Consequently the whole difference of pressure at the inlet and outlet surfaces of the wheel is

$$h_i - h_0 = h'_i + h''_i - h'_0 - h''_0$$

$$= \frac{V_i^2 - V_0^2}{2g} + \frac{v_{r0}^2 - v_{ri}^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad (17).$$

Case 1. *Axial Flow Turbines.*—$V_i = V_0$; and the first term on the right, in equation 17, disappears. Adding, however, the work of gravity due to a fall of d feet in passing through the wheel,

$$h_i - h_0 = \frac{v_{r0}^2 - v_{ri}^2}{2g} - d \quad . \quad . \quad . \quad . \quad . \quad (17a).$$

Case 2. *Outward Flow Turbines.*—The inlet radius is less than the outlet radius, and $\frac{V_i^2 - V_0^2}{2g}$ is negative. The centrifugal head diminishes the pressure at the inlet surface, and increases the velocity with which the water enters the wheel. This somewhat increases the frictional loss of head. Further, if the wheel varies in velocity from variations in the useful work done, the quantity $\frac{V_i^2 - V_0^2}{2g}$ increases when the turbine speed increases, and *vice versa*. Consequently the flow into the turbine increases when the speed increases, and diminishes when the speed diminishes, and this again augments the variation of speed. The action of the centrifugal head in an outward flow turbine is therefore prejudicial to steadiness of motion. For this reason $r_0 : r_i$ is made small, generally about 5 : 4. Even then a governor is sometimes required to regulate the speed of the turbine.

Case 3. *Inward Flow Turbines.*—The inlet radius is greater than the outlet radius, and the centrifugal head diminishes the velocity of flow into the turbine. This tends to diminish the frictional losses, but it has a more important influence in securing steadiness of motion. Any increase of speed diminishes the flow into the turbine, and *vice versa*. Hence the variation of speed is less than the variation of resistance overcome. In the so-called centre vent wheels in America, the ratio $r_i : r_0$ is about 5 : 4, and then the influence of the centrifugal head is not very important. Professor James Thomson first pointed out the advantage of a much greater difference of radii. By making $r_i : r_0 = 2 : 1$, the centrifugal head balances about half the head in the supply chamber. Then the velocity through the guide-blades does not exceed the velocity due to half the fall, and the action of the centrifugal head in securing steadiness of speed is considerable.

Since the total head producing flow through the turbine is $H - \mathfrak{h}$, and of this $h_i - h_0$ is expended in overcoming the pressure in the wheel, the velocity of flow into the wheel is

$$v_i = c_v \sqrt{\left\{2g\left(H - \mathfrak{h} - \frac{V_i^2 - V_0^2}{2g} + \frac{v_{r0}^2 - v_{ri}^2}{2g}\right)\right\}} \quad . \quad . \quad . \quad (18),$$

where c_v may be taken 0·96.

From (14*a*),

$$v_{r0} = V_0 \sqrt{\left(1 + \frac{u_0^2}{V_0^2}\right)}.$$

It will be shown immediately that

$$v_{ri} = u_i \operatorname{cosec} \theta;$$

or, as this is only a small term, and θ is on the average 90°, we may take, for the present purpose, $v_{ri} = u_i$ nearly.

Inserting these values, and remembering that for an axial flow turbine $V_i = V_0$, $\mathfrak{h} = 0$, and the fall d in the wheel is to be added,

$$v_i = c_v \sqrt{\left\{2g\left(H - \frac{V_i^2}{2g}\left(1 + \frac{u_0^2}{V_0^2}\right) + \frac{u_i^2}{2g} - d\right)\right\}}.$$

For an outward flow turbine,

$$v_i = c_v \sqrt{\left[2g\left\{H - \mathfrak{h} - \frac{V_i^2}{2g}\left(1 + \frac{u_0^2}{V_i^2}\right) + \frac{u_i^2}{2g}\right\}\right]}.$$

For an inward flow turbine,

$$v_i = c_v \sqrt{\left[2g\left\{H - \frac{V_i^2}{2g}\left(1 + \frac{u_0^2}{V_i^2}\right) + \frac{u_i^2}{2g}\right\}\right]}.$$

179. *Angle which the Guide-Blades make with the Circumference of the Wheel.*—At the moment the water enters the wheel, the radial component of the velocity is u_i, and the velocity is v_i. Hence, if γ is the angle between the guide-blades and a tangent to the wheel

$$\gamma = \sin^{-1}\frac{u_i}{v_i}.$$

This angle can, if necessary, be corrected to allow for the thickness of the guide-blades.

180. *Condition Determining the Angle of the Vanes at the Inlet Surface of the Wheel.*—The single condition necessary to be satisfied at the inlet surface of the wheel is that the water should enter the wheel without shock. This condition is satisfied if the direction of relative motion of the water and wheel is parallel to the first element of the wheel vanes.

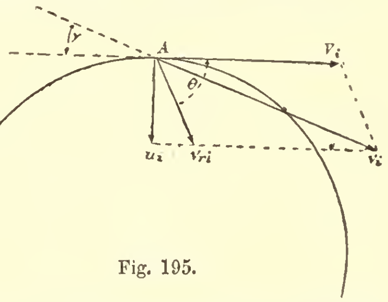


Fig. 195.

Let A (fig. 195) be a point on the inlet surface of the wheel, and let v_i represent in magnitude and direction the velocity of the water entering the wheel, and V_i the velocity of the wheel. Completing the parallelogram, v_{ri} is the direction of relative motion. Hence the angle between v_{ri} and V_i is the angle θ which the vanes should make with the inlet surface of the wheel.

181. *Example of the Method of Designing a Turbine. Professor James Thomson's Inward Flow Turbine.*—

Let H = the available fall after deducting loss of head in pipes and channels from the gross fall;
Q = the supply of water in cubic feet per second; and
η = the efficiency of the turbine.

The work done per second is

$$\eta GQH,$$

and the horse-power of the turbine is

$$h.p. = \frac{\eta GQH}{550}.$$

If η is taken at 0·75, an allowance will be made for the frictional losses in the turbine, the leakage, and the friction of the turbine shaft. Then $h.p. = 0·085QH$.

The velocity of flow through the turbine (uncorrected for the space occupied by the vanes and guide-blades) may be taken

$$u_i = u_0 = 0·125\sqrt{2gH},$$

in which case about $\frac{1}{64}$th of the energy of the fall is carried away by the water discharged.

The areas of the outlet and inlet surface of the wheel are then

$$2\pi r_0 d_0 = 2\pi r_i d_i = \frac{Q}{0{\cdot}125\sqrt{2gH}} .$$

If we take r_0, so that the axial velocity of discharge from the central orifices of the wheel is equal to u_0, we get

$$r_0 = 0{\cdot}3984 \sqrt{\frac{Q}{\sqrt{H}}},$$

$$d_0 = r_0.$$

If, to obtain considerable steadying action of the centrifugal head,

$r_i = 2r_0$, then $d_i = \frac{1}{2}d_0$.

Speed of the Wheel.—Let $V_i = 0{\cdot}66\sqrt{2gH}$, or the speed due to half the fall nearly. Then the number of rotations of the turbine per second is

$$N = \frac{V_i}{2\pi r_i} = 1{\cdot}0579 \sqrt{\left\{\frac{H\sqrt{H}}{Q}\right\}} ;$$

also $$V_0 = \frac{r_0}{r_i}V_i = 0{\cdot}33\sqrt{2gH} .$$

Angle of Vanes with Outlet Surface.

$$\text{Tan } \phi = \frac{u_0}{V_0} = \frac{0{\cdot}125}{0{\cdot}33} = {\cdot}3788 ;$$

$$\phi = 21° \text{ nearly} .$$

If this value is revised for the vane thickness it will ordinarily become about 25°.

Velocity with which the Water enters the Wheel.—The head producing the velocity is

$$H - \frac{V_i^2}{2g}\left(1 + \frac{u_0^2}{V_i^2}\right) + \frac{u_i^2}{2g}$$

$$= H\left\{1 - {\cdot}4356(1 + 0{\cdot}0358) + {\cdot}0156\right\}$$

$$= 0{\cdot}5646H.$$

Then the velocity is

$$= {\cdot}96\sqrt{2g({\cdot}5646H)} = 0{\cdot}721\sqrt{2gH}.$$

Angle of Guide-Blades.

$$\text{Sin } \gamma = \frac{u_i}{v_i} = \frac{{\cdot}125}{{\cdot}721} = 0{\cdot}173 ;$$

$$\gamma = 10° \text{ nearly}.$$

Tangential Velocity of Water entering Wheel.

$$w_i = v_i \cos \gamma = 0{\cdot}7101\sqrt{2gH}.$$

Angle of Vanes at Inlet Surface.

$$\text{Cot } \theta = \frac{w_i - V_i}{u_i} = \frac{{\cdot}7101 - {\cdot}66}{{\cdot}125} = {\cdot}4008 ;$$

$$\theta = 68° \text{ nearly}.$$

Hydraulic Efficiency of Wheel.

$$\eta = \frac{w_i V_i}{gH} = {\cdot}7101 \times {\cdot}66 \times 2$$

$$= 0{\cdot}9373.$$

This, however, neglects the friction of wheel covers and leakage. The efficiency from experiment has been found to be 0·75 to 0·80.

Impulse and Partial Admission Turbines.

182. The principal defect of most turbines with complete admission is the imperfection of the arrangements for working with less than the normal supply. With most forms of turbine the efficiency is considerably reduced when the regulating sluices are partially closed, but it is exactly when the supply of water is deficient that it is most important to get out of it the greatest possible amount of work. The imperfection of the regulating arrangements is, therefore, from the practical point of view, a serious defect. All turbine makers have sought by various methods to improve the regulating mechanism. Fourneyron, by dividing his wheel by horizontal diaphragms, virtually obtained three or more separate radial flow turbines, which could be successively set in action at their full power, but the arrangement is not altogether successful, because of the spreading of the water in the space between the wheel and guide-blades. M. Fontaine similarly employed two concentric axial flow turbines formed in the same casing. One was worked at full power, the other regulated. By this arrangement the loss of efficiency due to the action of the regulating sluice affected only half the water power. Many makers have adopted the expedient of erecting two or three separate turbines on the same waterfall. Then one or more could be put out of action and the others worked at full power. This is an excellent plan, but the separate turbines cost more than a single one. All these methods are rather palliatives than remedies. The movable guide-blades of Professor James Thomson meet the difficulty directly, but of course they are not applicable to every form of turbine.

A subsidiary defect of turbines with complete admission is their very great speed of rotation on high falls. The turbine wheel cannot be increased in diameter without great increase of the fluid friction in the passages and on the surface of the wheel, and it also becomes impossible in radial flow turbines to adjust properly the vane angles, if the diameter is made very large.

M. Callon, in 1840, patented an arrangement of sluices for axial or outward flow turbines, which were to be closed successively as the water supply diminished. By preference the sluices were closed by pairs, two diametrically opposite sluices forming a pair. The water was thus admitted to opposite but equal arcs of the wheel, and the forces driving the turbine were symmetrically placed. As soon as this arrangement was adopted, a modification of the mode of action of the water in the turbine became necessary. If the turbine wheel passages remain full of water during the whole rotation, the water contained in each passage must be put into motion each time it passes an open portion of the sluice, and stopped each time it passes a closed portion of the sluice. It is thus put into motion and stopped twice in each rotation. This gives rise to violent eddying motions and great loss of energy in shock. To prevent this, the turbine wheel with partial admission must be placed above the tail water, and the wheel passages be allowed to clear themselves of water, while passing from one open portion of the sluices to the next.

But if the wheel passages are free of water when they arrive at the open sluices, then there can be no pressure other than atmospheric pressure in the space between the sluices and wheel. The water must issue from the sluices with the whole velocity due to the head; received on the curved vanes of the wheel, the jets must be gradually deviated and discharged with a radial velocity only, precisely in the same way as when a single jet strikes a curved vane in the free air. Turbines of this kind are therefore termed turbines of free deviation. There is no variation of pressure in the jet during the whole time of its action on the wheel, and the whole energy of the jet is imparted to the wheel, simply by the impulse due to its gradual change of momentum. It is clear that the water may be admitted in exactly the same way to any fraction of the circumference at pleasure, without altering the efficiency of the wheel. The diameter of the wheel may be made as large as convenient, and thus the speed of rotation on high falls may be kept down to a manageable amount. The Poncelet water wheel is a turbine of free deviation, in which, however, the action of gravity causes the water to flow back along the vanes, so that it is discharged at the same point of the wheel at which it enters.

So long as the tail-water level is invariable, no difficulty arises in adopting the system of partial admission. But if, as is more commonly the case, the tail-water level varies, then there is danger that the turbine will be drowned in flood time, and the essential condition of the system that the wheel passages should be empty when they come in front of the open sluices will not be satisfied. If the fall is considerable, a portion of it may be sacrificed without much harm, and the wheel placed sufficiently high above the tail water to secure it from being drowned; but with low falls this is impossible. The difficulty has been overcome by a method invented by M. L. D. Girard in 1849, and termed the hydropneumatic system. The turbine is

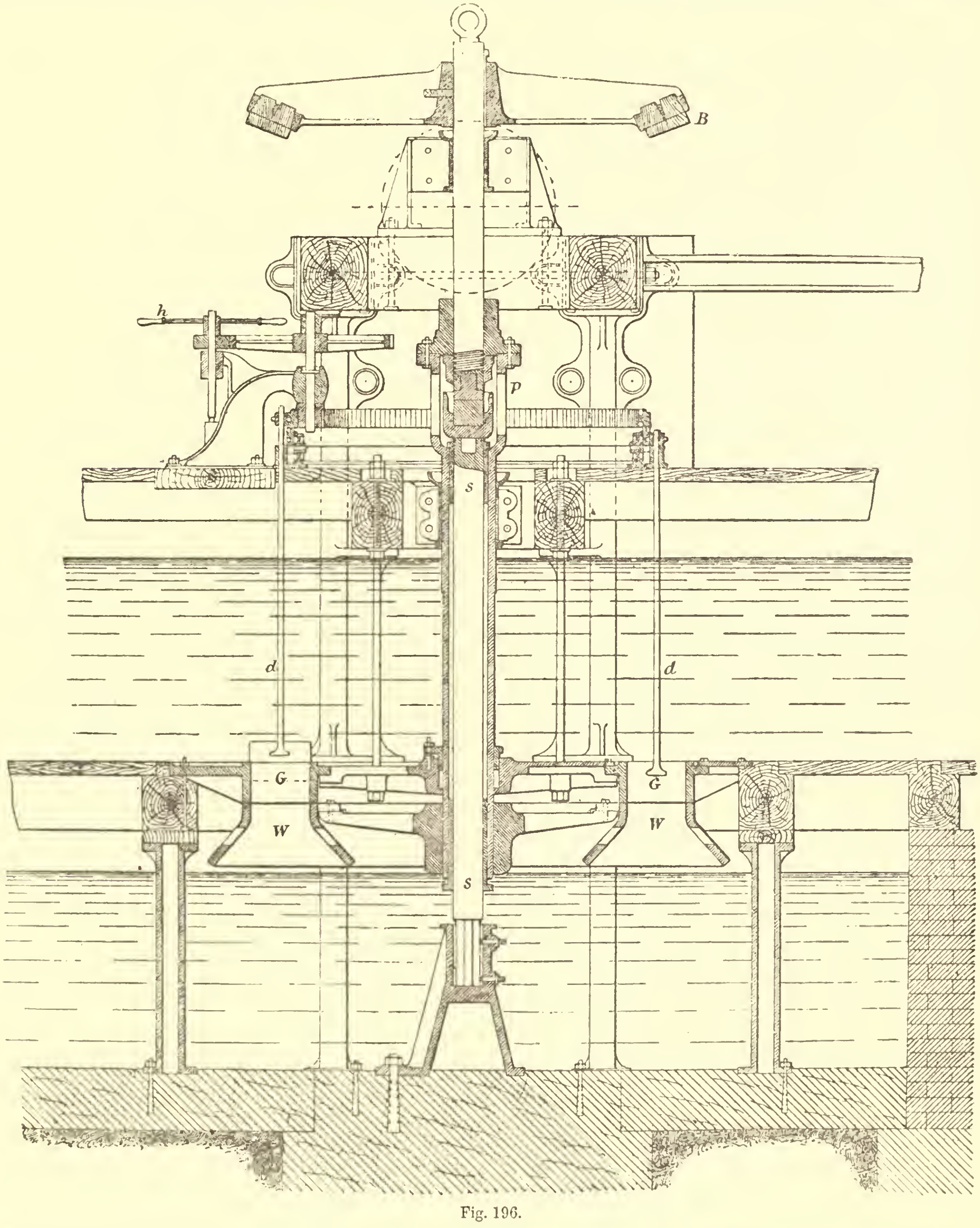


Fig. 196.

placed below the tail-water level in a casing supplied with air by a small air-pump. It therefore always discharges freely into an atmosphere of air, the pressure of which, however, varies with the height of the tail-water level outside the casing. Inside the casing the free water surface is maintained at an invariable level just below the discharge orifices of the wheel.

183. *General Description of an Impulse Turbine or Turbine with Free Deviation.*—Fig. 196 shows a general sectional elevation of a Girard turbine, in which the flow is axial. The water, admitted

above a horizontal floor, passes down through the annular wheel containing the guide-blades G, G, and thence into the revolving wheel WW. The revolving wheel is fixed to a hollow shaft suspended from the pivot p. The solid internal shaft ss is merely a fixed column supporting the pivot. The advantage of this is that the pivot is accessible for lubrication and adjustment. B is the mortise bevel wheel by which the power of the turbine is given off. The sluices are worked by the hand wheel h, which raises them successively, in a way to be described presently. a, a are the sluice rods. Figs. 197, 198 show the sectional form of the guide-blade chamber and wheel and the curves of the wheel vanes and guide-blades, when drawn on a plane development of the cylindrical section of the wheel; a, a, a are the sluices for cutting off the water; b, b, b are apertures by which the entrance or exit of air is facilitated as the buckets empty and fill. Figs. 199, 200 show the guide-blade gear. a, a, a are the sluice rods as before. At the top of each sluice rod is a small block c, having a projecting tongue, which slides in the groove of the circular cam plate d, d. This circular plate is supported on the frame e, and

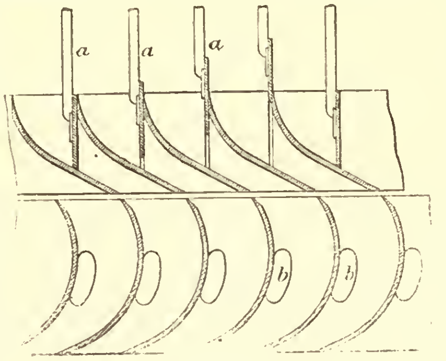


Fig. 197.

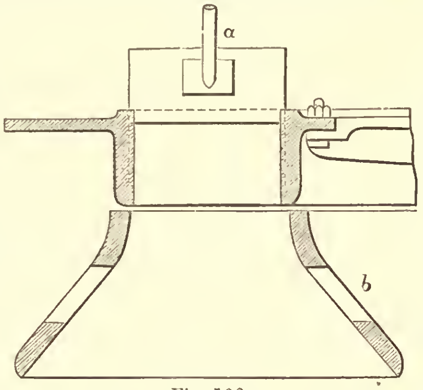


Fig. 198.

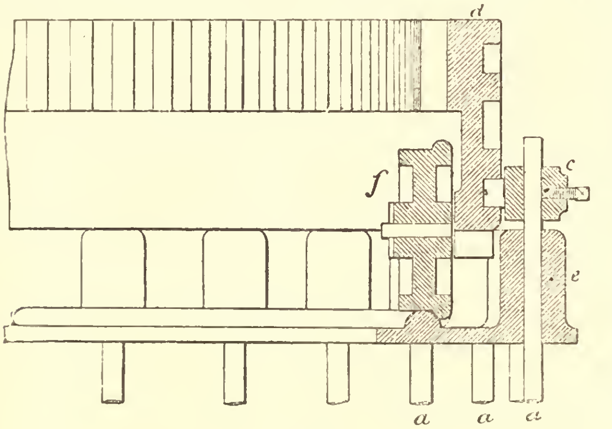


Fig. 199.

revolves on it by means of the flanged rollers f. Inside, at the top, the cam plate is toothed, and gears into a spur pinion connected with the hand wheel h. At gg is an inclined groove or shunt.

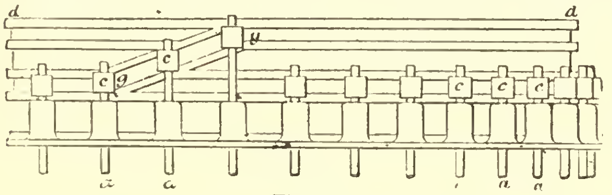


Fig. 200.

When the tongues of the blocks c, c arrive at g, they slide up to a second groove, or the reverse, according as the cam plate is revolved in one direction or in the other. As this operation takes place with each sluice successively, any number of sluices can be opened or closed as desired. The turbine is of 48 horse power on 5·12 feet fall, and the supply of water varies from 35 to 112 cubic feet per second. The efficiency in normal working is given as 73 per cent. The mean diameter of the wheel is 6 feet, and the speed 27·4 revolutions per minute.[1]

184. *Theory of the Impulse Turbine.*—The theory of the impulse turbine does not essentially differ from that of the reaction turbine, except that there is no pressure in the wheel opposing the discharge from the guide-blades. Hence the velocity with which the water enters the wheel is simply

$$v_i = 0{\cdot}96\sqrt{2g(\mathrm{H}-\mathfrak{h})},$$

where $\mathfrak{h}$ is the height of the top of the wheel above the tail water. If the hydropneumatic system is used, then $\mathfrak{h}=0$. Let Q_m be the maximum supply of water, r_1, r_2 the internal and external radii of the wheel at the inlet surface; then

$$u_i = \frac{\mathrm{Q}_m}{\pi(r_2^{\,2} - r_1^{\,2})}.$$

The value of u_i may be about $0{\cdot}45\sqrt{2g(\mathrm{H}-\mathfrak{h})}$, whence r_1, r_2 can be determined.

The guide-blade angle is then given by the equation

$$\sin\gamma = \frac{u_i}{v_i} = \frac{0{\cdot}45}{0{\cdot}94} = {\cdot}48\ ;$$
$$\gamma = 29^\circ.$$

The value of u_i should, however, be corrected for the space occupied by the guide-blades.

The tangential velocity of the entering water is

$$w_i = v_i\cos\gamma = 0{\cdot}82\sqrt{2g(\mathrm{H}-\mathfrak{h})}.$$

The circumferential velocity of the wheel may be (at mean radius)

$$\mathrm{V}_i = 0{\cdot}5\sqrt{2g(\mathrm{H}-\mathfrak{h})}.$$

Hence the vane angle at inlet surface is given by the equation

$$\cot\theta = \frac{w_i - \mathrm{V}_i}{u_i} = \frac{0{\cdot}82 - 0{\cdot}5}{0{\cdot}45} = {\cdot}71\ ;$$
$$\theta = 55^\circ.$$

The relative velocity of the water striking the vane at the inlet edge is $v_{ri} = u_i \operatorname{cosec}\theta = 1{\cdot}22u_i$. This relative velocity remains unchanged during the passage of the water over the vane; consequently the relative velocity at the point of discharge is $v_{ro} = 1{\cdot}22u_i$. Also in an axial flow turbine $\mathrm{V}_0 = \mathrm{V}_i$.

If the final velocity of the water is axial, then

$$\cos\phi = \frac{\mathrm{V}_0}{\mathrm{V}_{ro}} = \frac{\mathrm{V}_i}{\mathrm{V}_{ri}} = \frac{0{\cdot}5}{1{\cdot}22\times 0{\cdot}45} = \cos 24^\circ\ 23'.$$

This should be corrected for the vane thickness. Neglecting this, $u_0 = v_{ro}\sin\phi = v_{ri}\sin\phi = u_i\operatorname{cosec}\theta\sin\phi = 0{\cdot}5u_i$. The discharging area of the wheel must therefore be greater than the inlet area in the ratio of at least 2 to 1. In some actual turbines the ratio is 7 to 3. This greater outlet area is obtained by splaying the wheel, as shown in the section (fig. 198).

185. *The Hydraulic Ram.*—The hydraulic ram is an arrangement by which a quantity of water falling a distance h forces a portion of the water to rise to a height h_1, greater than h. It consists of a supply reservoir (A, fig. 201), into which the water enters from some natural stream. A pipe s of considerable length conducts the water to a lower level, where it is discharged intermittently through a self-acting pulsating valve at d. The supply pipe s may be fitted with a flap-valve for stopping the ram, and this is attached in some cases to a float, so that the ram starts and stops itself automatically, according as the supply cistern fills or empties. The pipe s should be as long and as straight as possible, and as it is subjected to considerable pressure from the sudden arrest of the motion of the water, it must be strong and strongly jointed. d is an air vessel, and e the delivery pipe leading to the reservoir at a higher level than A, into which water is to be pumped. Fig. 202 shows in section the construction of the ram itself. d is the pulsating discharge valve already mentioned, which opens inwards and downwards. The stroke of the valve is regulated by the cotter through the spindle, under which are washers by

[1] The drawings of this turbine have been taken partly from Meissner, *Die Hydraulik*, partly from Uhland, *Skizzenbuch*.

which the amount of fall can be regulated. At o is a delivery valve, opening outwards, which is often a ball-valve but sometimes a flap-valve. The water which is pumped passes through this valve into the air vessel a, from which it flows by the delivery pipe in a regular stream into the cistern to which the water is to be raised. In the vertical chamber behind the outer valve a small air vessel is formed,

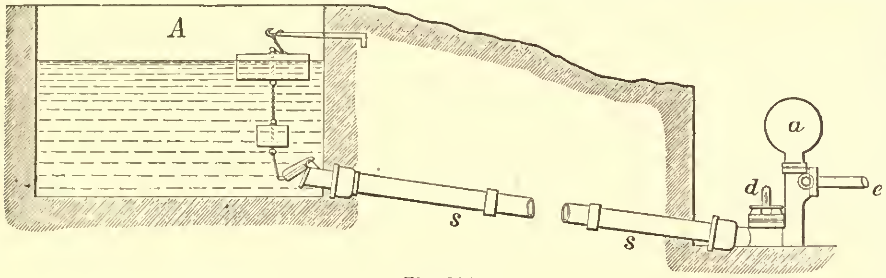


Fig. 201.

and into this opens an aperture $\frac{1}{4}$ inch in diameter, made in a brass screw plug b. The hole is reduced to $\frac{1}{16}$ inch in diameter at the outer end of the plug and is closed by a small valve opening inwards. Through this, during the rebound after each stroke of the ram, a small quantity of air is sucked in which keeps the air vessel supplied with its elastic cushion of air.

The discharge valve d is of greater weight than the statical pressure of the water on its under side. When, therefore, the water is at rest in the supply pipe this valve opens. In consequence of the flow through this valve, the water in the supply pipe acquires a gradually increasing velocity. The upward flow o the water, towards the valve d, increases the pressure tending to lift the valve, and at last, if the valve is not too heavy, lifts and closes it. The forward momentum of the column in the supply pipe being destroyed by the stoppage of the flow, the water exerts a pressure at the end of the pipe sufficient to open the delivery valve o, and to cause a portion of the water to flow into the air vessel. As the water in the supply pipe comes to rest, the valve d opens again and the operation is repeated. Part of the energy of the descending column is employed in compressing the air at the end of the supply pipe and expanding the pipe itself. This causes a recoil of the water which momentarily diminishes the pressure in the pipe below the pressure due to the statical head. This assists in opening the valve d. Mr W. Anderson states that the recoil of the water is sufficiently great to enable a pump to be attached to the ram body instead of the direct rising pipe. With this arrangement a ram working with muddy water may be employed to raise clear spring water. Instead of lifting the delivery valve as in the ordinary ram, the momentum of the column drives a sliding or elastic piston, and the recoil brings it back. This piston lifts and forces alternately the clear water through ordinary pump valves.

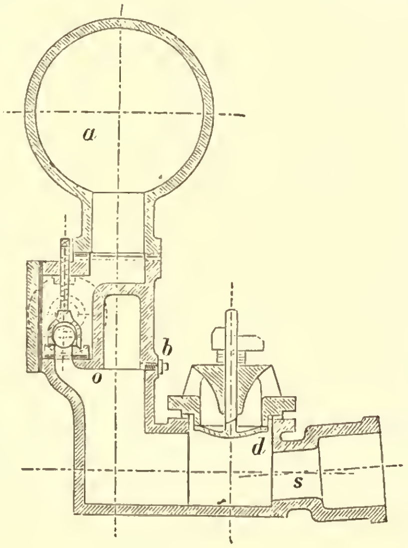


Fig. 202.

Pumps.

186. The different classes of pumps correspond almost exactly to the different classes of water motors, although the mechanical details of the construction are somewhat different. They are properly reversed water motors. Ordinary reciprocating pumps correspond to water-pressure engines. Chain and bucket pumps are in principle similar to water wheels in which the water acts by weight. Scoop wheels are similar to undershot water wheels, and centrifugal pumps to turbines.

Reciprocating Pumps are single or double acting, and differ from water-pressure engines in that the valves are moved by the water instead of by automatic machinery. They may be classed thus :—

(1.) *Lift Pumps.*—The water drawn through a foot valve on the ascent of the pump bucket is forced through the bucket valve when it descends, and lifted by the bucket when it reascends. Such pumps give an intermittent discharge.

(2.) *Plunger* or *Force Pumps*, in which the water drawn through the foot valve is displaced by the descent of a solid plunger, and forced through a delivery valve. They have the advantage that the friction is less than that of lift pumps, and the packing round the plunger is easily accessible, whilst that round a lift pump bucket is not. The flow is intermittent.

(3.) *The Double-acting Force Pump* is in principle a double plunger pump. The discharge fluctuates from zero to a maximum and back to zero each stroke, but is not arrested for any appreciable time.

(4.) *Bucket and Plunger Pumps* consist of a lift pump bucket combined with a plunger of half its area. The flow varies as in a double-acting pump.

(5.) *Diaphragm Pumps* have been used, in which the solid plunger is replaced by an elastic diaphragm, alternately depressed into and raised out of a cylinder.

The variation of velocity of discharge would cause great waste of work in the delivery pipes when they are long, and even danger from the hydraulic ramming action of the long column of water. An air vessel is interposed between the pump and the delivery pipes, of a volume from 5 to 100 times the space described by the plunger per stroke. The air in this must be replenished from time to time, or continuously, by a special air-pump. At low speeds not exceeding 30 feet per minute the delivery of a pump is about 90 to 95 per cent. of the volume described by the plunger or bucket, from 5 to 10 per cent. of the discharge being lost by leakage. At high speeds the quantity pumped occasionally exceeds the volume described by the plunger, the momentum of the water keeping the valves open after the turn of the stroke.

The velocity of large mining pumps is about 140 feet per minute, the indoor or suction stroke being sometimes made at 250 feet per minute. Rotative pumping engines of large size have a plunger speed of 90 feet per minute. Small rotative pumps are run faster, but at some loss of efficiency. Fire-engine pumps have a speed of 180 to 220 feet per minute.

The efficiency of reciprocating pumps varies very greatly. Small reciprocating pumps, with metal valves on lifts of 15 feet, were found by Morin to have an efficiency of 16 to 40 per cent., or on the average 25 per cent. When used to pump water at considerable pressure, through hose pipes, the efficiency rose to from 28 to 57 per cent., or on the average, with 50 to 100 feet of lift, about 50 per cent. A large pump with barrels 18 inches diameter, at speeds under 60 feet per minute, gave the following results :—

Lift in feet	$14\frac{1}{2}$	34	47
Efficiency	·46	·66	·70

The very large steam-pumps employed for waterworks, with 150 feet or more of lift, appear to reach an efficiency of 90 per cent., not including the friction of the discharge pipes.

The Centrifugal Pump.

187. The efficiency of reciprocating pumps diminishes with the lift. When large quantities of water are to be raised on a low lift, no pump is so suitable as a centrifugal pump. The first pump of this kind which attracted notice was one exhibited by Mr Appold in 1851, and the special features of his pump have been retained in the best pumps since constructed. Mr Appold's pump raised continuously a volume of water equal to 1400 times its own capacity per minute. It had no valves, and it permitted the passage of solid bodies, such as walnuts and oranges, without obstruction to its working. Its efficiency was also found to be good.

Fig. 203 shows a centrifugal pump differing from ordinary centrifugal pumps in one feature only. The water rises through a suction pipe S, which divides so as to enter the pump wheel at the centre on each side. The pump disk or wheel is very similar to a turbine wheel. It is keyed on a shaft driven by a belt on a fast and loose pulley arrangement at P. The water rotating in the pump disk presses outwards, and if the speed is sufficient a continuous flow is maintained through the pump and into the discharge pipe D. The special feature in this pump is that the water, discharged by the pump disk with a whirling velocity of not inconsiderable magnitude, is allowed to continue

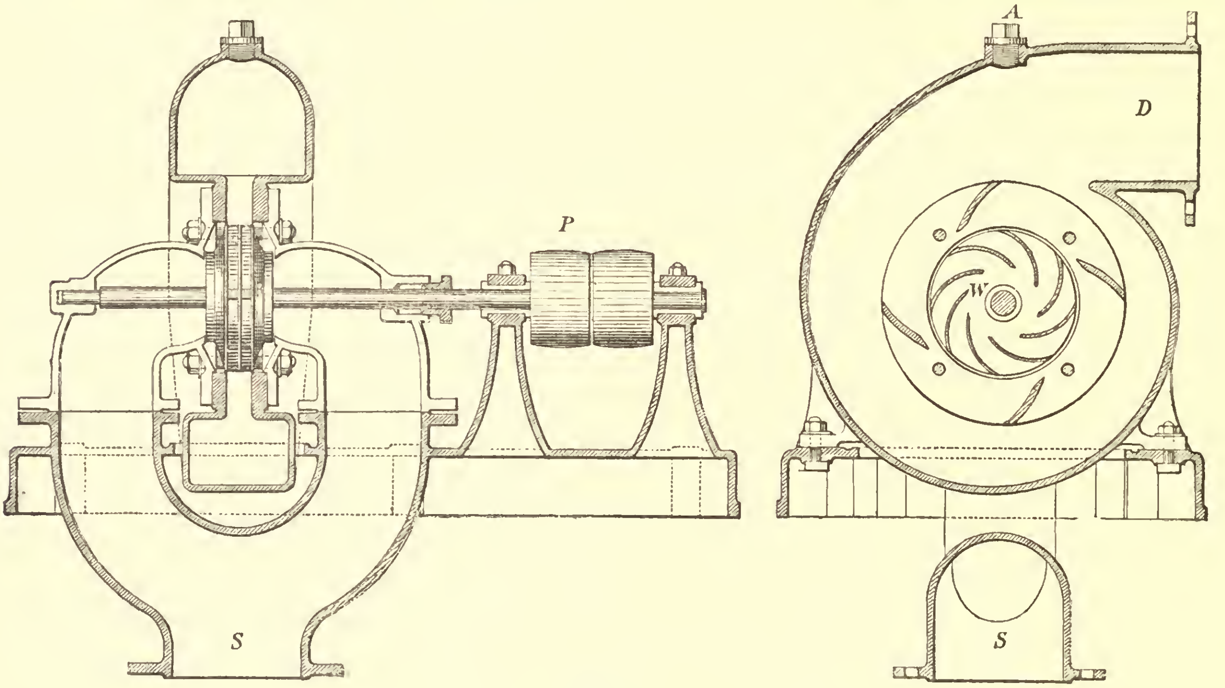


Fig. 203.

rotation in a chamber somewhat larger than the pump. The use of this whirlpool chamber was first suggested by Professor James Thomson. It utilizes the energy due to the whirling velocity of the water which in most pumps is wasted in eddies in the discharge pipe. In the pump shown guide-blades are also added which have the direction of the stream lines in a free vortex. They do not therefore interfere with the action of the water when pumping the normal quantity, but only prevent irregular motion. At A is a plug by which the pump case is filled before starting. If the pump is above the water to be pumped, a foot valve is required to permit the pump to be filled. Sometimes instead of the foot valve a delivery valve is used, an air-pump or steam jet pump being employed to exhaust the air from the pump case.

188. *Design and Proportions of a Centrifugal Pump.*—The design of the pump disk is very simple. Let r_i, r_0 be the radii of the inlet and outlet surfaces of the pump disk, d_i, d_0 the clear axial width at those radii. The velocity of flow through the pump may be taken the same as for a turbine. If Q is the quantity pumped, and H the lift,

$$u_i = 0{\cdot}25\sqrt{2g\mathrm{H}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

$$2\pi r_i d_i = \frac{\mathrm{Q}}{u_i}.$$

Also in practice

$$d_i = 1{\cdot}2 r_i \quad . \quad . \quad .$$

Hence,

$$r_i = {\cdot}2571 \sqrt{\frac{\mathrm{Q}}{\sqrt{\mathrm{H}}}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Usually $r_0 = 2r_i$,

and $d_0 = d_i$ or $\frac{1}{2} d_i$

according as the disk is parallel-sided or coned. The water enters the wheel radially with the velocity u_i, and

$$u_0 = \frac{\mathrm{Q}}{2\pi r_0 d_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Fig. 204 shows the notation adopted for the velocities. Suppose the water enters the wheel with the velocity v_i, while the velocity of the wheel is V_i. Completing the parallelogram, v_{ri} is the relative velocity of the water and wheel, and is the proper direction of the wheel vanes. Also, by resolving, u_i and w_i are the component velocities of flow and velocities of whir of the velocity v_i of the water. At the outlet surface, v_0 is the final velocity of discharge, and the rest of the notation is similar to that for the inlet surface.

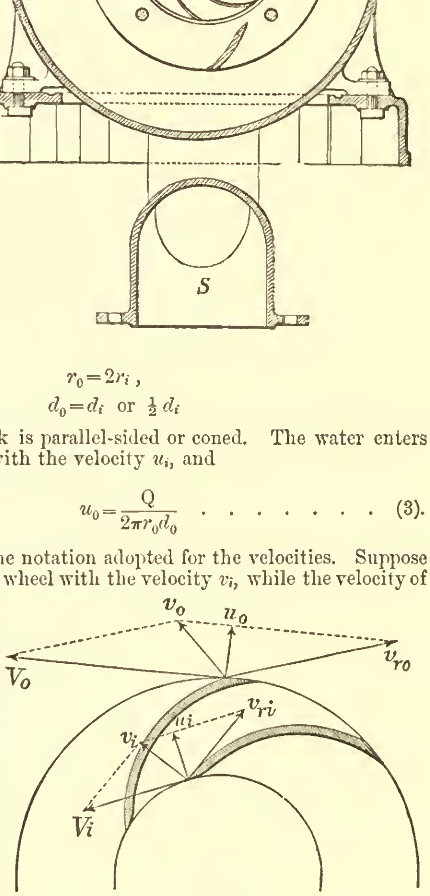


Fig. 204.

Usually the water flows equally in all directions in the eye of the wheel, in that case v_i is radial. Then, in normal conditions of working, at the inlet surface,

$$\left.\begin{array}{l} v_i = u_i \\ w_i = 0 \\ \tan\theta = \dfrac{u_i}{V_i} \\ v_{ri} = u_i \operatorname{cosec}\theta = \sqrt{u_i^2 + V_i^2} \end{array}\right\} \quad . \quad . \quad . \quad . \quad (4).$$

If the pump is raising less or more than its proper quantity, θ will not satisfy the last condition, and there is then some loss of head in shock.

At the outer circumference of the wheel or outlet surface,

$$\left.\begin{array}{l} v_{r0} = u_0 \operatorname{cosec}\phi \\ w_0 = V_0 - u_0 \cot\phi \\ v_0 = \sqrt{\{u_0^2 + (V_0 - u_0 \cot\phi)^2\}} \end{array}\right\} \quad . \quad . \quad . \quad (5).$$

Variation of Pressure in the Pump Disk.—Precisely as in the case of turbines, it can be shown that the variation of pressure between the inlet and outlet surfaces of the pump is

$$h_0 - h_i = \frac{V_0^2 - V_i^2}{2g} - \frac{v_{r0}^2 - v_{ri}^2}{2g}.$$

Inserting the values of v_{r0}, v_{ri} in (4) and (5), we get for normal conditions of working

$$h_0 - h_i = \frac{V_0^2 - V_i^2}{2g} - \frac{u_0^2 \operatorname{cosec}^2\phi}{2g} + \frac{u_i^2 + V_i^2}{2g}$$

$$= \frac{V_0^2}{2g} - \frac{u_0^2 \operatorname{cosec}^2\phi}{2g} + \frac{u_i^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

Hydraulic Efficiency of the Pump.—Neglecting disk friction, journal friction, and leakage, the efficiency of the pump can be found in the same way as that of turbines (§ 172). Let M be the moment of the couple rotating the pump, and α its angular velocity; w_0, r_0 the tangential velocity of the water and radius at the outlet surface; w_i, r_i the same quantities at the inlet surface. Q being the discharge per second, the change of angular momentum per second is

$$\frac{GQ}{g}(w_0 r_0 - w_i r_i).$$

Hence
$$M = \frac{GQ}{g}(w_0 r_0 - w_i r_i).$$

In normal working, $w_i = 0$. Also, multiplying by the angular velocity, the work done per second is

$$M\alpha = \frac{GQ}{g} w_0 r_0 \alpha.$$

But the useful work done in pumping is GQH. Therefore the efficiency is

$$\eta = \frac{GQH}{M\alpha} = \frac{gH}{w_0 r_0 \alpha} = \frac{gH}{w_0 V_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

189. Case 1. *Centrifugal Pump with no Whirlpool Chamber.*—When no special provision is made to utilize the energy of motion of the water leaving the wheel, and the pump discharges directly into a chamber in which the water is flowing to the discharge pipe, nearly the whole of the energy of the water leaving the disk is wasted. The water leaves the disk with the more or less considerable velocity v_0, and impinges on a mass flowing to the discharge pipe at the much slower velocity v_s. The radial component of v_0 is almost necessarily wasted. From the tangential component there is a gain of pressure

$$\frac{w_0^2 - v_s^2}{2g} - \frac{(w_0 - v_s)^2}{2g}$$

$$= \frac{v_s(w_0 - v_s)}{g},$$

which will be small, if v_s is small compared with w_0. Its greatest value, if $v_s = \frac{1}{2}w_0$, is $\frac{1}{2}\frac{w_0^2}{2g}$, which will always be a small part of the whole head. Suppose this neglected. The whole variation of pressure in the pump disk then balances the lift and the head $\frac{u_i^2}{2g}$ necessary to give the initial velocity of flow in the eye of the wheel.

$$\frac{u_i^2}{2g} + H = \frac{V_0^2}{2g} - \frac{u_0^2 \operatorname{cosec}^2\phi}{2g} + \frac{u_i^2}{2g},$$

$$\left.\begin{array}{l} H = \dfrac{V_0^2}{2g} - \dfrac{u_0^2 \operatorname{cosec}^2\phi}{2g} \\ \text{or} \quad V_0 = \sqrt{(2gH + u_0^2 \operatorname{cosec}^2\phi)} \end{array}\right\} \quad . \quad . \quad . \quad . \quad (8);$$

and the efficiency of the pump is, from (7),

$$\eta = \frac{gH}{V_0 w_0} = \frac{gH}{V_0(V_0 - u_0 \cot\phi)}$$

$$= \frac{V_0^2 - u_0^2 \operatorname{cosec}^2\phi}{2V_0(V_0 - u_0 \cot\phi)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

For $\phi = 90°$,
$$\eta = \frac{V_0^2 - u_0^2}{2V_0^2},$$

which is necessarily less than $\frac{1}{2}$. That is, half the work expended in driving the pump is wasted. By recurving the vanes, a plan introduced by Mr Appold, the efficiency is increased, because the velocity v_0 of discharge from the pump is diminished. If ϕ is very small,

$$\operatorname{cosec}\phi = \cot\phi;$$

and then
$$\eta = \frac{V_0^2 + u_0 \operatorname{cosec}\phi}{2V_0},$$

which may approach the value 1, as ϕ tends towards 0. Equation (8) shows that $u_0 \operatorname{cosec}\phi$ cannot be greater then V_0. Putting

$$u_0 = 0{\cdot}25\sqrt{2gH}$$

we get the following numerical values of the efficiency and the circumferential velocity of the pump:—

ϕ	η	V_0
90°	0·47	$1{\cdot}03\sqrt{2gH}$
45°	0·56	1·06 ,,
30°	0·65	1·12 ,,
20°	0·73	1·24 ,,
10°	0·84	1·75 ,,

ϕ cannot practically be made less than 20°; and, allowing for the frictional losses neglected, the efficiency of a pump in which $\phi = 20°$ is found to be about ·60.

190. Case 2. *Pump with a Whirlpool Chamber*, as in fig. 203.—Professor James Thomson first suggested that the energy of the water after leaving the pump disk might be utilized, if a space were left in which a free vortex could be formed. In such a free vortex the velocity varies inversely as the radius. The gain of pressure in the vortex chamber is, putting r_0, r_w for the radii to the outlet surface of wheel and to outside of free vortex,

$$\frac{v_0^2}{2g}\left(1 - \frac{r_0^2}{r_w^2}\right) = \frac{v_0^2}{2g}\left(1 - k^2\right),$$

if
$$k = \frac{r_0}{r_w}.$$

The lift is then, adding this to the lift in the last case,

$$H = \frac{1}{2g}\left\{V_0^2 - u_0^2 \operatorname{cosec}^2\phi + v_0^2(1 - k^2)\right\}.$$

But
$$v_0^2 = V_0^2 - 2V_0 u_0 \cot\phi + u_0^2 \operatorname{cosec}^2\phi;$$

$$\therefore \quad H = \frac{1}{2g}\left\{(2 - k^2)V_0^2 - 2kV_0 u_0 \cot\phi - k^2 u_0^2 \operatorname{cosec}^2\phi\right\} \quad (10).$$

Putting this in the expression for the efficiency, we find a considerable increase of efficiency. Thus with

$\phi = 90°$ and $k = \frac{1}{2}$, $\eta = \frac{7}{8}$ nearly;
ϕ a small angle and $k = \frac{1}{2}$, $\eta = 1$ nearly.

With this arrangement of pump, therefore, the angle at the outer ends of the vanes is of comparatively little importance. A moderate angle of 30° or 40° may very well be adopted. The following numerical values of the velocity of the circumference of the pump have been obtained by taking $k = \frac{1}{2}$, and $u_0 = 0{\cdot}25\sqrt{2gH}$.

ϕ	v_0
90°	$\cdot762\sqrt{2gH}$
45°	·842 ,,
30°	·911 ,,
20°	1·023 ,,

The quantity of water to be pumped by a centrifugal pump necessarily varies, and an adjustment for different quantities of water cannot easily be introduced. Hence it is that the average efficiency of pumps of this kind is in practice less than the efficiencies given above. The advantage of a vortex chamber is also generally neglected. The velocity in the supply and discharge pipes is also often made greater than is consistent with a high degree of efficiency. Velocities of 6 or 7 feet per second in the discharge and suction pipes, when the lift is small, cause a very sensible waste of energy; 3 to 6 feet would be much better. Centrifugal pumps of very large size have been constructed. Messrs Easton and Anderson have made pumps for the North Sea Canal in Holland which deliver each 670 tons of water per minute on a lift of 5 feet. The pump disks are 8 feet diameter. Messrs J. and H. Gwynne constructed some pumps for draining the Ferrarese Marshes, which together deliver 2000 tons per minute. A pump made under Professor J. Thomson's direction for drainage works in Barbados had a pump disk 16 feet in diameter and a whirlpool chamber 32 feet in diameter. The efficiency of centrifugal pumps when delivering less or more than the normal quantity of water is discussed in a paper in the *Proc. Inst. of Civil Engineers*, vol. liii. (W. C. U.)

HYDROMETER. The object of the hydrometer is the determination of the density of bodies, generally of fluids, but some forms of the instrument are adapted to the determination of the density of solids.

It is shown in the article HYDROMECHANICS that, when a body floats in a fluid under the action of gravity, the weight of the body is equal to that of the fluid which it displaces. It is upon this principle that the hydrometer is constructed, and it obviously admits of two modes of application in the case of fluids: either we may compare the weights of floating bodies which are capable of displacing the same volume of different fluids, or we may compare the volumes of the different fluids which are displaced by the same weight. In the latter case, the densities of the fluids will be inversely proportional to the volumes thus displaced.

Perhaps the simplest method of experimentally determining the densities of different liquids is afforded by the series of areometrical glass beads, or hollow balls, first proposed by Dr Wilson, professor of astronomy in the university of Glasgow. As subsequently improved by Mrs Lovi, these beads were constructed in sets, each bead in the set differing in density from its predecessor by ·002 (of the density of water). Each bead is numbered according to its density, and in order to determine the specific gravity of a liquid it is only necessary to throw into it the set of beads, or so many of them as are known to include between their extremes the density of the liquid, when all the beads whose densities exceed that of the liquid will sink, while those whose densities are less than that of the liquid will float. If there is a bead of exactly the same density as the liquid, it will rest in any position, provided it is completely immersed. Failing this, all that is immediately apparent is that the density is intermediate between that of the lightest bead that sinks and that of the heaviest that floats. For example, if all the beads numbered 1·466 and upwards sink, while those below 1·466 float, it is obvious that the density of the liquid is intermediate between 1·464 and 1·466. In the case of most fluids the intervals may be divided approximately by slightly warming the liquid. Thus, if on heating the liquid 6° C. it is found that the bead 1·466 begins to sink, and on heating it still farther through 12° C. (*i.e.*, through 18° C. altogether) the bead 1·468 begins to sink, then the density of the liquid is approximately 1·465.

The hydrometer is said by Synesius Cyreneus in his fifth letter to have been invented by Hypatia at Alexandria,[1] but appears to have been neglected until it was reinvented by Robert Boyle, whose "New Essay Instrument," as described in the *Phil. Trans.* for June 1675, differs in no essential particular from Nicholson's hydrometer. This instrument was devised for the purpose of detecting counterfeit coin, especially guineas and half-guineas. In the first section of the paper (*Phil. Trans.*, No. 115, p. 329) the author refers to a glass instrument exhibited by himself many years before, and "consisting of a bubble furnished with a long and slender stem, which was to be put into several liquors, to compare and estimate their specific gravities." This seems to be the first reference to the hydrometer in modern times.

In fig. 1 C represents the instrument used for guineas, the circular plates A representing plates of lead, which are used as ballast when lighter coins than guineas are examined. B represents "a small glass instrument for estimating the specific gravities of liquors," an account of which was promised by Boyle in the following number of the *Phil. Trans.*, but did not appear.

[1] In *Nicholson's Journal*, vol. iii. p. 89, Citizen Eusebe Salverte calls attention to the poem "De Ponderibus et Mensuris" generally ascribed to Rhemnius Fannius Palæmon, and consequently 300 years older than Hypatia, in which the hydrometer is described, and attributed to Archimedes.

The instrument represented at B (fig. 1), which is copied from Robert Boyle's sketch in the *Phil. Trans.* for 1675, is generally known as the common hydrometer. It is usually made of glass, the lower bulb being loaded with mercury or small shot which serves as ballast, causing the instrument to float with the stem vertical. The quantity of mercury or shot inserted depends upon the density of the liquids for which the hydrometer is to be employed, it being essential that the whole of the bulb should be immersed in the heaviest liquid for which the instrument is used, while the length and diameter of the stem must be such that the hydrometer will float in the lightest liquid for which it is required. The stem is usually divided into a number of equal parts, the divisions of the scale being varied in different instruments, according to the purposes for which they are employed.

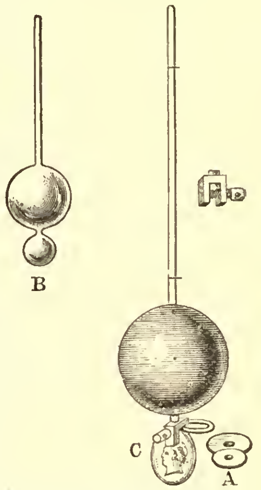


FIG. 1.—Boyle's New Essay Instrument.

Let V denote the volume of the instrument immersed (*i.e.*, of liquid displaced) when the surface of the liquid in which the hydrometer floats coincides with the lowest division of the scale, A the area of the transverse section of the stem, l the length of a scale division, n the number of divisions on the stem, and W the weight of the instrument. Suppose the successive divisions of the scale to be numbered 0, 1, 2 . . . . n starting with the lowest, and let w_0, w_1, w_2 . . . w_n be the weights of unit volume of the liquids in which the hydrometer sinks to the divisions 0, 1, 2 . . . . n respectively. Then, by the principle of Archimedes,

$$W = Vw_0 ;$$

or

$$w_0 = \frac{W}{V} .$$

Also

$$W = (V + lA)w_1$$

or

$$w_1 = \frac{W}{V + lA} .$$

So

$$w_p = \frac{W}{V + plA} ,$$

and

$$w_n = \frac{W}{V + nlA} ;$$

or the densities of the several liquids vary inversely as the respective volumes of the instrument immersed in them; and, since the divisions of the scale correspond to equal increments of volume immersed, it follows that the densities of the several liquids in which the instrument sinks to the successive divisions form a harmonic series.

If $V = NlA$ then N expresses the ratio of the volume of the instrument up to the zero of the scale to that of one of the scale-divisions. If we suppose the lower part of the instrument replaced by a uniform bar of the same sectional area as the stem and of volume V, the indications of the instrument will be in no respect altered, and the bottom of the bar will be at a distance of N scale-divisions below the zero of the scale.

In this case we have

$$w_p = \frac{W}{(N + p)lA} ;$$

or the density of the liquid varies inversely as $N + p$, that is, as the whole number of scale-divisions between the bottom of the tube and the plane of flotation.

If we wish the successive divisions of the scale to correspond to equal increments in the density of the corresponding liquids, then the volumes of the instrument, measured up to the successive divisions of the scale, must form a series in harmonical progression, the lengths of the divisions increasing as we go up the stem.

The greatest density of the liquid for which the instrument described above can be employed is $\frac{W}{V}$, while the least density is $\frac{W}{V + nlA}$, or $\frac{W}{V + v}$, where v represents the volume of the stem between the extreme divisions of the scale. Now, by increasing v, leaving W and V unchanged, we may increase the range of the instrument indefinitely. But it is clear that if we increase A, the sectional area of the stem, we shall diminish l, the length of a scale-division corresponding to a given variation of density, and thereby proportionately diminish the sensibility of the instrument, while diminishing the section A will increase l and proportionately increase the sensibility, but will diminish the range over which the instrument can be employed, unless we increase the length of the stem in the inverse ratio of the sectional area. Hence, to obtain great sensibility along with a considerable range, we require very long slender stems, and to these two objections apply in addition to the question of portability; for, in the first place, an instrument with a very long stem requires a very deep vessel of liquid for its complete immersion, and, in the second place, when most of the stem is above the plane of flotation, this diminishes or may destroy the stability of the instrument when floating. The various devices which have been adopted to overcome this difficulty will be described in the account given of the several hydrometers which have been hitherto generally employed.

The plan commonly adopted to obviate the necessity of inconveniently long stems is to construct a number of hydrometers as nearly alike as may be, but to load them differently, so that the scale-divisions at the bottom of the stem of one hydrometer just overlap those at the top of the stem of the preceding. By this means a set of six hydrometers, each having a stem rather more than five inches long, will be equivalent to a single hydrometer with a stem of thirty inches. But, instead of employing a number of instruments differing only in the weights with which they are loaded, we may employ the same instrument, and alter its weight either by adding mercury or shot to the interior (if it can be opened) or by attaching weights to the exterior. These two operations are not quite equivalent, since a weight added to the interior does not affect the volume of liquid displaced when the instrument is immersed up to a given division of the scale, while the addition of weights to the exterior increases the displacement. This difficulty may be met, as in Keene's hydrometer, by having all the weights of precisely the same volume but of different masses, and never using the instrument except with one of these weights attached.

The first hydrometer intended for the determination of the densities of liquids, and furnished with a set of weights to be attached when necessary, was that constructed by Mr Clarke, and described by Dresaguliers in the *Philosophical Transactions* for March and April 1730, No. 413, p. 278. The following is Desaguliers's account of the instrument (fig. 2):—

"After having made several fruitless trials with ivory, because it imbibes spirituous liquors, and thereby alters its gravity, he (Mr Clarke) at last made a copper hydrometer, represented in fig. 2, having a brass wire of about 1 inch thick going through, and soldered into the copper ball B*b*. The upper part of this wire is filed flat on one side, for the stem of the hydrometer, with a mark at *m*, to which it sinks exactly in proof spirits. There are two other marks, A and B, at top and bottom of the stem, to show whether the liquor be $\frac{1}{10}$th above proof (as when it sinks to A), or $\frac{1}{10}$th under proof (as when it emerges to B), when a brass weight such as C has been screwed on to the bottom at *c*. There are a great many such weights, of different sizes, and marked to be screwed on instead of C, for liquors that differ more than $\frac{1}{10}$th from proof, so as to serve for the specific gravities in all such proportions as relate to the mixture of spirituous liquors, in all the variety made use of in trade. There are also other balls for showing the specific gravities quite to common water, which make the instrument perfect in its kind."

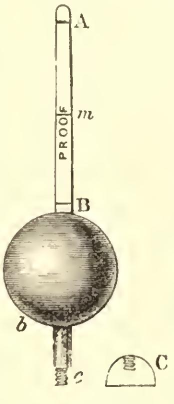


Fig. 2.—Clarke's Hydrometer.

Clarke's hydrometer, as afterwards constructed for the purposes of the excise, was provided with thirty-two weights to adapt it to spirits of different specific gravities, and eleven smaller weights, or "weather weights" as they were called, which were attached to the instrument in order to correct for variations of temperature. The weights were adjusted for successive intervals of 5° Fahr., but for degrees intermediate between these no additional correction was applied. The correction for temperature thus afforded was not sufficiently accurate for excise purposes, and Mr Speer in his essay on the hydrometer (Tilloch's *Phil. Mag.*, vol. xiv.) mentions cases in which this imperfect compensation led to the extra duty payable upon spirits which were more than 10 per cent. over proof being demanded on spirits which were purposely diluted to below 10 per cent. over proof in order to avoid the charge.

Desaguliers himself constructed a hydrometer of the ordinary type for comparing the specific gravities of different kinds of water (Desaguliers's *Experimental Philosophy*, vol. ii. p. 234). In order to give great sensibility to the instrument, the large glass ball was made nearly 3 inches in diameter, while the stand consisted of a wire 10 inches in length and only $\frac{1}{40}$ inch in diameter. The instrument weighed 4000 grains, and the addition of a grain caused it to sink through an inch. By altering the quantity of shot in the small balls the instrument could be adapted for liquids other than water.

To an instrument constructed for the same purpose, but on a still larger scale than that of Desaguliers, M. Deparcieux added a small dish on the top of the stem for the reception of the weights necessary to sink the instrument to a convenient depth. The effect of weights placed in such a dish or pan is of course the same as if they were placed within the bulb of the instrument, since they do not alter the volume of that part which is immersed.

The first important improvement in the hydrometer after its reinvention by Boyle was introduced by Fahrenheit, who adopted the second mode of construction above referred to, arranging his instrument so as always to displace the same volume of liquid, its weight being varied accordingly. Instead of a scale, only a single mark is placed upon the stem, which is very slender, and bears at the top a small scale pan into which weights are placed until the instrument sinks to the mark upon its stem. The volume of the displaced liquid being then always the same, its density will be proportional to the whole weight supported, that is, to the weight of the instrument together with the weights required to be placed in the scale pan.

Nicholson's hydrometer (fig. 3) combines the characteristics of Fahrenheit's hydrometer and of Boyle's essay instrument.[1] The following is the description given of it by Nicholson in the *Manchester Memoirs*, vol. ii. p. 374.

"AA represents a small scale. It may be taken off at D. Diameter $1\frac{1}{2}$ inch, weight 44 grains.

"B a stem of hardened steel wire. Diameter $\frac{1}{100}$ inch.

"E a hollow copper globe. Diameter $2\frac{8}{10}$ inches. Weight with stem 369 grains.

"FF a stirrup of wire screwed to the globe at C.

"G a small scale, serving likewise as a counterpoise. Diameter $1\frac{1}{2}$ inch. Weight with stirrup 1634 grains.

"The other dimensions may be had from the drawing which is one-sixth of the linear magnitude of the instrument itself.

"In the construction, it is assumed that the upper scale shall constantly carry 1000 grains when the lower scale is empty, and the instrument sunk in distilled water at the temperature of 60° Fahrenheit to the middle of the wire or stem. The length of the stem is arbitrary, as is likewise the distance of the lower scale from the surface of the globe. But, the length of the stem being settled, the lower scale may be made lighter, and, consequently, the globe less, the greater its distance is taken from the surface of the globe; and the contrary."

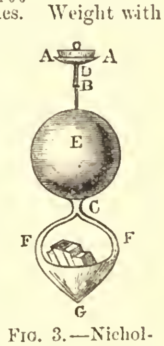


Fig. 3.—Nicholson's Hydrometer.

In comparing the densities of different liquids, it is clear that this instrument is precisely equivalent to that of Fahrenheit, and must be employed in the same manner, weights being placed in the top scale only until the hydrometer sinks to the mark on the wire, when the specific gravity of the liquid will be proportional to the weight of the instrument together with the weights in the scale.

In the subsequent portion of the paper above referred to,

[1] *Nicholson's Journal*, vol. i. p. 111, footnote.

Nicholson explains how the instrument may be employed as a thermometer, since, fluids generally expanding more than the solids of which the instrument is constructed, the instrument will sink as the temperature rises.

To determine the density of solids heavier than water with this instrument, let the solid be placed in the upper scale pan, and let the weight now required to cause the instrument to sink in distilled water at standard temperature to the mark B be denoted by w, while W denotes the weight required when the solid is not present. Then $W - w$ is the weight of the solid. Now let the solid be placed in the lower pan, care being taken that no bubbles of air remain attached to it, and let w_1 be the weight now required in the scale pan. This weight will exceed w in consequence of the water displaced by the solid, and the weight of the water thus displaced will be $w_1 - w$, which is therefore the weight of a volume of water equal to that of the solid. Hence, since the weight of the solid itself is $W - w$, its density must be $\frac{W - w}{w_1 - w}$.

The above example illustrates how Nicholson's or Fahrenheit's hydrometer may be employed as a weighing machine for small weights.

In all hydrometers in which a part only of the instrument is immersed, there is a liability to error in consequence of the surface tension, or capillary action, as it is frequently called, along the line of contact of the instrument and the surface of the liquid (see CAPILLARY ACTION). This error diminishes as the diameter of the stem in reduced, but is sensible in the case of the thinnest stem which can be employed, and is the chief source of error in the employment of Nicholson's hydrometer, which otherwise would be an instrument of extreme delicacy and precision. The following is Nicholson's statement on this point:—

"One of the greatest difficulties which attends hydrostatical experiments arises from the attraction or repulsion that obtains at the surface of the water. After trying many experiments to obviate the irregularities arising from this cause, I find reason to prefer the simple one of carefully wiping the whole instrument, and especially the stem, with a clean cloth. The weights in the dish must not be esteemed accurate while there is either a cumulus or a cavity in the water round the stem."

It is possible by applying a little oil to the upper part of the bulb of a common or of a Sikes's hydrometer, and carefully placing it in pure water, to cause it to float with the upper part of the bulb and the whole of the stem emerging as indicated in fig. 4, when it ought properly to sink almost to the top of the stem, the surface tension of the water around the circumference of the circle of contact, AA′, providing the additional support required.

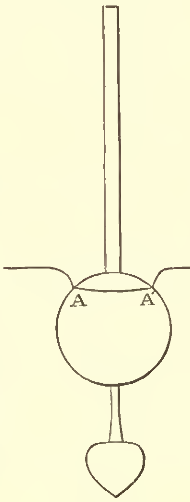


Fig. 4.

The universal hydrometer of Mr G. Atkins, described in the *Phil. Mag.* for 1808, vol. xxxi. p. 254, is merely Nicholson's hydrometer with the screw at C projecting through the collar into which it is screwed, and terminating in a sharp point above the cup G. To this point soft bodies lighter than water (which would float if placed in the cup) could be attached, and thus completely immersed. Atkins's instrument was constructed so as to weigh 700 grains, and when immersed to the mark on the stem in distilled water at 60° F., it carried 300 grains in the upper dish. The hydrometer therefore displaced 1000 grains of distilled water at 60° F., and hence the specific gravity of any other liquid was at once indicated by adding 700 to the number of grains in the pan required to make the instrument sink to the mark on the stem. The small divisions on the scale corresponded to differences of $\frac{1}{10}$th of a grain in the weight of the instrument.

The "Gravimeter," constructed by Citizen Guyton and described in *Nicholson's Journal*, 4to, vol. i. p. 110, differs from Nicholson's instrument in being constructed of glass, and having a cylindrical bulb about 21 centimetres in length and 22 millimetres in diameter. Its weight is so adjusted that an additional weight of 5 grammes must be placed in the upper pan to cause the instrument to sink to the mark on the stem in distilled water at the standard temperature. The instrument is provided with an additional piece, or "plongeur," whose weight exceeds 5 grammes by the weight of water which it displaces; that is to say, it is so constructed as to weigh 5 grammes in water, and consists of a glass envelope filled with mercury. It is clear that the effect of this "plongeur," when placed in the lower pan, is exactly the same as that of the 5 gramme weight in the upper pan. Without the extra 5 grammes the instrument weighs about 20 grammes, and therefore floats in a liquid of specific gravity ·8. Thus deprived of its additional weight it may be used for spirits. To use the instrument for liquids of much greater density than water additional weights must be placed in the upper pan, and the "plongeur" is then placed in the lower pan for the purpose of giving to the instrument the requisite stability.

Charles's balance areometer is similar to Nicholson's hydrometer, except that the lower basin admits of inversion, thus enabling the instrument to be employed for solids lighter than water, the inverted basin serving the same purpose as the pointed screw in Atkins's modification of the instrument.

Adie's sliding hydrometer is of the ordinary form, but can be adjusted for liquids of widely differing specific gravities by drawing out a sliding tube, thus changing the volume of the hydrometer while its weight remains constant.

Adie's statical hydrometer is really a specific gravity balance, one of the arms of which is $2\frac{1}{2}$ inches in length, and the other 8 inches. A brass ball, whose volume is ·01 gallon, is suspended from the shorter arm, and immersed in the liquid whose density is to be determined. The ball is balanced by means of a weight which slides along the beam, and a smaller weight which also slides along the beam serves to make the necessary correction for temperature.

The hydrometer of Beaumé, which has been extensively used in France, consists of a common hydrometer graduated in the following manner. Certain fixed points were first determined upon the stem of the instrument. The first of these was found by immersing the hydrometer in pure water, and marking the stem at the level of the surface. This formed the zero of the scale. Fifteen standard solutions of pure common salt in water were then prepared, containing respectively 1, 2, 3, ... 15 per cent. (by weight) of dry salt. The hydrometer was plunged in these solutions in order, and the stem having been marked at the several surfaces, the degrees so obtained were numbered 1, 2, 3, ... 15. These degrees were, when necessary, repeated along the stem by the employment of a pair of compasses till 80 degrees were marked off. The instrument thus adapted to the determination of densities exceeding that of water was called the hydrometer for salts.

The hydrometer intended for densities less than that of water, or the hydrometer for spirits, is constructed on a similar principle. The instrument is so arranged that it floats in pure water with most of the stem above the surface. A solution containing 10 per cent. of pure salt is used to indicate the zero of the scale, and the point at which the instrument floats when immersed in distilled water at 10° R. ($54\frac{1}{2}$° F.) is numbered 10. Equal divisions are then marked off upwards along the stem as far as the 50th degree.

The densities corresponding to the several degrees of Beaumé's hydrometer are given by Nicholson (*Journal of Philosophy*, vol. i. p. 89) as follows:—

Beaumé's Hydrometer for Spirits. Temperature 10° R.

Degrees.	Density.	Degrees.	Density.	Degrees.	Density.
10	1·000	21	·922	31	·861
11	·990	22	·915	32	·856
12	·985	23	·909	33	·852
13	·977	24	·903	34	·847
14	·970	25	·897	35	·842
15	·963	26	·892	36	·837
16	·955	27	·886	37	·832
17	·949	28	·880	38	·827
18	·943	29	·874	39	·822
19	·935	30	·867	40	·817
20	·928				

Beaumé's Hydrometer for Salts.

Degrees.	Density.	Degrees.	Density.	Degrees.	Density.
0	1·000	27	1·230	51	1·547
3	1·020	30	1·261	54	1·594
6	1·040	33	1·295	57	1·659
9	1·064	36	1·333	60	1·717
12	1·089	39	1·373	63	1·779
15	1·114	42	1·414	66	1·848
18	1·140	45	1·455	69	1·920
21	1·170	48	1·500	72	2·000
24	1·200				

Cartier's hydrometer was very similar to that of Beaumé, Cartier having been employed by the latter to construct his instruments for the French revenue. The point at which the instrument floated in distilled water was marked 10° by Cartier, and 30° on Cartier's scale corresponded to 32° on Beaumé's.

Though constructed upon a very different principle from ordinary hydrometers, we may briefly refer here to Brewster's capillary hydrometer or staktometer, which is based upon the difference in the surface tension and density of pure water, and of mixtures of alcohol and water in varying proportions. If a small piece of paper be bent into such a shape as this, /\, it may be made to rest upon the surface of water without being immersed. If now a drop of alcohol be placed on one corner of the paper, it will rush violently away and generally spin round, somewhat resembling the action of pieces of camphor, indicating that the surface tension of the water is diminished by the presence of alcohol. If the water be very pure it is sufficient to bring a drop of alcohol on the extremity of a pipette near to the paper, without touching either it or the water, and the vapour absorbed will produce the same effect. For other proofs of the same action see the article CAPILLARY ACTION. Now, if a drop of water be allowed to form at the extremity of a fine tube, it will go on increasing until its weight overcomes the surface tension by which it clings to the tube, and then it will fall. Hence any impurity which diminishes the surface tension of the water will diminish the size of the drop (unless the density is proportionately diminished). Now, according to Quincke, the surface tension of pure water in contact with air at 20° C. is 81 dynes per linear centimetre, while that of alcohol is only 25·5 dynes. Also, a small percentage of alcohol produces much more than a proportional decrease in the surface tension when added to pure water. The capillary hydrometer consists simply of a small pipette with a bulb in the middle of the stem, the pipette terminating in a very fine capillary point. The instrument being filled with distilled water, the number of drops required to empty the bulb and portions of the stem between two marks m and n (fig. 5) on the latter is carefully counted, and the experiments repeated at different temperatures. The pipette having been carefully dried, the process is repeated with pure alcohol or with proof spirits, and the strength of any admixture of water and spirits is determined from the corresponding number of drops, but the formula generally given is not based upon sound data. Sir David Brewster found with one of these instruments that the number of drops of pure water was 734, while of proof spirit, sp. gr. 920, the number of drops required was 2117.

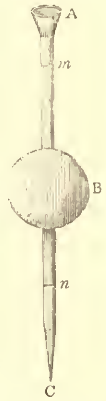


FIG. 5.—Brewster's Staktometer.

Perhaps the main object for which hydrometers have been constructed is the determination of the value of spirituous liquors, chiefly for revenue purposes. To this end an immense variety of hydrometers have been constructed, differing mainly in the character of their scales.

In Speer's hydrometer the stem has the form of an octagonal prism, and upon each of the eight faces a scale is engraved, indicating the percentage strength of the spirit corresponding to the several divisions of the scale, the eight scales being adapted respectively to the temperatures 35°, 40°, 45°, 50°, 55°, 60°, 65°, and 70° F. Four small pins, which can be inserted into the counterpoise of the instrument, serve to adapt the instrument to the temperatures intermediate between those for which the scales are constructed. William Speer was supervisor and chief assayer of spirits in the port of Dublin. For a more complete account of this instrument see Tilloch's *Phil. Mag.*, vol. xiv. p. 151.

The hydrometer constructed by Mr Jones of Holborn, consists of a spheroidal bulb with a rectangular stem (fig. 6). Between the bulb and counterpoise is placed a thermometer, which serves to indicate the temperature of the liquid, and the instrument is provided with three weights which can be attached to the top of the stem. On the four sides of the stem AD are engraved four scales corresponding respectively to the unloaded instrument, and to the instrument loaded with the respective weights. The instrument when unloaded serves for the range from 74 to 47 above proof; when loaded with the first weight it indicates from 46 to 13 over proof, with the second weight from 13 over proof to 29 under proof, and with the third from 29 under proof to pure water, the graduation corresponding to which is marked W at the bottom of the fourth scale. One side of the stem AD is shown in fig. 6, the other three in fig. 7. The thermometer is also provided with four scales corresponding to the scales above mentioned. Each scale has its zero in the middle corresponding to 60° F. If the mercury in the thermometer stand above this zero the spirit must be reckoned weaker than the hydrometer indicates by the number on the thermometer scale level with the top of the mercury, while if the thermometer indicate a temperature lower than the zero of the scale (60° F.) the spirit must be reckoned stronger by the scale reading. At the side of each of the four scales on the stem of the hydrometer is engraved a set of small numbers indicating the contraction in volume which would be experienced if the requisite amount of water (or spirit) were added to bring the sample tested to the proof strength.

FIG. 6.—Jones's Hydrometer.

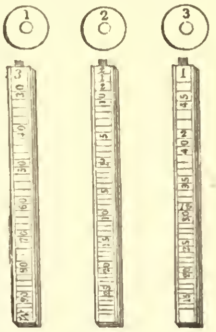


Fig. 7.

The hydrometer constructed by Mr Dicas of Liverpool is provided with a sliding scale which can be adjusted for different temperatures, and which also indicates the contraction in volume incident on bringing the spirit to proof strength. It is provided with thirty-six different weights which, with the ten divisions on the stem, form a scale from 0 to 370. The employment of so many weights renders the instrument ill-adapted for practical work where speed is an object. It was adopted for the United States revenue by Act of Congress, August 10, 1790.

Quin's universal hydrometer is described in the *Transactions of the Society of Arts*, vol. viii. p. 98. It is provided with a sliding rule to adapt it to different temperatures, and has four scales, one of which is graduated for spirits and the other three serve to show the strengths of worts. The peculiarity of the instrument consists in the pyramidal form given to the stem, which renders the scale-divisions more nearly equal in length than they would be on a prismatic stem.

Atkins's hydrometer, as originally constructed, is described in *Nicholson's Journal*, 8vo, vol. ii. p. 276. It is made of brass, and is provided with a spheroidal bulb whose axis is 2 inches in length, the conjugate diameter being $1\frac{1}{2}$ inches. The whole length of the instrument is 8 inches, the stem square of about $\frac{1}{8}$ inch side, and the weight about 400 grains. It is provided with four weights, marked 1, 2, 3, 4, and weighing respectively 20, 40, 61, and 84 grains, which can be attached to the shank of the instrument at C (fig. 8), and retained there by the fixed weight B. The scale engraved upon one face of the stem contains fifty-five divisions, the top and bottom being marked 0 or zero, and the alternate intermediate divisions (of which there are twenty-six) being marked with the letters of the alphabet in order. The four weights are so adjusted that, if the instrument floats with the stem emerging as far as the lower division 0 with one of the weights attached, then replacing the weight by the next heavier causes the instrument to sink through the whole length of the scale to the upper division 0, and the first weight produces the same effect when applied to the naked instrument. The stem is thus virtually extended to five times its length, and the number of divisions increased practically to 272. When no weight is attached the instrument indicates densities from ·806 to ·843; with No. 1 it registers from ·843 to ·880, with No. 2 from ·880 to ·918, with No. 3 from ·918 to ·958, and with No. 4 from ·958 to 1·000, the temperature being 55° F. It will thus be seen that the whole length of the stem corresponds to a difference of density of about ·04, and one division to about ·00074, indicating a difference of little more than $\frac{1}{8}$ per cent. in the strength of any sample of spirits.

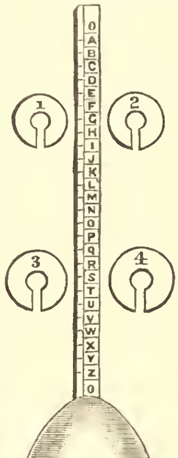


FIG. 8.—Atkins's Hydrometer.

The instrument is provided with a sliding rule, with scales corresponding to the several weights, which indicate the specific gravity corresponding to the several divisions of the hydrometer scale compared with water at 55° F. The slider upon the rule serves to adjust the scale for different temperatures, and then indicates the strength of the spirit in percentages over or under proof. The slider is also provided with scales, marked respectively Dicas and Clarke, which serve to show the readings which would have been obtained had the instruments of those makers been employed. The line on the scale marked "concentration" indicates the diminution in volume consequent upon reducing the sample to proof strength (if it is O. P.) or upon reducing proof spirit to the strength of the sample (if it is U. P.). By applying the several weights in succession in addition to No. 4, the instrument can be employed for liquids heavier than water; and graduations on the other three sides of the stem, together with an additional slide rule, adapt the instrument for the determination of the strength of worts.

Mr Atkins subsequently modified the instrument (*Nicholson's Journal*, 8vo, vol. iii. p. 50) by constructing the different weights of different shapes, viz., circular, square, triangular, and pentagonal, instead of numbering them 1, 2, 3 and 4 respectively, a figure of the weight being stamped on the sliding rule opposite to every letter in the series to which it belongs, thus diminishing the probability of mistakes. He also replaced the letters on the stem by the corresponding specific gravities referred to water as unity. Further information concerning these instruments and the state of hydrometry in 1803 will be found in Mr Atkins's pamphlet *On the Relation between the Specific Gravities and the Strength of Spirituous Liquors*, 1803; or *Phil. Mag.*, vol. xvi. pp. 26–33, 205–212, 305–312; vol. xvii. pp. 204–210 and 329–341.

In Gay Lussac's alcoholometer the scale is divided into 100 parts corresponding to the presence of 1, 2, . . . per cent. by volume of alcohol at 15° C., the highest division of the scale corresponding to the purest alcohol he could obtain (density ·7947) and the lowest division corresponding to pure water. A table provides the necessary corrections for other temperatures.

Tralles's hydrometer differs from Gay Lussac's only in being graduated at 4° C. instead of 15° C., and taking alcohol of density ·7939 at 15·5° C. for pure alcohol instead of ·7947 as taken by Gay Lussac (Keene's *Handbook of Hydrometry*).

In Beck's hydrometer the zero of the scale corresponds to density 1·000 and the division 30 to density ·850, and equal divisions on the scale are continued as far as is required in both directions. The following table serves to indicate the relation between the degrees and the corresponding densities:—

Relation between Degrees of Beck's Hydrometer and Densities.

Degrees.	Density. Greater than 1·000.	Density. Less than 1·000.	Degrees.	Density. Greater than 1·000.	Density. Less than 1·000.	Degrees.	Density. Greater than 1·000.	Density. Less than 1·000.
1	1·006	·994	25	1·172	·872	48	1·393	·780
2	1·012	·988	26	1·181	·867	49	1·405	·776
3	1·018	·983	27	1·189	·863	50	1·417	·773
4	1·024	·977	28	1·197	·859	51	1·429	·769
5	1·030	·971	29	1·206	·854	52	1·441	·766
6	1·037	·966	30	1·214	·850	53	1·453	·762
7	1·043	·960	31	1·223	·846	54	1·466	·759
8	1·049	·955	32	1·232	·842	55	1·478	·756
9	1·056	·950	33	1·241	·837	56	1·491	·752
10	1·063	·944	34	1·250	·833	57	1·504	·749
11	1·069	·939	35	1·259	·829	58	1·518	·746
12	1·076	·934	36	1·268	·825	59	1·532	·742
13	1·083	·929	37	1·278	·821	60	1·546	·739
14	1·090	·924	38	1·288	·817	61	1·560	·736
15	1·097	·919	39	1·298	·813	62	1·574	·733
16	1·104	·914	40	1·308	·810	63	1·589	·730
17	1·111	·909	41	1·318	·806	64	1·604	·727
18	1·118	·904	42	1·328	·802	65	1·619	·723
19	1·126	·899	43	1·339	·798	66	1·635	·720
20	1·133	·895	44	1·349	·794	67	1·651	·717
21	1·141	·890	45	1·360	·791	68	1·667	·714
22	1·149	·885	46	1·371	·787	69	1·683	·711
23	1·157	·881	47	1·382	·783	70	1·700	·708
24	1·164	·876						

In the centesimal hydrometer of M. Francœur the volume of the stem between successive divisions of the scale is always $\frac{1}{100}$th of the whole volume immersed when the instrument floats in water at 4° C. In order to graduate the stem the instrument is first weighed, then immersed in distilled water at 4° C., and the line of flotation marked zero. The first degree is then found by placing on the top of the stem a weight equal to $\frac{1}{100}$th of the weight of the instrument, which increases the volume immersed by $\frac{1}{100}$th of the original volume. The addition to the top of the stem of successive weights, each $\frac{1}{100}$th of the weight of the instrument itself, serves to determine the successive degrees. The length of 100 divisions of the scale, or the length of the uniform stem the volume of which would be equal to that of the hydrometer up to the zero graduation, Francœur called the "modulus" of the hydrometer. He constructed his instruments of glass, using different instruments for different portions of the scale (Francœur, *Traité d'areometrie*, Paris, 1842).

Dr Boriés of Montpellier constructed an hydrometer which was based upon the results of his experiments on mixtures of alcohol and water. The interval between the points corresponding to pure alcohol and to pure water Boriés divided into 100 equal parts, though the stem was prolonged so as to contain only 10 of these divisions, the other 90 being provided for by the addition of 9 weights to the bottom of the instrument as in Clarke's hydrometer.

Sikes's hydrometer, on account of its similarity to that of Boriés, appears to have been borrowed from that instrument. It is made of brass, and consists of a spherical ball A (fig. 9), 1·5 inches in diameter, below which is a weight B connected with the ball by a short conical stem C. The stem D is rectangular in section, and about 3½ inches in length. This is divided into ten equal parts, each of which is subdivided into five. As in Boriés's instrument, a series of 9 weights, each of the form shown at E, serves to extend the scale to 100 principal divisions. In the centre of each weight is a hole capable of admitting the lowest and thickest end of the conical stem C, and a slot is cut into it just wide enough to allow the upper part of the cone to pass. Each weight can thus be dropped on to the lower stem so as to rest on the counterpoise B. The weights are marked 10, 20, ... 90; and in using the instrument that weight must be selected which will allow it to float in the liquid with a portion only of the stem submerged. Then the reading of the scale at the line of flotation, added to the number on the weight, gives the reading required. A small supernumerary weight F is added, which can be placed upon the top of the stem. F is so adjusted that when the 60 weight is placed on the lower stem the instrument sinks to the same point in distilled water when F is attached as in proof spirit when F is removed.

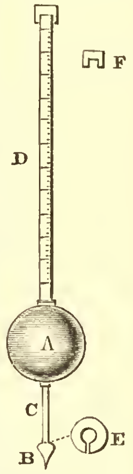


Fig. 9:—Sikes's Hydrometer.

The following table gives the specific gravities corresponding to the principal graduations on Sikes's hydrometer at 60° F. and at 62° F., together with the corresponding strengths of spirits. The latter are based upon the tables of Gilpin, for which the reader is referred to the *Phil. Trans.* for 1794.

Table showing the Densities corresponding to the Indications of Sikes's Hydrometer.

Sikes's Indications.	60° F. Density.	60° F. Proof Spirit per cent.	62° F. Density.	62° F. Proof Spirit per cent.	Sikes's Indications.	60° F. Density.	60° F. Proof Spirit per cent.	62° F. Density.	62° F. Proof Spirit per cent.
0	·815297	167·0	·815400	166·5	51	·905024	111·4	·905138	110·7
1	·816956	166·1	·817059	165·6	52	·906869	110·0	·906983	109·3
2	·818621	165·3	·818725	164·8	53	·908722	108·6	·908837	107·9
3	·820294	164·5	·820397	163·9	54	·910582	107·1	·910697	106·5
4	·821973	163·6	·822077	163·1	55	·912450	105·6	·912565	105·0
5	·823659	162·7	·823763	162·3	56	·914326	104·2	·914441	103·5
6	·825352	161·8	·825457	161·4	57	·916209	102·7	916323	102·0
7	·827052	160·9	·827157	160·5	58	·918100	101·3	·918216	100·5
8	·828759	160·0	·828864	159 6	59	·919999	99·7	·920115	98·9
9	·830473	159·1	830578	158·7	60	·921966	98·1	·922022	97·4
10	·832195	158·2	·832300	157·8	60B	·921884	98·1	·922000	97·4
11	·833888	157·3	·833993	156·8	61	·923760	96·6	·923877	95·9
12	·835587	156·4	·835692	155·9	62	925643	95·0	·925760	94·2
13	·837294	155·5	·837400	155·0	63	·927534	93·3	·927652	92·6
14	·839008	154·6	·839114	154·0	64	·929433	91·7	·929550	90·9
15	·840729	153·7	·840835	153·1	65	·931339	90·0	931457	89·2
16	·842458	152·7	·842564	152·1	66	·933254	88·3	·933372	87·5
17	·844193	151·7	·844299	151·1	67	935176	86·5	·935294	85·8
18	·845936	150·7	·846042	150·1	68	·937107	84·7	·937225	84·0
19	·847685	149·7	·847792	149·1	69	·939045	82·9	·939163	82·2
20	·849442	148·7	·849549	148·1	70	·940991	81·1	·941110	80·3
20B	·849393	148·7	·849500	148·1	70B	·940981	81·1	·941100	80·3
21	·851122	147·6	·851229	147·1	71	·942897	79·2	·943016	78·4
22	·852857	146·6	·852964	146·1	72	·944819	77·3	·944938	76·5
23	·854599	145·6	·854707	145·1	73	·946749	75·3	946869	74·5
24	·856348	144·6	·856456	144·0	74	·948687	73·3	·948807	72·5
25	·858105	143·5	·858213	142·9	75	·950634	71·2	·950753	70·4
26	·859869	142·4	·859978	141·8	76	·952588	69·0	·952708	68·2
27	·861640	141·3	·861749	140 8	77	·954550	66·8	·954670	66·0
28	·863419	140·2	·863528	139·7	78	·956520	64·4	·956641	63·5
29	·865204	139·1	·865313	138 5	79	·958498	61·9	·958619	61·1
30	·866998	138·0	·867107	137·4	80	·960485	59·4	·960606	58·5
30B	·866991	138·0	·867100	137·4	80B	·960479	59·4	·960600	58·5
31	·868755	136·9	·868865	136·2	81	·962433	56·7	·962555	55·8
32	·870526	135·7	·870636	135·1	82	·964395	53·9	·964517	53·0
33	·872305	134·5	·872415	133·9	83	·966366	50·9	·966488	50·0
34	·874090	133·4	874200	132 8	84	·968344	47·8	·968466	47·0
35	·875883	132·2	·875994	131·6	85	·970331	44·5	·970453	43·8
36	·877684	131·0	·877995	130·4	86	·972325	41·0	·972448	40·4
37	·879492	129·8	·879603	129·1	87	·974328	37·5	·974451	36·9
38	·881307	128·5	881419	127·9	88	·976340	34·0	·976463	33·5
39	·883129	127·3	·883241	126·7	89	·978359	30·6	·978482	30·1
40	·884960	126·0	·885072	125·4	90	·980386	27·2	·980510	26·7
40B	·884888	126·0	·885000	125·4	90B	·980376	27·2	·980500	26·7
41	·886689	124·8	·886801	124·2	91	·982371	23·9	·982496	23·6
42	·888497	123·5	·888609	122·9	92	·984374	20·8	·984498	20·5
43	·890312	122·2	·890425	121 6	93	·986385	17·7	·986510	17·4
44	·892135	120·9	·892248	120·3	94	·988404	14·8	·988529	14·5
45	·893965	119 6	·894078	119·0	95	·990431	12·0	·990557	11·7
46	·895803	118·3	·895916	117 6	96	·992468	9·3	·992593	9·0
47	·897647	116·9	·897761	116 3	97	·994512	6·7	·994637	6·5
48	·899500	115·6	·899614	114 9	98	·996565	4·1	·996691	4·0
49	·901360	114·2	·901417	113·5	99	·998626	1·8	·998752	1·6
50	·903229	112 8	·903343	112·1	100	1·000696	0·0	1·000822	0·0
50B	·903186	112·8	·903300	112·1					

Table of the Densities of Bodies (from Mr Tod's series of Tables).

Name of Bodies.	Weight of a cubic foot in oz. and lb.		Weight of a cubic inch in oz.	Number of cubic in. in a lb.
	oz.	lb.	oz.	cub. in.
Metals.				
Antimony, cast	6702	418·8750	3·8748	3·8866
Zinc, cast	7190	449·3750	4·1608	3·8431
Iron, cast	7207	450·4375	4·1797	3·8364
Tin, cast	72[illegible]1	455·6875	4·2193	3·7920
Tin, hardened	7299	456·1875	4·2239	3·7878
Pewter	7471	466·9375	4·3234	3·7007
Iron, bar	7788	486·7500	4·5069	3·5500
Cobalt, cast	7811	488·1875	4·5202	3·5396
Steel, hard	7816	488·5000	4·5231	3·5373
Steel, soft	7833	489·5625	4·5329	3·5296
Iron, meteoric, hammered	7965	497·8125	4·6093	3·4792
Nickel, cast	8279	517·4375	4·7910	3·3395
Brass, cast	8395	524·6875	4·8582	3·2933
Brass, wire	8544	534·0000	4·9444	3·2359
Nickel, hammered	8666	541·6250	5·0150	3·1903
Gun metal	8784	549·0000	5·0833	3·1476
Copper, cast	8788	549·2500	5·0856	3·1461
Copper, wire	8878	554·8750	5·1377	3·1140
Copper, coin	8915	557·1875	5·1591	3·0959
Bismuth, cast	9822	613·8750	5·6840	2·8149
Silver, hammered	10510	656·8750	6·0821	2·6306
Silver, coin	10534	658·3750	6·0960	2·6246
Silver, pure, cast	10744	671·5000	6·2175	2·5733
Rhodium	11000	687·5000	6·3657	2·5134
Lead, cast	11352	709·5000	6·5694	2·4355
Palladium	11800	737·5000	6·8287	2·5134
Mercury (quicksilver), common	13568	848·0000	7·8518	2·0377
Mercury, „ pure	14000	875·0000	8·1018	1·9748
Gold, trinket	15709	981·8125	9·0908	1·7600
Gold, coin	17647	1102·9375	10·2123	1·6124
Gold, pure, cast	19258	1203·6250	11·1446	1·4356
Gold, hammered	19316	1210·0625	11·2042	1·4280
Platinum, pure	19500	1218·7500	11·2847	1·4178
Platinum, hammered	20336	1271·0000	11·7685	1·3595
Platinum, wire	21041	1315·0625	12·1765	1·3140
Platinum, laminated	22069	1379·3125	12·7714	1·2528
Iridium, hammered	23000	1437·5000	13·3101	1·2021
Earth, Stones, &c.				
Amber	1078	67·3750	0·62384	25·6474
Coal	1250	78·7500	0·72337	21·9428
Sand	1500	93·7500	0·86803	18·4320
Brick	2000	125·0000	1·15740	13·8240
Sulphur, native	2033	127·0625	1·17650	13·5996
Opal	2114	132·1250	1·22337	13·0785
Clay	2160	135·0000	1·25000	12·8000
Gypsum	2280	142·5000	1·31944	12·1263
Porcelain, Limoges	2341	146·3125	1·35474	11·8103
Porcelain, China	2385	147·2500	1·38020	11·7351
Stone, paving	2416	151·4000	1·39814	11·4437
Stone, common	2520	157·5000	1·45833	10·9714
Flint	2594	162·1250	1·50115	10·6584
Spar	2594	162·1250	1·50115	10·6584
Pebble, English	2619	163·6875	1·51562	10·5566
Granite, Aberdeen	2625	164·0625	1·51909	10·5325
Quartz	2640	165·0000	1·52777	10·4727
Glass, green	2642	165·1250	1·52893	10·4648
Crystal, rock	2653	165·8125	1·53530	10·4214
Granite, red Egyptian	2654	165·8750	1·53587	10·4175
Granite, Cornish	2662	166·3750	1·53935	10·3861
Marble, Egyptian	2668	166·7500	1·54976	10·3628
Slate	2672	167·0000	1·54629	10·3473
Coral	2680	167·5000	1·55092	10·3164
Pearl, Oriental	2684	167·7500	1·55324	10·3010
Glass, bottle	2733	170·8125	1·58159	10·1163
Marble, green Campanian	2742	171·3750	1·58735	10·0831
Emerald of Peru	2775	173·4375	1·60590	9·3632
Chalk, British	2784	174·0000	1·61111	9·9310
Marble, Parian	2837	177·3125	1·64178	9·7455
Basalt, Giants' Causeway	2864	179·0000	1·65740	9·6536
Glass, white	2892	180·7500	1·67361	9·5601
Limestone	2950	184·3750	1·70717	9·3721
Asbestos	2996	187·2500	1·73379	9·2283
Hornblende	3000	187·5000	1·73611	9·2160
White lead	3160	197·5000	1·82870	8·7493
Glass, British flint	3329	208·0625	1·92650	8·3052
Diamond, average	3536	221·0000	2·04629	7·8190
Beryl, Oriental	3549	221·8125	2·05381	7·7903
Garnet, common	3576	223·5000	2·06944	7·7315
Topaz, average	3800	237·5000	2·19907	7·2800
Sapphire, Oriental	3994	243·3750	2·25347	7·1001
Garnet, precious	4230	264·3750	2·44791	6·5361
Ruby, Oriental	4283	267·6875	2·47858	6·4590
Jargon of Ceylon	4416	276·0000	2·55555	6·2608
Spar, heavy	4430	276·8750	2·56365	6·2410
Loadstone	4930	308·1250	2·85300	5·6081
The earth (mean of the globe)	5210	325·6250	3·01504	5·3067
Resins, Gums, &c.				
Gunpowder, loose heap	836	52·2500	0·48379	33·0717
Living men	891	55·6875	0·51562	31·0303

Name of Bodies.	Weight of a cubic foot in oz. and lb.		Weight of a cubic inch in oz.	Number of cubic in. in a lb.
	oz.	lb.	oz.	cub. in.
Resins, Gums, &c.				
Wax	897	56·0625	0·51909	30·8227
Ice	930	58·1250	0·53819	29·7293
Gunpowder, close shaken	937	58·5625	0·54224	29·5069
Tallow	942	58·8750	0·54513	29·3503
Butter	942	58·8750	0·54513	29·2993
Beeswax	956	59·7500	0·55324	28·9205
Sodium	972	60·7500	0·56250	28·4444
Camphor	989	61·8125	0·56655	27·9555
Rosin	1100	68·7500	0·63657	25·0909
Pitch	1150	71·8750	0·66550	24·0417
Opium	1337	83·5625	0·77372	20·6791
Gum Arabic	1452	90·7500	0·84027	19·0413
Honey	1456	91·0000	0·84259	18·9890
Bone, of an ox	1659	103·6875	0·96006	16·6654
Bone, dry	1660	103·7500	0·96064	16·6554
Phosphorus	1714	107·1250	0·99184	16·1307
Alum	1714	107·1250	0·99184	16·1307
Gunpowder, solid	1745	109·0625	1·00983	15·8441
Nitre (saltpetre)	1900	118·7500	1·09953	14·5515
Ivory	1917	119·8125	1·10937	14·4422
Woods.				
Cork	240	15·0000	0·13888	115·2000
Poplar	383	23·9375	0·22164	71·7660
Larch	544	34·0000	0·31481	50·8235
Fir, North of England	556	34·7500	0·32175	49·7266
Mahogany, Honduras	560	35·0000	0·32407	49·3714
Cedar, American	561	35·0625	0·32465	49·2833
Poon	579	36·1875	0·33506	47·7512
Willow	585	36·5625	0·35854	47·2615
Cedar	596	37·2500	0·34490	46·3892
Cypress	598	37·3750	0·34664	46·2341
Elm	600	37·5000	0·34722	46·0800
Pitch pine	660	41·2500	0·38194	41·8909
Pear-tree	661	41·3125	0·38252	41·8275
Walnut	681	42·5625	0·39467	40·5991
Fir, Mar Forest	694	43·3750	0·40162	39·8386
Elder-tree	695	43·4375	0·40219	39·7812
Orange-tree	705	44·0625	0·40798	39·2170
Cherry-tree	715	44·6875	0·41377	38·6685
Teak	745	46·5625	0·43113	37·1114
Fir, Riga	750	46·8750	0·43402	36·8640
Maple	755	47·1857	0·43692	36·6198
Oak, Dantzic	760	47·5000	0·43981	36·3789
Yew, Dutch	788	49·2500	0·45590	35·0862
Apple-tree	793	49·5625	0·45891	34·8656
Yew, Spanish	807	50·4375	0·46701	34·2602
Ash	845	52·8125	0·48900	32·7195
Beech	852	53·2500	0·49305	32·4507
Oak, Canadian	872	54·5000	0·50694	31·7064
Logwood	913	57·0625	0·53125	30·2825
Oak, English	970	60·6250	0·56134	28·5030
Box, French	1030	64·3750	0·59606	26·8427
Brazil wood, red	1031	64·3125	0·59664	26·8680
Mahogany, Spanish	1063	66·4250	0·61516	26·0143
Oak, English, 60 years old	1170	73·1250	0·67708	23·6307
Ebony, American	1331	83·1875	0·77025	20·7723
Lignum-vitæ	1333	83·3125	0·77141	20·7411
Liquids.				
Ether, sulphuric	720	45·0000	0·41666	38·4000
Alcohol, absolute	796	49·7500	0·46064	34·7487
Brandy	837	52·3125	0·48437	33·0322
Bitumen, liquid	848	53·0000	0·49074	32·6037
Turpentine, oil of	870	54·3750	0·50347	31·9632
Ether, muriatic	874	54·6250	0·50578	31·63[illegible]8
Olive oil	915	57·1875	0·52951	30·2163
Moselle wine	916	57·2500	0·53009	30·1834
Whale oil	923	57·6875	0·53414	29·9544
Proof spirit	930	58·1250	0·53819	29·7290
Linseed oil	940	58·7500	0·54398	29·4127
Castor oil	970	60·6250	0·56134	28·5030
Wine, red port	990	61·8750	0·57291	27·9272
Wine of Burgundy	991	61·9375	0·57349	27·8990
Wine of Bordeaux	994	62·1250	0·57523	27·8148
Wine, white Champagne	997	62·3125	0·57696	27·7311
Water, distilled	1000	62·5000	0·57870	27·6480
Tar	1015	63·4375	0·58738	27·2396
Vinegar	1026	64·1250	0·59375	26·9473
Sea-water	1028	64·2500	0·59490	26·8949
Milk	1030	64·3750	0·59606	26·8427
Ale (average)	1035	64·6875	0·59895	26·7130
Blood, human	1045	65·3125	0·60474	26·4574
Muriatic acid of commerce	1218	76·1250	0·70486	22·6995
Aqua regia	1234	77·1250	0·71412	22·4051
Water of Dead Sea	1240	77·5000	0·71759	22·2580
Nitrous acid	1452	90·7500	0·84024	19·0082
Nitric acid, or aquafortis	1500	93·7500	0·86805	18·4000
Boracic acid	1830	114·3750	1·05902	15·1081
Sulphuric acid	1848	128·0000	1·06944	13·5000
Quicksilver. (See metals)	...	...	...	...

Name of Bodies.	Weight of a cubic foot in oz. and lb.		Weight of a cubic in. in oz.	Number of cubic in. in a lb.	Number of cubic ft. in a lb.
Gases.	oz.	lb.	oz.	cubic in.	cubic ft.
Hydrogen	0·069	·0043125	·0000399	400695·6	231·8840
Ammonia	0·590	·0368750	·0003414	46861·0	27·1186
Nitrogen	0·972	·0607500	·0005625	28444·4	16·4609
Olefiant gas	0·982	·0613750	·0005682	28154·7	16·2932
Atmospheric air	1·000	·0625000	·0005787	27648·0	16·0000
Nitric oxide	1·042	·0651250	·0006030	26533·5	15·3550
Oxygen	1·111	·0694375	·0006429	24885·6	14·4014

Name of Bodies	Weight of a cubic foot in oz. and lb.		Weight of a cubic in. in oz.	Number of cubic in. in a lb.	Number of cubic ft. in a lb.
Gases.	oz.	lb.	oz.	cubic in.	cubic ft.
Muriatic acid	1·280	·0800000	·0007407	21600·0	12·5000
Carbonic acid	1·524	·0952500	·0008819	18141·7	10·4986
Cyanogen	1·805	·1128125	·0010445	15317·4	8·8642
Sulphurous acid	2·222	·1388750	·0012858	12442·8	7·2007
Chlorine	2·444	·1527500	·0014143	11312·6	6·5466
Fluosilicic acid	3·611	·2256875	·0020896	7656·6	4·4309
Hydriodic acid	4·300	·2687500	·0024884	6429·7	3·7209

In the above table for Sikes's hydrometer two densities are given corresponding to each of the degrees 20, 30, 40, 50, 60, 70, 80, and 90, indicating that the successive weights belonging to the particular instrument for which the table has been calculated do not quite agree. The discrepancy, however, does not produce any sensible error in the strength of the corresponding spirit.

A table which indicates the weight per gallon of spirituous liquors for every degree of Sikes's hydrometer is printed in 23 and 24 Vict. c. 114, schedule B. This table differs slightly from that given above, which has been abridged from the table given in Keene's *Handbook of Hydrometry*, apparently from the equal divisions on Sikes's scale having been taken as corresponding to equal increments of density.

Sikes's hydrometer was established for the purpose of collecting the revenue of the United Kingdom by Act of Parliament, 56 Geo. III. c. 140, by which it was enacted that "all spirits shall be deemed and taken to be of the degree of strength which the said hydrometers called Sikes's hydrometers shall, upon trial by any officer or officers of the customs or excise, denote such spirits to be." This Act came into force on January 5, 1817, and was to have remained in force until August 1, 1818, but was repealed by 58 Geo. III. c. 28, which established Sikes's hydrometer on a permanent footing. By 3 and 4 Will. IV. c. 52, § 123, it was further enacted that the same instruments and methods should be employed in determining the duty upon imported spirits as should in virtue of any Act of Parliament be employed in the determination of the duty upon spirits distilled at home. It is the practice of the officers of the inland revenue to adjust Sikes's hydrometer at 62° F., that being the temperature at which the imperial gallon is defined as containing 10 lb avoirdupois of distilled water. The specific gravity of any sample of spirits thus determined, when multiplied by ten, gives the weight in pounds per imperial gallon, and the weight of any bulk of spirits divided by this number gives its volume at once in imperial gallons.

Mr J. B. Keene of the Hydrometer Office, London, has constructed an instrument after the model of Sikes's, but provided with twelve weights of different masses but equal volumes, and the instrument is never used without having one of these attached. When loaded with either of the lightest two weights the instrument is specifically lighter than Sikes's hydrometer when unloaded, and it may thus be used for specific gravities as low as that of absolute alcohol. The volume of each weight being the same, the whole volume immersed is always the same when it floats at the same mark whatever weight may be attached.

Besides the above, many hydrometers have been employed for special purposes. Twaddell's hydrometer is adapted for densities greater than that of water. The scale is so arranged that the reading multiplied by 5 and added to 1000 gives the specific gravity with reference to water as 1000. To avoid an inconveniently long stem, different instruments are employed for different parts of the scale as mentioned above.

The lactometer constructed by Dicas of Liverpool is adapted for the determination of the quality of milk. It resembles Sikes's hydrometer in other respects, but is provided with eight weights. It is also provided with a thermometer and slide rule, to reduce the readings to the standard temperature of 55° F.

The marine hydrometers, as supplied by the British Government to the royal navy and the merchant marine, are glass instruments with slender stems, and generally serve to indicate specific gravities from 1·000 to 1·040. Before being issued they are compared with a standard instrument, and their errors determined. They are employed for taking observations of the density of sea-water.

The salinometer is a hydrometer intended to indicate the strength of the brine in marine boilers in which sea-water is employed. Saunders's salinometer consists of an hydrometer which floats in a chamber through which the water from the boiler is allowed to flow in a gentle stream, at a temperature of 200° F. The peculiarity of the instrument consists in the stream of water, as it enters the hydrometer chamber, being made to impinge against a disk of metal, by which it is broken into drops, thus liberating the steam, which would otherwise disturb the instrument.

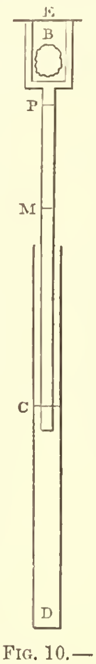


Fig. 10.—Say's Stereometer.

Say's stereometer is an instrument for the determination of the volumes, and hence of the densities, of bodies which cannot be conveniently measured by the ordinary hydrometer, as, for example, soluble and porous bodies, powders, &c. The instrument consists of a glass tube PC (fig. 10), of uniform bore, terminating in a cup PE, the mouth of which can be rendered air-tight by the plate of glass E. The substance whose volume is to be determined is placed in the cup PE, and the tube PC is immersed in the vessel of mercury D, until the mercury reaches the mark P. The plate E is then placed on the cup, and the tube PC raised until the surface of the mercury in the tube stands at M, that in the vessel D being at C, and the height MC is measured. Let k denote this height, and let PM be denoted by l. Let u represent the volume of air in the cup before the body was inserted, v the volume of the body, a the area of the horizontal section of the tube PC, and h the height of the mercurial barometer. Then, by Boyle's law,

$$(u-v+al)(h-k)=(u-v)h,$$

$$\therefore \quad v=u-al\frac{h-k}{k}.$$

The volume u may be determined by repeating the experiment when only air is in the cup. In this case $v=0$, and the equation becomes

$$(u+al')(h-k')=uh,$$

whence

$$u=al'\frac{h-k'}{k'}.$$

Substituting this value in the expression for v, the volume of the body inserted in the cup becomes known, and if m represents its mass its density is $\frac{m}{v}$. (W. G.)

HYDROPATHY is the treatment of disease by water, used outwardly and inwardly. Like many descriptive names, the word "hydropathy" is defective and even misleading, the active agents in the treatment being heat and cold, of which water is little more than the vehicle, and not the only one. Thermo-therapeutics (or thermotherapy) is a term less open to objection. The name "hydropathy," however, as being itself an advance on an earlier and less happy designation, "the water cure," as having obtained general currency, is here employed.

Hydropathy, as a system, or mode of treatment complete in itself, dates from about 1829, when Vincenz Priessnitz (1801–51), a farmer of Gräfenberg in Silesia, Austria, began his public career in the paternal homestead, extended so as to accommodate the increasing numbers attracted by the fame of his cures. Two English works, however, on the medical uses of water had been translated into German in the century preceding the rise of the movement under Priessnitz. One of these was by Sir John Floyer, a physician of Lichfield, who, struck by the remedial use of certain springs by the neighbouring peasantry, investigated the history of cold bathing, and published in 1702 his "*Ψυχρολουσία, or the History of Cold Bathing, both Ancient and Modern.*" The book ran through six editions within a few years, and the translation was largely drawn upon by Dr J. S. Hahn of Silesia, in a work published in 1738, *On the Healing Virtues of Cold Water, Inwardly and Outwardly applied, as proved by Experience.* The other work was that of Dr Currie of Liverpool, entitled *Medical Reports on the Effects of Water, Cold and Warm, as a Remedy in Fevers and other Diseases*, published in 1797, and soon after translated into German by Michaelis (1801) and Hegewisch (1807). It was highly popular, and first placed the subject on a scientific basis. Hahn's writings had meanwhile created much enthusiasm among his countrymen, societies having been everywhere formed to promote the medicinal and dietetic use of water; and in 1804 Professor Oertel of Ansbach republished them and quickened the popular movement by unqualified commendation of water drinking as a remedy for all diseases. In him the rising Priessnitz found a zealous advocate, and doubtless an instructor also. The origin of hydropathy is thus to be traced to an English source and to the medical profession. The broad conception that water had curative relations to the whole realm of disease seems to have been first grasped by a Capuchin monk of Sicily, Father Bernardo, who, at Malta, in 1724, obtained results by iced water alone, which, according to Hahn, caused a great stir throughout Europe; but, owing to the excesses of his imitators, it was of no long duration. With this exception there is, as regards the remedial use of water, nothing in the history of medicine that approaches in completeness the system of Priessnitz, though much leading up to it can be discovered. Among most primitive peoples, indeed, both in the Old and in the New World, the existence of one kind or another of hydropathic practice can be traced; and the fathers of medicine made frequent reference in their writings to the employment of water. The warm bath came into use at an early period (see BATHS, vol. iii. p. 434); and the clyster, shower bath, douche, plunge, wet compress, drop bath, head and foot baths, are mentioned from time to time, as also combinations of heat and cold and primitive modes of sweating, until, before the end of the 17th century, all the processes of modern hydropathy, the wet sheet pack and induced cutaneous crisis alone excepted, had become known and were in a measure practised. Prominent in the roll of names associated more or less with the advocacy of water in earlier times are those of Asclepiades of Prusa (90 B.C.), surnamed Ψυχρολούτης ("cold bather"), Antoninus Musa (30 B.C.), famed for his cure of Augustus by cold water (comp. Hor., *Epist.* i. 15, 3–5), Galen (130 A.D.), Rhazes (923), Avicenna (1036), Cardan, and Van der Heyden. Raymond of Marseilles (1755) gained a prize for the best treatise on the applications of cold water in disease, and another prize essay by Marteau shows what knowledge of the subject prevailed in his time.

At Gräfenberg, to which the fame of Priessnitz drew people of every rank and many countries, medical men were conspicuous by their numbers, some being attracted by curiosity, others by the desire of knowledge, but the majority by the hope of cure for ailments which had as yet proved incurable. Many records of experiences at Gräfenberg were published, all more or less favourable to the claims of Priessnitz, and some enthusiastic in their estimate of his genius and penetration; and from these alone can a knowledge of his practice and views be obtained, not a line having ever been written by this singular man. To Captain Claridge was due the introduction in 1840 of hydropathy to England, his writings and lectures, and later those of Drs Wilson, Gully, and Edward Johnson, making numerous converts, and filling the establishments opened soon after at Malvern and elsewhere. In Germany, France, and America hydropathic establishments multiplied with great rapidity. Antagonism ran high between the old practice and the new. Unsparing condemnation was heaped by each on the other; and a legal prosecution, leading to a royal commission of inquiry, served but to make Priessnitz and his system stand higher in public estimation.

But increasing popularity diminished before long that timidity which hitherto had in great measure prevented trial of the new method from being made on the weaker and more serious class of cases, and had caused hydropathists to occupy themselves mainly with a sturdy order of chronic invalids well able to bear a rigorous regimen and the severities of unrestricted crisis. The need of a radical adaptation to the former class was first adequately recognized by John Smedley, a manufacturer of Derbyshire, who, impressed in his own person with the severities as well as the benefits of "the cold water cure," practised among his workpeople a milder form of hydropathy, and began about 1852 a new era in its history, founding at Matlock a counterpart of the establishment at Gräfenberg.

Whilst hydropathy as a system has been gaining favour with the people, and receiving ample acknowledgment from the more liberal members of the medical profession, individual measures have from time to time been advocated in the medical journals and adopted more or less widely in particular diseases. Brand of Berlin, Räljen and Jürgensen of Kiel, and Liebermeister of Basel, between 1860 and 1870, employed the cooling bath in abdominal typhus with results which, after every deduction on the score of defective classification had been made, were striking enough, and led to its introduction to England by Dr Wilson Fox, whose able monograph commanded general acceptance. In the Franco-German war the cooling bath was largely employed, in conjunction frequently with quinine; and it now holds a recognized position in the treatment of hyperpyrexia. The wet sheet pack has of late been much used in fevers of all kinds both in private and hospital practice; and the Turkish bath, introduced about twenty-four years ago by Mr David Urquhart on his return from the East, and ardently adopted by Mr Barter of Cork, has become a public institution, and, with the "morning tub" and the general practice of water drinking, is the most noteworthy of the many contributions by hydropathy to public health.

The theoretical basis of hydropathy is wide and fundamental enough to include within its scope all disease. Each individual cell of the mass constituting in various forms and combinations the human body being in its growth and function dependent on and regulated by the nervous and vascular systems, themselves cellular, and every derangement of these cells originating in or being attended with a derangement of their nervous and vascular supply, and that supply being powerfully and in quite diverse ways influenced by heat and cold,—all morbid conditions of the economy may be influenced materially by the regulated employment of heat and cold, which are entitled therefore to rank as powerful factors in therapeutics.

Hydropathy insists in quite a special way on the necessity of regarding disease first in relation to its cause. It next requires that whatever assistance may be afforded to the *vis medicatrix naturæ* should in the first place be similar in kind (*i.e.*, should be natural or physiological), rather than alien to it and drawn from sources remote and strange; and, while proceeding on lines which have been common to all medical practice from an early period, it does so by agents hitherto strangely neglected, though not unknown, and effects its purpose in ways less open to objection than those it would displace. For example, when local depletion is required, as of the lung in pneumonia, or the brain in hæmorrhagic apoplexy, the final withdrawal from the general circulation of a quantity of blood is deprecated as unnecessary for the attainment of the object in view, and prejudicial in the after period of convalescence. Hydropathy substitutes a diversion to parts indifferent, as the extremities and general cutaneous surface, and so material and sustained as to be much more effectual; while at the same time it holds in reserve the abstracted blood to perform its part in the restoration of strength. Where purgation is employed to derive blood from the brain, liver, or kidneys, a highly sensitive and vital membrane is more or less injured thereby, and convalescence proportionately imperilled. Hydropathy selects the skin as more accessible than the mucous membrane of the alimentary tract, more serviceable also, and less, if at all, susceptible of injury, either temporary or permanent. The skin can with safety be used for counter-irritation, and is a reservoir of capacity almost unlimited, into which to divert the excess of blood from the brain or other part, while for purposes of excretion it is not inferior to the bowels themselves, and, unlike the latter, is left even more efficient than before. In the febrile state, a reduction of pulse and temperature, and relief from pain and sleeplessness, were commonly attempted, at the period when hydropathy was introduced, by depressants, as antimony, ipecacuanha, and perhaps large doses of alcohol, in combination with sedatives, as opium and chloral. Impaired digestion and depressed vitality were results in some measure inevitable, and always of moment, especially in the more protracted fevers, where recovery becomes a question often of simple physical endurance. By means of the wet sheet pack, cooling compresses, spongings, and allied measures, these ends are attained with comparative ease, certainty, and simplicity, and with entire freedom from objectionable secondary effects.

The agents of hydropathy are at once simple and complex,—simple in their elements, and complex in their combinations and modifications. They afford the physician a series of effects almost infinite in variety, both in kind and in degree, both immediate and remote. According as heat and cold[1] are used in their extreme or their intermediate degrees, singly or in combination, successively or alternately, momentarily or continuously, dry or moist, and according as the primary action is utilized or the secondary, do their effects differ. The direct or primary effect of cold is to depress, cool, and deplete the part concerned. If its exhibition is brief, reaction (an important factor in hydropathic practice) quickly establishes an opposite condition, stimulating the part, and determining an increased flow of blood to it, with increase of its temperature and vital activity. If it is continuous, the primary depression is maintained, and the revulsive or secondary effect delayed or averted. The direct effect of heat is to increase the amount of blood present; but if the exhibition is brief, and evaporation is permitted, the contrary effect is produced, viz., depression, coolness, and depletion; if it is continuous, the primary effect is preserved. Thus with truth it may be said that cold heats and heat cools, while the converse holds good, and that by simple variations of detail. From the intermediate temperatures (80° to 100°) simple sedative effects are obtained, with absence of secondary or revulsive effects in proportion as the temperature of the part is approximated to. Results vary also according to the heat of the subject. In local inflammations, continuous cold benumbs and contracts, continuous heat soothes and relaxes. Momentary cold excites, heats by reaction, and intensifies inflammation; while momentary heat soothes and ultimately cools the inflamed part by the after evaporation. In the earlier stages and acute varieties of inflammation, therefore, continuous cold or transient hot applications are appropriate, and brief applications of cold in the later, congestive, and chronic forms. But where the local inflammation coexists with general feverishness, continuous cold as the local application is preferable, helping, as it does, to reduce the general exaltation of temperature. In collapse the low general temperature makes heat the best local application. On internal parts the application of heat and cold externally has definite therapeutic effects either identical or opposite (as remarked by John Hunter) through reflex or sympathetic nervous action. Through the vascular system also remote effects are produced, as in heating the lower extremities to derive blood from the brain. The counter relation also of the entire cutaneous surface to the internal organs, as the kidneys and alimentary mucous membrane, is, in hydropathy, largely utilized for remedial purposes. This sympathy is familiar enough in the etiology of disease, which may be said likewise of all the physiological laws applied to curative purposes in hydropathy.

The appliances and arrangements by means of which heat and cold are brought to bear on the economy are—(*a*) Packings, hot and cold, general and local, sweating and cooling; (*b*) hot air and steam baths; (*c*) general baths, of hot water and cold; (*d*) sitz, spinal, head, and foot baths; (*e*) bandages (or compresses), wet and dry; also (*f*) fomentations and poultices, hot and cold, sinapisms, stupes, rubbings, and water potations, hot and cold.

(*a.*) Packings.—The full pack consists of a wet sheet enveloping the body, with a number of dry blankets packed tightly over it, including a macintosh covering or not. In an hour or less these are removed and a general bath administered. The pack is a derivative, sedative, sudorific, and stimulator of cutaneous excretion. There are numerous modifications of it, notably the cooling pack, where the wrappings are loose and scanty, permitting evaporation, and the application of indefinite duration, the sheet being rewetted as it dries; this is of great value in protracted febrile conditions. There are also local packs, to trunk, limbs, or head separately, which are derivative, soothing, or stimulating, according to circumstance and detail.

(*b.*) Hot air baths, the chief of which is the Turkish (properly, the Roman) bath, consisting of two or more chambers ranging in temperature from 120° to 212° or higher, but mainly used at 150° for curative purposes. Exposure is from twenty minutes up to two hours according to the effect sought, and is followed by a general bath, and occasionally by soaping and shampooing. It is stimulating, derivative, depurative, sudorific, and alterative, powerfully promoting tissue change by increase of the natural waste and repair. It determines the blood to the surface, reducing internal congestions, is a potent diaphoretic, and, through the extremes of heat and cold, is an effective nervous and vascular stimulant and tonic. Morbid growths and secretions, as also the uræmic, gouty, and rheumatic diathesis, are beneficially influenced by it. The full pack and Turkish bath have between them usurped the place and bettered the function of the once familiar hot bath. The Russian or steam bath and the lamp bath are primitive and inferior varieties of the modern Turkish bath, the atmosphere of which cannot be too dry and pure.

(*c.*) General baths comprise the rain (or needle), spray (or rose), shower, shallow, plunge, douche, wave, and common morning sponge baths, with the dripping sheet, and hot and cold spongings, and are combinations, as a rule, of hot and cold water. They are stimulating, tonic, derivative, and detergent.

(*d.*) Local baths comprise the sitz (or sitting), douche (or spouting), spinal, foot, and head baths, of hot or cold water, singly or in combination, successive or alternate. The sitz, head, and foot baths are used "flowing" on occasion. Rapid alternations of hot and cold water have a powerful effect in vascular stasis and lethargy of the nervous system and absorbents, yielding valuable results in local congestions and chronic inflammations.

(*e.*) Bandages (or compresses) are of two kinds,—*cooling*, of wet material left exposed for evaporation, used in local inflammations and fevers; and *heating*, of the same, covered with waterproof material, used in congestion, external or internal, for short or long periods. Poultices, warm, of bread, linseed, bran, &c., changed but twice in twenty-four hours, are identical in action with the heating bandage, and superior only in the greater warmth and consequent vital activity their closer application to the skin ensures.

(*f.*) Fomentations and poultices, hot or cold, sinapisms, stupes, rubefacients, irritants, frictions, kneadings, calisthenics, gymnastics, electricity, &c., are adjuncts largely employed in hydropathic practice. Water drinking, while still an important factor in hydropathy, has declined somewhat since the early times of the system.

But that which has from the first distinguished modern hydropathy, and still makes its strict practice a thing apart, is the "crisis" so called. It is related of Priessnitz that, when a boy of fourteen, and treating a sprain, as was the native custom, with wet cloths, he observed an eruption appear beneath them, with immediate recovery of the part. Gradually the significance and wider application of this eruption dawned upon him, until it came to hold so prominent a place in his practice as to be regarded by many as his greatest discovery. The eruption coinciding in point of time with recovery as a rule, it was called the crisis, involving doubtless a reference to the term as used by Hippocrates and his successors. But with Priessnitz crisis attained a higher rank, a wider application, and a more definite character. He first showed it to be producible at will under given conditions of the patient, and amenable to direction and control. This eruption, it is claimed, appears only in morbid states of the blood (cachexia) resulting from derangement or defect in the organs of assimilation or excretion or both (*e.g.*, gout, rheumatism), or from the presence of a specific poison (*e.g.*, syphilis). The continuous application to a given tract of skin of the heating bandage or poultice (mediums merely for the exhibition of warmth and moisture) stimulates, in a cumulative way, its vascular and nervous activity, and leads, it may be in a few days or weeks (in some cases hours, in others months), to an eruption, papular, then pustular, and ultimately resolving itself into a suppurating surface commensurate with the area covered by the bandage. There is, in the latter stage, a copious discharge of yellowish-green pus, usually fœtid, varied occasionally with patches of brown, blue, or metallic green, and accompanied with itching, sometimes intense. The general temperature is not, as a rule, disturbed; the pulse, except perhaps for the first day or two, falls, if previously quick, to a natural rate; the weight and strength, in the most favourable cases from the outset, and in the rest later on, increase, and it is not uncommon to find the anomaly of a patient exulting in freedom from suffering and a return of the impulses of health simultaneously with the appearance of an extensive inflammation of the skin. The applications, continued without intermission and unaltered (save as cleanliness requires) for weeks or months, according to the nature of the case, are at last no more stained with pus but with serum

[1] Roughly, and for practical purposes, temperature lower than 60° may be called cold; from 60° to 90°, temperate or tepid; from 90° to 100°, warm; and above 100°, hot (compare vol. iii. p. 440).

simply; and finally, still without change of application, the skin will heal, or, at most, show a little psoriasis, pityriasis, or eczema, or, it may be, but a faint tinge of red. The bandages are then withdrawn. The original symptoms meanwhile have disappeared with more or less celerity and completeness; and with the eruption has departed the disease that called for it and made it possible. Strength grows apace, no longer taxed by disease or crisis, until recovery in appropriate cases is absolute and secure.

Occasionally the cutaneous inflammation extends in the form of psoriasis, eczema, sudamina, a papular rash, or a succession of boils, invading parts untouched by the wet compress. This is called a general crisis; it usually occurs in the last stage of the local one, sometimes after it has ceased, and is advantageous and transient. Debility, whether pre-existing or consequent on the crisis, may call for some modification of its severity and duration, whether by instalments at proper intervals, or curtailment in the later stages, the natural emunctories being relied on to complete the work of purification at greater leisure. A residuum of incurable organic degeneration, as of the kidneys or liver, may likewise put limits to recovery, and provide perpetual material for crisis until the patient is worn out in a vain and ignorant attempt at cure. It was the failure of the earlier hydropathists—through inexperience, default of medical education, or inordinate enthusiasm—to recognize these limitations, that brought crisis into its present discredit and comparative desuetude. Where it is necessary from these or other causes to relieve the patient of the eruption, the substitution of simple ointment, unsalted lard, or other oleaginous or viscid material for the stimulating bandages or poultices, permits the excitement to subside, and, with occasional exceptions, the skin, in a few days, it may be hours, bears little trace of the eruption.

In the course of hydropathic treatment there occur, though rarely, attacks of diarrhœa, sickness, diuresis, or diaphoresis, which, having been observed frequently to mark the turning point in the history of the case, are held to be varieties of crisis, disturbances attendant on the expulsion of the materies morbi from the system.

The theory of crisis may be stated thus. The digestive and assimilative organs are, as is well known, involved, whether primarily or secondarily, in by far the majority of morbid conditions. Their product, the blood, undergoing constant renewal, becomes necessarily more or less impaired,—deprived of the blandness that pertains alone to a pure and perfect condition, with what may be termed an inflammatory disposition as the result. The most familiar, because pronounced, forms are the gouty, rheumatic, tubercular, and strumous diatheses. Later the excretory organs, in common with the whole economy, must more or less become deranged, with additions, in consequence, to the sum of morbid elements in the blood, such as uræmic and biliary matters. A vicious circle of action and reaction is established from which escape is difficult, if not impossible, in its more pronounced developments. The digestive disorder begets imperfect and impure blood, and the morbid blood keeps up, and *cæteris paribus* increases, the initial and originating digestive disorder. In all but its most advanced stages ordinary measures, hydropathic or other, may suffice to break this chain, and, by eliminating one or more of its links, render recovery possible, or accomplish it. It is when the complication is beyond their reach that the domain peculiar to crisis begins. The superior vascularity and vitality of the digestive organs—the alimentary tract of mucous membrane, the pancreas, and the liver—is what makes them (in addition to their susceptibility to injury through errors in diet) so commonly the seat of diseased action. The highly nervous and vascular structure of the skin makes easy its elevation to at least an equality in vital activity with the mucous membrane. Warmth and moisture continuously applied to a given portion will, in time, effect this, aided doubtless by maceration and denudation of the cuticle and exposure of the sensitive cutis vera. It thus becomes the seat of greatest vital activity; pre-eminence in morbid activity naturally follows, and a genuine metastasis is effected, such as the natural history of disease is rich in examples of. There is a decline, *pro tanto*, of the primary internal disorder under this combined pressure, first by the diversion of morbific elements, and then by the diversion of an appreciable quantity of the blood itself, and by counter-irritation, when the site of the vicarious inflammation has been selected with that in view. The aid of a sustained derivation to the entire cutaneous surface and the extremities is at the same time secured by means of the Turkish bath, full packs, and other stimulating agents, while, at the same time, due care is taken to eliminate and negative the original causes of disease. The sum of morbid activity is for the time being increased and intensified; but, in the new location, no longer self-supporting and self-perpetuating, it is sooner or later exhausted. The change in the relation of the materies morbi to the digestive system puts an end at one and the same time to the originating and sustaining conditions. The failure of simple counter-irritation (where, as by sinapisms, vesicatories, &c., the irritant is derived from without) to effect the same result in many of the cases afterwards cured by crisis negatives of itself the view that the results of the latter are to be attributed to the element in it of counter-irritation alone.

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HYDROPHOBIA, from ὕδωρ, water, and φοβέω, to fear (Syn. *Rabies, Lyssa*), an acute infectious disease, occurring chiefly in certain of the lower animals, particularly the canine species, and liable to be communicated by them to other animals, and to man. The main features of the disease are similar alike in the lower animals and men, but that peculiar symptom from which the malady derives its name, viz., the dread of water, appears only to affect the latter. Rabies as it manifests itself in animals belongs to the subject of veterinary medicine; the present notice refers only to hydrophobia occurring in man. The disease has been known from early times, and is alluded to in the works of Aristotle, Xenophon, Plutarch, Virgil, Horace, Ovid, and many others, as well as in those of the early writers on medicine. Celsus gives detailed instructions respecting the treatment of men who have been bitten by rabid dogs, and dwells on the dangers attending such wounds. After recommending suction of the bitten part by means of a dry cupping glass, and thereafter the application of the actual cautery or of strong caustics, and the employment of baths and various internal remedies, he says: "Idque cum ita per triduum factum est, tutus esse homo a periculo videtur. Solet autem ex eo vulnere, ubi parum occursum est, aquæ timor nasci, ὑδροφοβίαν Græci appellant. Miserrimum genus morbi; in quo simul æger et siti et aquæ metu cruciatur; quo oppressis in angusto spes est." Subsequently Galen described minutely the phenomena of hydrophobia, and recommended the excision of the wounded part as a protection against the disease. Throughout many succeeding centuries little or nothing was added to the facts which the early physicians had made known upon the subject. The malady was regarded with universal horror and dread, and the unfortunate sufferers were generally abandoned by all around them and left to their terrible fate. In later times the investigations of Boerhaave, Van Swieten, John Hunter, Magendie, Breschet, Virchow, Reder, as also of Youatt, Fleming, Meynell, Hertwig, and others, have furnished important information; nevertheless much remains obscure as to the nature and pathology of this formidable disease.

Whatever may be said as to the spontaneous development of rabies in animals—a view which is now generally discredited—there can be no doubt that in man the disease is in every instance the result of the inoculation of the virus contained in the secretions of the mouth of the affected animal into a wound or abrasion of the skin or mucous membrane. In the great majority of cases (90 per cent.) this is due to the bite of a rabid dog, but bites of rabid cats, wolves, foxes, jackals, &c., are occasionally the means of conveying the disease. There is no evidence that the poison can be introduced into the system without an abrasion of the surface. But it must be observed that even of those who have undoubtedly been bitten by rabid animals, only a proportion subsequently suffer from hydrophobia. Thus where the bite has been inflicted on a part of the body protected by clothing, the virus may be wiped from the teeth of the animal before they penetrate the skin. Hence it is found that bites on exposed parts such as the face are very much more dangerous than on other parts which are ordinarily covered. But further, individual susceptibility must be taken into account, for it is undeniable that many persons in whom the virus of rabies has been inoculated escape hydrophobia. John Hunter mentions one remarkable instance in which of twenty-one persons bitten by a rabid dog only one subsequently died from hydrophobia; and a comparison of the best authorities would seem to show that the proportion of those who are attacked with the disease to those who are bitten is less than one-half, Numerous popular fallacies prevail on the subject of hydrophobia. Thus it is supposed that the bite of an angry dog may produce the disease, and all the more if the animal should subsequently develop symptoms of rabies. The ground for this erroneous notion is the fact, which is unquestionable, that animals in whom rabies is in the stage of incubation, during which there are few if any symptoms, may by their bites convey the disease, though fortunately during this early stage they are little disposed to bite. The bite of a non-rabid animal, however enraged, cannot give rise to hydrophobia. Another fallacious notion, not altogether of popular origin, but maintained by a few eminent professional authorities, is to the effect that there is no such disease as hydrophobia at all, but that the symptoms designated by that name are entirely mental phenomena produced by the effect of fear of the consequences following a bite. It might be sufficient as a reply to this to point to the uniform sequence of terrible symptoms which mark the progress of the malady when it has commenced, and to its acute course and invariably fatal termination; but there is the additional fact that very young children, in whom this feeling could scarcely be expected to operate, may suffer and die from hydrophobia.

The period of incubation of the disease, or that time which elapses between the introduction of the virus and the development of the symptoms, appears to vary in a remarkable degree, being in some cases as short as a fortnight, and in others as long as several months or even years. On an average it seems to be from about six weeks to three months. The rare instances of the appearance of hydrophobia many years after the introduction of the poison are always more or less open to question as to subsequent inoculation. During the period of latency, in which the patient seems perfectly well, it is supposed that the poison is undergoing a sort of multiplication, both in the previously wounded part and in the system at large, somewhat analogous to the fermentive process, and that ultimately it comes to tell with deadly effect upon certain portions of the nervous system.

When the disease is about to declare itself it not unfrequently happens that the wound, which had quickly and entirely healed after the bite, begins to exhibit evidence of irritation or inflammatory action, or at least to be the seat of morbid sensations such as numbness, tingling, or itching. The symptoms characterizing the premonitory stage are great mental depression and disquietude, together with restlessness and a kind of indefinite fear. There is an unusual tendency to talk, and the articulation is abrupt and rapid. Although in some instances the patients will not acknowledge that they have been previously bitten, and deny it with great obstinacy, yet generally they are well aware of the nature of their malady, and speak despairingly of its consequences. There is in this early stage a certain amount of constitutional disturbance showing itself by feverishness, loss of appetite, sleeplessness, headache, great nervous excitability, respiration of a peculiar sighing or sobbing character, and even occasionally a noticeable aversion to liquids. These symptoms—constituting what is termed the melancholic stage—continue in general for one or two days, when they are succeeded by the stage of excitement in which all the characteristic phenomena of the malady are fully developed. Sometimes the disease first shows itself in this stage, without antecedent symptoms.

The agitation of the sufferer now becomes greatly increased, and the countenance exhibits anxiety and terror. There is noticed a marked embarrassment of the breathing, but the most striking and terrible features of this stage are the effects produced by attempts to swallow fluids. The patient suffers from thirst and desires eagerly to drink, but on making the effort is seized with a most violent suffocative paroxysm produced by spasm of the muscles of swallowing and breathing, which continues for several seconds, and is succeeded by a feeling of intense alarm and distress. With great caution and determination the attempt is renewed, but only to be followed with a repetition of the seizure, until the unhappy sufferer ceases from sheer dread to try to quench the thirst which torments him. Indeed the very thought of doing so suffices to bring on a choking paroxysm, as does also the sound of the running of water. The patient is extremely sensitive to any kind of external impression; a bright light, a loud noise, a breath of cool air, contact with any one, are all apt to bring on one of these seizures. But besides these suffocative attacks there also occur general convulsions affecting the whole muscular system of the body, and occasionally a condition of tetanic spasm. These various paroxysms increase in frequency and severity with the advance of the disease, but alternate with intervals of comparative quiet, in which, however, there is intense anxiety and more or less constant difficulty of breathing, accompanied with a peculiar sonorous expiration, which has suggested the notion that the patient barks like a dog. In many instances there is great mental disturbance, with fits of maniacal excitement, in which he strikes at every one about him, and accuses them of being the cause of his sufferings,—these attacks being succeeded by calm intervals in which he expresses great regret for his violent behaviour. During all this stage of the disease the patient is tormented with a viscid secretion accumulating in his mouth, which from dread of swallowing he is constantly spitting about him. There may also be noticed snapping movements of the jaws as if he were attempting to bite, but these are in reality a manifestation of the spasmodic action which affects the muscles generally. There is no great amount of fever, but there is constipation, diminished flow of urine, and often sexual excitement.

After two or three days of suffering of the most terrible description the patient succumbs, death taking place either in a paroxysm of choking, or on the other hand in a tranquil manner from exhaustion, all the symptoms having abated, and the power of swallowing returned before the end. The duration of the disease from the first declaration of the symptoms is generally from three to five days.

Post-mortem examination has not hitherto thrown much light upon this malady, but the subject is at the present time engaging the special attention of certain eminent pathologists, and important and valuable information may be anticipated. The chief morbid changes which have been described are evidences of congestion and inflammatory action in certain portions of the brain and spinal cord, but more particularly in the locality known as the "respiratory centre" of the medulla oblongata, where the accumulation of "leucocytes" around the small blood-vessels and in the surrounding nervous substance are a prominent phenomenon. Similar changes have been found in the salivary glands. On the whole, however, it can scarcely be said that the formidable array of symptoms above narrated are accounted for by these appearances, which in the opinion of some are in all likelihood merely the results of antecedent processes of an occult nature affecting the nerve centres and forming the essence of the disease.

That emotional disturbance is present is undeniable, for it is found that those cases of hydrophobia are less severe where there is no suspicion on the part of the sufferer of the nature of his complaint; yet this only represents one of many elements. The function of the eighth pair of nerves (which are largely concerned in the processes of respiration and deglutition) is disturbed in a marked degree, and it is probable that this is the portion of the nervous system upon which the poison most powerfully exerts its specific action. But that the great nerve centres, viz., the brain and spinal cord as a whole, are profoundly affected, is manifest in the tendency to general convulsion, the remarkable hyperæsthesia, and the mental perturbation of the patient.

The treatment of most avail in this disease is that which is directed towards preventing the absorption of the poison into the system. This may be accomplished by excision of the part involved in the bite of the rabid animal, or, where this from its locality is impracticable, in the application to the wound of some chemical agent which will destroy the activity of the virus, such as potassa fusa, lunar caustic (nitrate of silver), or the actual cautery in the form of a red-hot wire. The part should be thoroughly acted on by these agents, no matter what amount of temporary suffering this may occasion. Such applications should be resorted to immediately after the bite has been inflicted, or as soon thereafter as possible. Further, even though many hours or days should elapse, these local remedies should still be applied; for if, as appears probable, some at least of the virus remains for long at the injured part, the removal or effectual destruction of this may prevent the dread consequences of its absorption. Every effort should be made to tranquillize and reassure the patient.

When once the symptoms of hydrophobia have declared themselves, little can be achieved by the resources of the physician beyond palliating the agonizing sufferings and rendering easier the inevitably fatal event.

Medicines cannot be administered by the mouth, owing to the impossibility of swallowing and the distress occasioned by the effort to do so; they must therefore be given either by the bowel in the form of enema, by hypodermic injection, or by inhalation. The most approved and potent agents are opium, belladonna, curara, chloral, and chloroform inhalation. The vapour bath is also recommended. It need scarcely be said that those coming in contact with the patient should guard against the risk of being bitten during the paroxysms of excitement, or of being inoculated by the saliva, for although there are few if any well-authenticated cases of the disease being communicated in this way, yet the possibility must be admitted.

It should be remarked that occasionally an individual who may have at some time been bitten by a non-rabid dog manifests symptoms strongly resembling in many points those of hydrophobia. These are often simply the effect of fear, and have much of the hysterical element mixed up with them. They are generally of much less severity in every way than those of the true disease, and yield readily to treatment appropriate to the disturbed nervous condition. (J. O. A.)

HYDROZOA

THE HYDROZOA form one of the three classes into which the *Cœlentera nematophora* (distinguished from the *Cœlentera porifera*, or Sponges) have been divided,—recognized as such in the article CŒLENTERA, to which the reader is referred. It results from observations made by Ernst Haeckel, since that article and the article ACTINOZOA were penned, that the *Ctenophora* should not be regarded as a class equivalent to the *Hydrozoa* and *Actinozoa*, nor as a subdivision of the latter class, but that they must be considered as a peculiar modification of the medusiform *Hydrozoa* (see final paragraph). If this conclusion be accepted, it will be necessary to divide the *Hydrozoa* into two primary groups or grades, for which the names *Polypomorpha* and *Ctenophora* are proposed.

The *Hydrozoa* correspond to the Linnæan genera *Hydra*, *Tubularia*, *Sertularia*, and *Medusa*. The name was applied by Huxley in 1856 to a group corresponding to that termed *Hydromedusæ* by Vogt (1851) and *Medusæ* by Leuckart (1853), and embracing the forms placed by Gegenbaur in his *Elements of Comparative Anatomy* (1878) in four classes, viz., *Hydromedusæ*, *Calycozoa*, *Thecomedusæ*, and *Medusæ*. Our knowledge of the structure and life-history of the *Hydrozoa*, many of which, on account of their delicacy and oceanic habits, are excessively difficult to obtain in a state fit for investigation, has greatly extended within the last five years. Whilst in the two decades preceding this period the admirable researches of Huxley, Gegenbaur, Agassiz, and Allman had brought to light and systematized a vast mass of information with regard to these organisms, the later observations of Claus, the Hertwigs, Haeckel, and Metschnikoff, have corrected, extended, and added to their history, especially in respect of embryological and histological detail. An epitome of the present condition of our knowledge of the group is afforded by the subjoined tabular classification of its families, orders, and sub-classes.

The definition and synonymy of the divisions recognized will be entered into, after a sketch has been given of the common structural features of typical *Hydrozoa*.

CLASS HYDROZOA.

	Examples.
Sub-Class I. **Scyphomedusæ** (syn. Ephyromedusæ).	
Order 1. LUCERNARIÆ.	
Fam. 1. Eleutherocarpidæ	Lucernaria (fig. 19). Haliclystus.
„ 2. Cleistocarpidæ	Craterolophus. Manania.
Order 2. DISCOMEDUSÆ (Haeckel).	
Sub-Order 1. Cubostomæ.	
Fam. 1. Protephyridæ.	
„ 2. Nausithoidæ	Nausithoe.
„ 3. Ephyrellidæ.	
„ 4. Atollidæ.	
„ 5. Cyclorchidæ.	
Sub-Order 2. Semostomæ.	
Fam. 1. Pelagidæ	Chrysaora (fig. 24, *b*) Pelagia.
„ 2. Cyanæidæ	Cyanæa.
„ 3. Sthenonidæ	Sthenonia.
„ 4. Aurelidæ	Aurelia (figs. 26–31).
Sub-Order 3. Rhizostomæ.	
Fam. 1. Tetragamellæ	Cephea. Cassiopeia.
„ 2. Monogameliæ	Rhizostoma (fig. 24, *a*). Crambessa.
Order 3. CONOMEDUSÆ (Haeckel).	
Fam. 1. Charybdeidæ	Charybdæa (figs. 20–23).
„ 2. Bursaridæ.	
„ 3. Chiropsalmidæ.	
Order 4. PEROMEDUSÆ (Haeckel).	
Fam. 1. Periphyllidæ.	
„ 2. Pericryptidæ.	

Sub-Class II. **Hydromedusæ.**

Order 1. Gymnoblastea-Anthomedusæ.

- Fam. 1. Tubularidæ .... Tubularia (fig. 35). Hybocodon. Corymorpha (fig. 34).
- „ 2. Pennaridæ .... Pennaria. Vorticlava.
- „ 3. Eudendridæ .... Bougainvillia (figs. 36, 37). Perigonium. Lizzia (fig. 44).
- „ 4. Cladonemidæ .... Cladonema. Clavatella.
- „ 5. Bimeridæ .... Garveia. Stylactis.
- „ 6. Dicorynidæ .... Dicoryne (fig. 40).
- „ 7. Corynidæ .... Sarsiadæ (fig. 45). Coryne. Syncoryne (figs. 41, 46).
- „ 8. Hydractinidæ .... Hydractinia (fig. 39). Podocoryne.
- „ 9. Clavidæ .... Clava-Turris (fig. 38). Cordylophora.
- „ 10. Hydridæ .... Hydra (fig. 42). Protohydra(?).

Order 2. Calyptoblastea-Leptomedusæ.

- Fam. 1. Plumularidæ .... Plumularia. Antennularia.
- „ 2. Sertularidæ .... Sertularia. Halecium.
- „ 3. Campanularidæ .... Eucopidæ. Campanularia (fig. 43). Laomedea. Obelia.
- „ 4. Thaumantiadæ .... Thaumantias. Lafoea. Melicertum. Tima.
- „ 5. Æquoridæ .... Æquorea. Zygodactyla. Rhegmatodes.

Order 3. Trachomedusæ (Haeckel).

- Fam. 1. Petasidæ .... Petasus.
- „ 2. Trachynemidæ .... Rhopalonema.
- „ 3. Aglauridæ .... Aglaura.
- „ 4. Geryonidæ .... Liriope. Carmarina (figs. 48, 49).

Order 4. Narcomedusæ (Haeckel).

- Fam. 1. Cunanthidæ .... Cunina (figs. 50, 51).
- „ 2. Peganthidæ .... Polyxenia.
- „ 3. Æginidæ .... Ægina. Æginopsis
- „ 4. Solmaridæ .... Solmissus. Solmaris.

Order 5. Hydrocorallinæ (Moseley).

- Fam. 1. Milleporidæ .... Millepora (figs. 52, 53).
- „ 2. Stylasteridæ .... Sporadopora. Distichopora. Astylus (fig. 54).

Order 6. Siphonophora.

Sub-Order 1. Physophoridæ.

- Fam. 1. Athorybiadæ .... Athorybia.
- „ 2. Physophoridæ .... Physophora (fig. 57, C).
- „ 3. Agalmidæ .... Forskallia. Halistemma. Agalma (fig. 57, E).
- „ 4. Apolemiadæ .... Apolemia.
- „ 5. Rhizophysidæ .... Rhizophysa.

Sub-Order 2. Physalidæ.

- Fam 1. Physalidæ .... Physalia.

Sub-Order 3. Calycophoridæ.

- Fam. 1. Hippopodiidæ .... Gleba.
- „ 2. Diphyidæ .... Praya. Diphyes (fig. 57, A). Abyla.
- „ 3. Monophyidæ .... Sphæronectes.

Sub-Order 4. Discoideæ.

- Fam. 1. Velellidæ .... Velella. Porpita.

The *Hydrozoa* present a greater simplicity of ultimate structure than do any animal organisms possessed of as great a complexity of external form. As in all *Metazoa* or *Enterozoa*, the life cycle of a hydrozoon starts with an egg which is at first a single cell or unit of protoplasm, but proceeds after fertilization to multiply by transverse fission in such a way that the resulting cells or units are arranged in two layers, each one cell deep, disposed around a central cavity—the enteron or archenteron. The sac thus formed is known as a diblastula (figs. 1, 2, and 25). By the formation[1] of a mouth to the sac, the enteron acquires the functions of a digestive retort in which food matters taken in at the mouth are brought into a chemical condition suitable for the nutrition of the surrounding cells. The two layers of cells (of which the outer only acquires additional layers[2] by the division of the primary cells, and that by no means in all cases) received from Allman (*Phil. Trans.*, 1855) the names respectively of the ectoderm and the endoderm, having previously been shown by Huxley (1849) to be the fundamental membranous constituents of which the most varied parts of the more complex *Hydrozoa*—such as tentacles, swimming bells, and air-bladders—are built up in the adult condition. Huxley also pointed out the identity of these membranes with the two primary layers of the vertebrate embryo. The endoderm and the ectoderm, which present themselves, as is now known, in the diblastula (or gastrula) phase of all *Enterozoa*, remain in *Hydrozoa* (and also in the allied groups of *Cœlentera*) as permanently distinguishable elements of structure. This important disposition is associated with and dependent on the simple character which the archenteron or primitive digestive space retains. Into whatever lobes or processes the sac-like body may be, so to speak, moulded, whether tentacles[3] or broader expansions, into these the cavity of the archenteron is extended in the first instance; and where the actual cavity is obliterated the endodermic cell-layer remains to represent it (Gefässplatte or endoderm-lamella, see figs. 7 and 16).

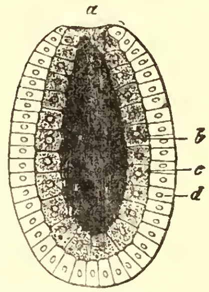

Fig. 1.—Diagram of a Diblastula. *a*, orifice of invagination (blastopore); *b*, archenteric cavity; *c*, endoderm; *d*, ectoderm. (From Gegenbaur's *Elements of Comparative Anatomy*)

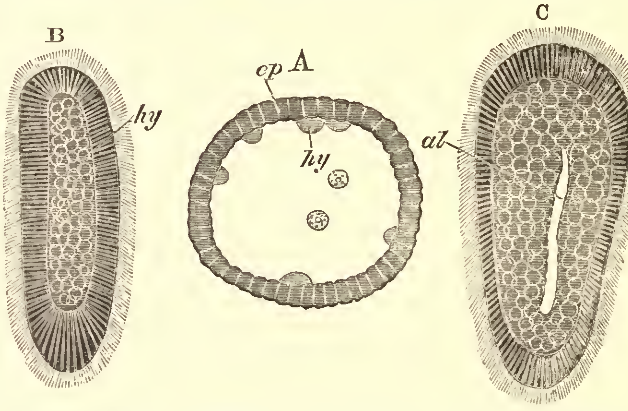

Fig. 2.—Formation of the Diblastula of *Eucope* (one of the Calyptoblastic *Hydromedusæ*) by delamination. (From Balfour, after Kowalewsky.) A, B, C, three successive stages. *ep*, ectoderm; *hy*, endoderm; *al*, enteric cavity.

Conversely, whatever canals or spaces are discovered in the substance of a hydrozoon (excepting only the cavity of ectodermal otocysts) are simple and direct continuations of the one original enteric cavity of the diblastula, and all such spaces are permanently in free communication with one another.[4]

The whole of the *Hydrozoa* seem to present a lower grade of structure than the *Actinozoa*, in so far as the latter, whilst retaining permanently free communication between all parts of the archenteric space, yet exhibit a differentiation of this space into an axial and a periaxial portion—a digestive tube and a body cavity. The differentiation has only to proceed a step further, namely, to the closure or shutting off of the axial from the periaxial portion of the archenteric space, and we obtain the condition which characterizes the adult forms of the *Cœlomata*, or animals

[1] In *Hydromedusæ* the inner layer of cells forms by delamination, in *Scyphomedusæ* by invagination. In the latter case the sac closes up, and the mouth is formed by a new opening.

[2] It is probable that the numerous rows of cells described in the endoderm of *Tubularia* and *Corymorpha* by Allman, in his great monograph of the *Tubularian Hydroids*, are due to a plication of the original endodermal cell-layer. The two kinds of cells in two layers figured by the same authority in the endoderm of *Gemmellaria implexa*, pl. vii. fig. 5, cannot, however, be thus explained.

[3] Some solid tentacles, with a single axial row of endodermal cells, form an exception to this statement.

[4] The observations of Eilhard Schulze cited in the article Cœlentera do not form any real exception to this statement.

with blood-lymph space distinct from digestive canal.[1] With the attainment of the cœlomate condition, the two fundamental cell-layers, ectoderm and endoderm, which still appear in the embryo, become so far interwoven, and their products so highly differentiated, that it is no longer possible to recognize them as anatomical structures in the adult.

The only deep-seated distinction between *Hydrozoa* and *Anthozoa* (the *Actinozoa* being thus termed when the *Ctenophora* are detached from them) appears to be the particular differentiation of the archenteric space in *Anthozoa* which has just been noted. It is no longer possible to separate the two groups from one another as *Exoarii* and *Endoarii*, as was proposed by Rapp (*Ueber die Polypen im Allgemeinen und die Actinien insbesondere*, Weimar, 1829)—the first term indicating the *Hydrozoa* as possessed of external generative organs, whilst by the latter term the *Anthozoa* are pointed to as having internal generative organs.[2] This distinction breaks down completely in the case of *Lucernaria*, and even in that of the so-called phanerocarpous and some other medusæ which discharge their genital products by the mouth, and quite rarely by rupture of the outer body-wall. The tendency to form calcareous deposits in the deep layers of the ectoderm, or mesoderm, as it has been termed, exhibited almost universally by the *Anthozoa* (whence the name *Coralligena* applied to them), is distinctive of them, though it has been shown first by Louis Agassiz, and more fully and recently by Moseley, to be paralleled among *Hydrozoa*, by the *external* calcareous deposits of the abundant and widely distributed Millepores and Stylasterids. A minute distinction between *Hydrozoa* and *Anthozoa*, which does not, however, hold good universally, is found in the form of the barbed threads ejected by the nematocysts. Instead of the complicated forms present in the latter group, the *Hydrozoa* are usually provided with either an unbarbed thread or one in which the barbs are confined to three at the base and a few minute barblets (fig. 5).

Fundamental Forms of the Hydrozoa.—The diblastula derived from the egg of a hydrozoon, when provided with a mouth, may be spoken of (as are the equivalent forms in other animals groups) as a person. Either this person elongates and develops tentacles in a circlet around or near the mouth, and usually becomes fixed by the aboral pole of the sac-like body, or the sac gradually assumes the form of a clapper-bell or of an umbrella with greatly thickened handle, the mouth being placed at the free end of the handle or of the clapper, and the animal freely swimming by the contractions and expansions of the dome of the bell (disc of the umbrella). The two forms of persons are known,—the former as the "hydriform" (2, 3 in fig. 16), the latter as the "medusiform" (4, 5, 6 in fig. 16).

The HYDRIFORM PERSONS usually occur as fixed branching colonies or trees (figs. 36 and 37) produced by lateral budding from an original hydra-form developed from a diblastula.

The hydriform person in its most fully developed state is seen in the colonies of *Tubularia*. In such a colony a number of hydriform persons are united like the flowers of a plant on its branches (whence Allman's terms hydranth, hydrophyton). Each hydriform person (fig. 35) has an elongated *body* with oral and aboral pole. The mouth is placed centrally at the oral pole, which is somewhat enlarged and conical. At the apex of the cone, immediately around the mouth, is a circlet of *small tentacles*; at the base of the cone is a second circlet of *larger tentacles*; the surface of the oral cone is termed the *hypostome*. In other genera (*e.g.*, *Hydra*, fig. 42) the smaller circle of tentacles is wanting; in others, again, the tentacles are irregularly placed and not concentrated into one circlet (fig. 38). We regard the former as the typical condition. In the hydriform persons of the *Scyphomedusæ* (figs. 26 and 27) the vertical axis is much shortened, the hypostome is flat, and the whole body cup-like or hemispherical.

The tentacles of the hydriform person are sometimes hollow (*Hydra*, *Garveia nutans*, *Hydrocorallinæ*), being mere prolongations of the sac-like body; but usually, though the endodermal cell-layer is continued into them, they are solid (2 in fig. 16). Very generally the tentacles of the hydra-form are indefinite in number, but in those belonging to the group of *Scyphomedusæ* a primary series indicating four radii (perradial) can be distinguished, to which are added four intermediate to these, marking four secondary radii (interradial), whilst eight more placed between the eight of the perradial and interradial series are known as adradial tentacles. The surface of the hydraform may be entirely naked, or encased in a horny tube (perisarc) formed by the ectoderm: this may be confined to the aboral portion of the hydranth and to the common stem which unites the persons of a colony, or it may rise up and form a cup (or hydrotheca) around the oral region of the hydranth (figs. 32 and 33).

The bodies of all hydriform persons, as well as the tentacles, are excessively contractile, and when hydrothecæ are present can be withdrawn into them.

The ectoderm or outer cell-layer furnishes the protective and contractile tissues of the hydra-form. Very usually it is not more than one or two cells deep, and is separated from the endoderm by a structureless lamella of firm consistence. In *Hydra* large cells of the ectoderm (neuro-muscular cells of Kleinenberg) bound the external surface (fig. 3) and give off horizontal muscular processes which lie side by side on the structureless lamella—forming thus a deep muscular coat, the fibrous elements of which are not independent cells. In larger species some of the fibres may become separated from the tegumentary or superficial cells, and acquire the character of independent nucleated corpuscles (*Hydractinia*, Van Beneden). No nervous elements nor sense-organs occur in any hydra-form (except perhaps the *Lucernariæ*). In *Antennularia* some ectoderm cells are amœbiform, and project processes which change shape (nematophors). Tactile hairs (palpocils),

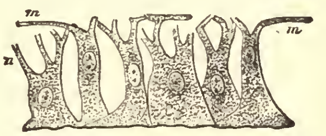

FIG. 3.—Epidermo-muscular cells of *Hydra*. *m*, muscular-fibre processes. (After Kleinenberg, from Gegenbaur.)

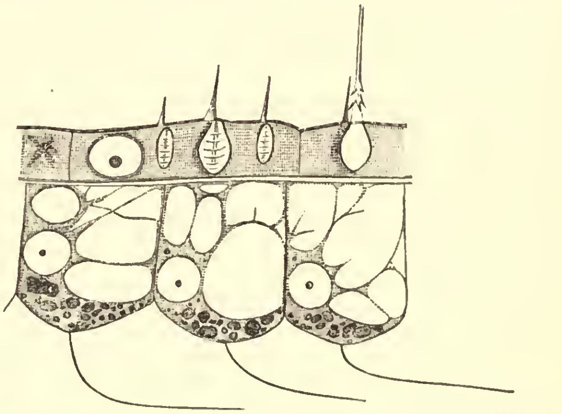

FIG. 4.—Portion of the body-wall of *Hydra*, showing ectoderm cells above, separated by "structureless lamella" from three flagellate endoderm cells below. The latter are vacuolated, and contain each a nucleus and several dark granules. In the middle ectoderm cell are seen a nucleus and three nematocysts, with trigger hairs projecting beyond the cuticle. A large nematocyst, with everted thread, is seen in the right-hand ectodermal cell. (After F. E. Schulze.)

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[1] The *Enterozoa* or *Metazoa* admit of division into two grades—(1) the *Cœlentera*, including sponges, polyps, jelly-fish, and corals, and (2) the *Cœlomata*, including all remaining forms.

[2] See, however, note to the paragraph headed *Definition of the Hydrozoa*, p. 555.

however, occur on the ectodermal cells, and the solid tentacles are essentially tactile organs. Placed in and between the large cells of the ectoderm (*Hydra*, *Cordylophora*, Allman, Kleinenberg, F. E. Schulze) are small nucleated cells which become converted into vesicles containing a three-barbed (figs. 4 and 5) or simple filament (nematocysts). These are frequently grouped on the surface in wart-like processes or "batteries." Nematocysts also are found in the endoderm; but it is probable that their presence there is due to their having been swallowed.

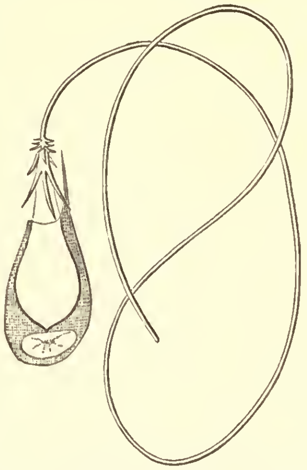


Fig. 5.—Nematocyst of *Hydra*, showing cell-substance and nucleus, cyst, trigger hair, and everted thread. (After F. E. Schulze.)

The endoderm is usually but one cell deep, and lines the entire cavity of the body starting from the margin of the mouth. In the region of the body proper, and in hollow tentacles, the cells are ciliated (fig. 4). In this region they are concerned in the secretion of digestive fluids and in absorption, and sometimes contain coloured granules (hepatic?). Allman found in *Myriothela* (*Phil. Trans.*, 1875) that the endoderm cells project processes like the pseudopodia of *Protozoa*, and suggests that solid food particles are incepted by them. T. J. Parker has published similar observation on *Hydra* (1880). In the solid tentacles the endodermal cells are greatly modified, forming a kind of skeletal tissue, each cell recalling by its vacuolation and firm cell-wall the characters of vegetable parenchyma (fig. 6). In the stems of *Siphonophora* endoderm cells give origin to muscular processes like those of the ectoderm (Claus). This latter fact has a morphological significance which cannot be too gravely estimated.

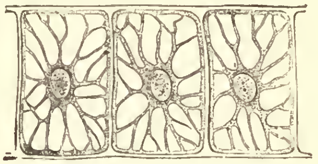


Fig. 6.—Vacuolated endoderm cells of cartilaginous consistence from the axis of the tentacle of a Medusa (*Cunina*). (From Gegenbaur's *Elements of Comparative Anatomy*.)

Generative products are not developed by any hydriform persons (excepting the *Lucernariæ*), the sexual process being carried on by a distinct set of buds developed on the sides of hydriform persons. These buds either become medusiform persons, or are degenerated representatives of such persons (sporosacs) (figs. 17 and 18). Even the fresh-water *Hydra* (fig. 42) does not appear to be an exception to this generalization. The single egg cell of *Hydra* projects at the breeding season in an ectodermal covering, as a wart, from the lower part of the body. A conical eminence or two nearer the mouth contains the spermatozoa. Each ovarium and each spermarium represents an aborted generative person. According to Kleinenberg the egg-cell and the sperm-cells are both derived from the ectoderm. The *Lucernariæ* develop internal generative organs (fig. 19) which correspond closely with those of the medusiform persons of the group *Scyphomedusæ* (see below), with which they are classified. Both ova and testis are endodermal in origin in *Lucernaria* and in the medusiform persons of the *Scyphomedusæ*, whilst they appear to be ectodermal in origin in the complete medusiform persons of *Hydromedusæ*, though in the degenerate medusiform persons known as sporosacs they may either or both have an endodermal origin.

Medusiform persons usually present themselves as isolated free-swimming individuals, but like hydriform persons they have the power of producing new persons by budding (figs. 44, 45, and 46), which may become detached or may remain connected with the primary person (fig. 57) to form a freely swimming colony (*Siphonophora*) comparable to the fixed colonies of hydriform persons. Medusiform persons are often produced as the immediate result of the development of the diblastula without any intermediate hydriform phase (*Pelagia* among *Scyphomedusæ*, *Trachomedusæ*, *Narcomedusæ*, and probably some *Anthomedusæ* and *Leptomedusæ*), but quite as frequently originate as lateral *buds* upon the body-walls of hydriform persons (figs. 34, 37, and 43), or of other medusiform persons (see below), or as metameric fission-products of hydra-forms. The typical medusa-form is a hemispherical cup (the *nectocalyx*, or *umbrella*, or *disc*), from the centre of which rises up a cylindrical or conical process (the *manubrium*, erroneously *polypite*) at the summit of which is the mouth (4, 5 in fig. 16). Four perradial (see above for use of this term) tentacle-like lobes very commonly surround the mouth, or numerous small tentacles (fig. 58), whilst the margin of the disc is beset with tentacles four in number, or a multiple of four (sometimes six, or one only, or indefinite). The aboral pole is dome-like, and is never attached except in those forms which take their origin as buds on a hydriform colony when the connexion exists at this point. The tentacles are, as in the hydriform persons, some solid, some hollow; both occur in the same individual.

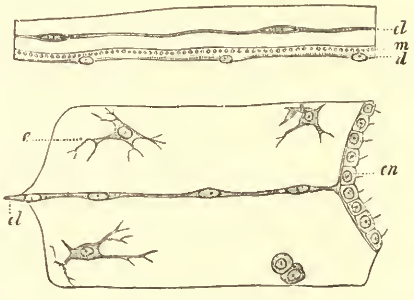


Fig. 7.—Portions of sections through the disc of medusæ,—the upper one of *Lizzia*, the lower of *Aurelia*. *el*, endoderm lamella, or vascular lamella; *m*, muscular processes of the ectoderm cells in cross section; *d*, ectoderm; *en*, endoderm lining the enteric cavity; *e*, wandering endoderm cells of the gelatinous substance. (After Hertwig.)

The body is not so completely hollowed out as in the hydriform persons. The mouth leads into a straight tube (the stomach) which occupies the axis of the manubrium, and expands at its insertion into the disc. The disc, even when thick and fleshy, is not fully excavated by the enteric cavity. In young forms the cavity does occupy it right up to the margin, but gradually the lumen disappears (fig. 29), leaving a series of canals and a continuous plate of endoderm (fig. 7) formed by the coalesced walls of the space (the endoderm-lamella of the Hertwigs, see *Organismus der Medusen*, 1878; the vascular-lamella of Claus, "Polypen und Quallen der Adria," *Wiener Denksch.*, 1878). The peripheral portion of the lumen of the original enteric cavity forms the ring-canal, which runs all round the margin of the disc, and is continued into the hollow tentacles. The lumen is further retained at intervals in the form of radiating canals connecting the axial enteric cavity with the ring-canal. These may be perradial, interradial, and adradial (see above as to tentacles of hydra-form), and may branch dichotomously in the disc or form networks.

The medusæ are thicker and more fleshy to the touch than are the hydra-forms, and are at the same time transparent. This is entirely due to the enormous development of a structureless substance between ectoderm and endoderm, corresponding to the "Stutz-lamella" or structureless lamella of the hydra-forms. (See figs. 49 and 51, representing sections of *Carmarina* and of *Cunina*.)

The remarkable development of this substance in a hyaline condition has led to the description of canals and spaces where none exist—the supposed spaces being really occupied by this hyaline substance. F. E. Schulze's statements as to extra-enteric spaces in *Sarsia* are thus explained—and more decidedly the supposed circular and longitudinal canals attributed by some authors to the scyphistoma phase of *Discomedusæ*. In the same manner (according to Claus) Allman's observations on *Stephanoscyphus* are reconciled with those of F. E. Schulze on *Spongicola*—clearly the same form. *Stephanoscyphus* is devoid of either circular or longitudinal canals, and though it has four remarkable ridges on the enteric wall like those of the scyphistoma of *Scyphomedusæ* (see fig. 26) stands in all probability very close indeed to the Tubularian genus, *Perigonimus*.

In a large number of medusa-forms the hyaline gelatinous substance is structureless, but in many of the larger *Scyphomedusæ* it is occupied by in-wandering amœboid cells derived from the endoderm and by fibrous trabeculæ (fig. 8).

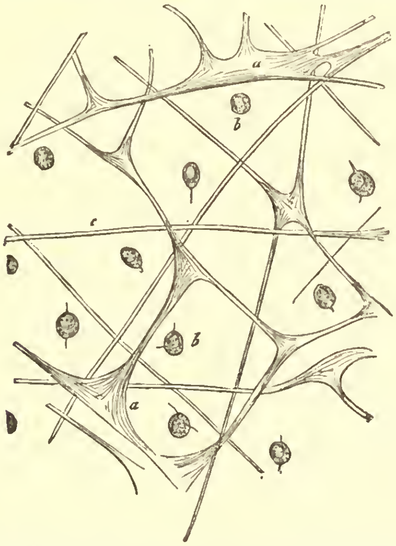


FIG. 8.—Gelatinous substance of the disc of *Aurelia*, showing—*a*, fibrous trabeculæ, and *b*, wandering endoderm cells, with amœboid movements. (From Gegenbaur.)

The wandering endodermal cells are nutrient in function, and represent so far isolated elements of the enteric canal system.

The medusiform person is fundamentally adapted to swimming movements. The muscular fibres are mostly transversely striated, and are as a rule outgrowths of superficial ectoderm cells as in *Hydra* (fig. 9), (though in some cases distinct cells); they are confined to a sheet spread on the oral face only of the disc or swimming-bell (sometimes called sub-umbrella), to the extensile manubrium and tentacles, and to an inwardly directed flap of the margin of the disc known as the *velum* (*Ve* in 4 of fig. 16), which is present in those medusæ that are not flattened but conical (bell-like). The muscular fibres on the oral face of the disc and on the velum have a circular direction, interrupted in some cases by radial tracts. The direction of the swimming movements is obvious from this arrangement.

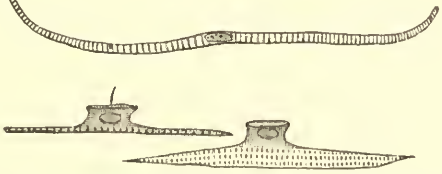


FIG. 9.—Muscular cells of medusæ (*Lizzia*). The uppermost is a purely muscular cell from the sub-umbrella; the two lower are epidermo-muscular cells from the base of a tentacle; the upstanding nucleated portion forms part of the epidermal mosaic on the free surface of the body. (After Hertwig.)

The velum is not a constant element in the medusa's disc; it serves to contract the space by which water is expelled from beneath the bell in the act of swimming. All fully-developed *Hydromedusæ* possess the velum, but only a few of the *Scyphomedusæ* (*Charybdæa*). In the former the endoderm plate (vascular lamella) is not continued into it; in the latter vessels of the enteric system are present in it (fig. 21), and, being probably morphologically distinct, it has been here termed the "pseudo-velum."

Unlike the hydra-forms, the medusa-forms of *Hydrozoa* possess in addition to the tentacles highly-developed sense-organs and ganglionic nerve-centres and nerves. The sense-organs appear to be either eye-spots, or else otocysts, or to combine the functions of both. In addition to these are olfactory tracts or pits connected with the preceding. The sense-organs are placed along the margin of the disc (hence called marginal bodies), and are of three kinds:—(1) ocelli—rounded pigment spots, rarely provided with a lens (*Lizzia*) (fig. 10), always placed at the base of a tentacle or in the radius of one on the oral surface (*Lizzia*), entirely ectodermal in origin; (2) vesiculi or otocysts—formed (as discovered by the Hertwigs, 1878) by an invagination of the ectoderm (fig. 11) containing concretions and hair cells; either open or entirely closed, generally numerous, and placed *between* tentacles, sometimes at the bases of tentacles (*Obelia*); (3) tentaculocysts—which are reduced and modified tentacles; into them alone of the three kinds of marginal bodies do the endoderm and, in the more complex, the enteric canal system enter (figs. 12, 13, and 30). The endodermal sac forms the axis of the tentaculocyst, its cells secrete crystalline concretions, and it functions as an otocyst; pigment spots, which may have cornea, lens, and retina well developed, are formed sometimes to the number of six (*Charybdæa*) on the ectoderm of the tentaculocyst (fig. 13). The olfactory sense-epithelium (fig. 14) is either distributed in a continuous band on the margin of the disc (*Hydromedusæ*, discovered here by the Hertwigs), or it is

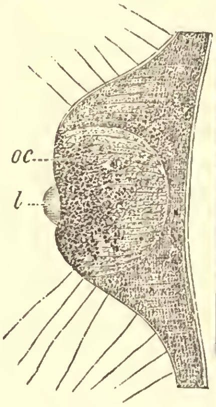


Fig. 10. Fig. 11.

FIG. 10.—Ocellus of a medusa (*Lizzia Koellikeri*). *oc*, pigmented ectodermal cells; *l*, lens. (After Hertwig.)

FIG. 11.—Otocyst (formed entirely by ectoderm) of *Phialidium*, one of the vesiculate medusæ. d^1, superficial layer of ectoderm; d^2, deep layer of ectoderm; *h*, auditory cells of ectoderm; *hh*, auditory hairs; *np*, nerve body; nr^1, upper nerve-ring; *r*, endoderm cells of the circular canal. The otolith cavity is seen above *h*.

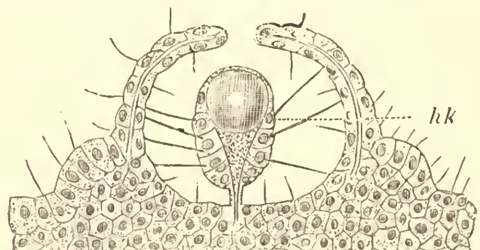


FIG. 12.—Simple tentaculocyst of one of the *Trachomedusæ* (*Rhopalonema velatum*). The process carrying the otolith or concretion *hk*, formed by endoderm cells, is enclosed by an upgrowth forming the "vesicle," which is not yet quite closed in at the top. (After Hertwig.)

confined to deep pits (foveæ nervosæ) from each of which a tentaculocyst arises (discovered in the *Scyphomedusæ* independently by Schäfer and Claus). With some exceptions, medusæ provided with ocelli are destitute of vesiculi, which alone occur in the vesiculate *Leptomedusæ*. Tentaculocysts

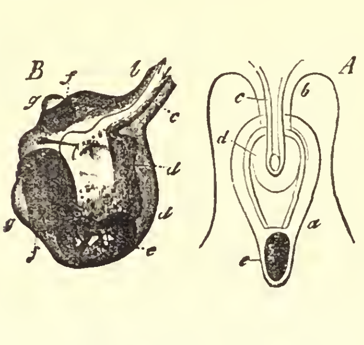


Fig. 13.

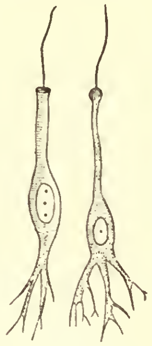


Fig. 14.

Fig. 13.—Tentaculocysts of medusæ (*A*, of *Pelagia*; *B*, of *Charybdæa*). *a*, the free tentacle hanging in the notch of the disc; *b*, stalk; *c*, enteric canal continued into it; *d*, enlarged portion of the canal; *e*, concretions on endodermal cells; *f*, pigmented ectoderm; *g*, lens. (From Gegenbaur.)

Fig 14.—Cells from the olfactory pits (foveæ nervosæ) of *Aurelia*. (After Schäfer.)

characterize to the exclusion of the ocelli and vesiculi the *Trachomedusæ* and *Narcomedusæ* among *Hydromedusæ* and all the *Scyphomedusæ*, except *Lucernaria*, where they are replaced by "colleto-cystophors."

The nervous system has only recently been correctly recognized in medusæ, though seen by Agassiz as long ago as 1849, and described both by Fritz Müller and Haeckel in certain forms (*Geryonidæ*) more recently (1860). It differs remarkably in the two great groups into which the *Hydrozoa* are divisible. In the *Scyphomedusæ* there is no continuous nerve-centre, but around and about each tentaculocyst nerve-fibres and cells are grouped in such a way as to divide the disc into zones of nerve supply corresponding to the number of tentaculocysts (usually eight).

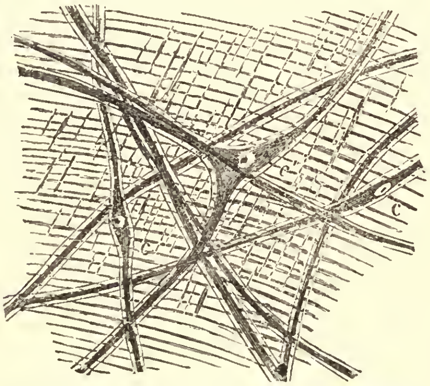


Fig. 15.—Scattered nerve ganglion cells, *c*, from the sub-umbrella of *Aurelia aurita*. (After Schäfer.)

Both the Hertwigs (*Nerven-System der Medusen*, 1878) and Eimer (*Die Medusen*, 1879) entirely missed in their researches the large nerve-fibres and prominent ganglion cells (fig. 15) which were discovered by Professor Schäfer of University College, London (*Phil. Trans.*, 1879), in the *Scyphomedusæ*. The writer can confirm Schäfer's observation of the existence of such fibres and ganglion cells in the region of the circular muscular zone on the oral face of the disc of *Aurelia*, immediately beneath the flattened epithelium of the ectoderm. Professor Claus of Vienna has independently described ("Polypen und Quallen der Adria," 1878) similar nerve-cells and fibres in *Chrysaora* and *Charybdæa*. Professor Schäfer failed to ascertain satisfactorily the origin and termination of the fibres, which appear, however, to originate in superficial ectodermal cells ("sense-epithelium") in the neighbourhood of the tentaculocysts and in the cells of those organs, and to terminate without any plexiform connexion with one another in the muscular fibres. Eimer has described very abundant and excessively fine fibres, often moniliform, which extend from epithelial cells in the neighbourhood of tentaculocysts and form a network traversing the gelatinous substance of the disc in every direction. This observation, though supported by the fact that such fibres are indicated by the extended experimental investigation of Eimer and of Romanes (Eimer, *Die Medusen*; Romanes, *Phil. Trans.*, 1876, *et seq.*), is not confirmed by other observers, and the fibres described are regarded as skeletal tissue. If Eimer's fibres do not exist, the muscular tissue of the medusæ must be regarded as acting to a large extent independently of nerve-control; and this is borne out by Claus's observation of the absence of sense-organs and nerve-fibres from the swimming-bells of the *Siphonophora* (compound medusæ). In the *Hydromedusæ* the nerve ganglion cells are grouped in a continuous ring around the margin of the disc, separated horizontally into an inferior and superior portion by the insertion of the velum. The difference in the form of the nervous system has led Eimer to propose the names *Cycloneura* for the *Hydromedusæ* and *Toponeura* for the *Scyphomedusæ*. Amongst the latter, however, *Charybdæa*, having a continuous velum like *Hydromedusæ*, has also a continuous nerve-ring.

Comparison and Relations of Hydriform and Medusiform Persons.—A simple shortening of the vertical axis, and a widening of the hypostome, with obliteration of the lumen (but not of the cells) of the endoderm over a considerable region of the disc thus produced, suffice to convert the hydraform into the medusa-form.[1] This change of proportion made (fig. 16), the sense-organs of the medusiform person have to be added, and the change is complete. Thus it becomes clear that we have to deal with one fundamental form, appearing in a lower, fixed, nutritive phase and a higher, locomotor, generative phase in the two cases respectively.

The phylogeny of the *Hydrozoa* and the historical relationship of the two phases (hydriform and medusiform) appears to be as follows.

A two-cell-layered sac-like form, with mouth and with or without tentacles, was the common ancestor of *Hydrozoa*, *Anthozoa*, and Sponges. The particular form which the proximate ancestor of the *Hydrozoa* took (1 in fig. 16) is most nearly exhibited at the present day in *Lucernaria* and in the scyphistoma larva (hydra-tuba) of *Discomedusæ*. It was a hemispherical cup-like polyp with tentacles in multiples of four, with four lobes to the wide enteric chamber. This polyp, after passing a portion of its life fixed by the aboral pole, loosened itself and swam freely by the contractions of the circular muscular fibres of its hypostome (sub-umbrella), and developed its ovaria and spermaria on the inner walls of the enteric chamber. This ancestor possessed, like its descendants, a very marked power of multiplication, either by buds or by detached fragments of its body. Accordingly it acquired definitely the character of multiplying by bud-formation during the earlier period of its life; each of the buds so formed completed in the course of time its growth into a free swimming person. We must suppose that the peculiarities of the two phases of development became more and more distinctly developed, the earlier budding phase exhibiting a more elongated form and simple enteric cavity (hydra-form), which subsequently

[1] This relationship, demonstrated by the Hertwigs' discovery of the endoderm layer of the medusa's disc, differs from that supposed to obtain by Professor Allman. He supposed the medusa's disc to represent the coalesced tentacles of a hydra-form, and cited the webbed tentacles of *Laomedea flexuosa* in support of the identification, which had at the time very much to commend it.

became changed in the course of the ontogeny (development of the individual) into the umbrella or disc-like form, with coalesced enteric walls and radial and circular surviving spaces (medusa-form). And now the ancestry took two distinct lines, which have given rise respectively to the two great groups into which the *Hydrozoa* are divisible—the *Scyphomedusæ* and the *Hydromedusæ*. In the one set the hydriform persons of a colony, instead of each becoming metamorphosed into a medusiform person, proceeded each to break up into a series of transverse divisions; each division became a medusiform person, and was liberated in its turn as a free swimming organism (figs. 26 and 27). We must suppose that this process began historically by the outgrowth of new tentacles around the point where the disc of a person fully transformed from the

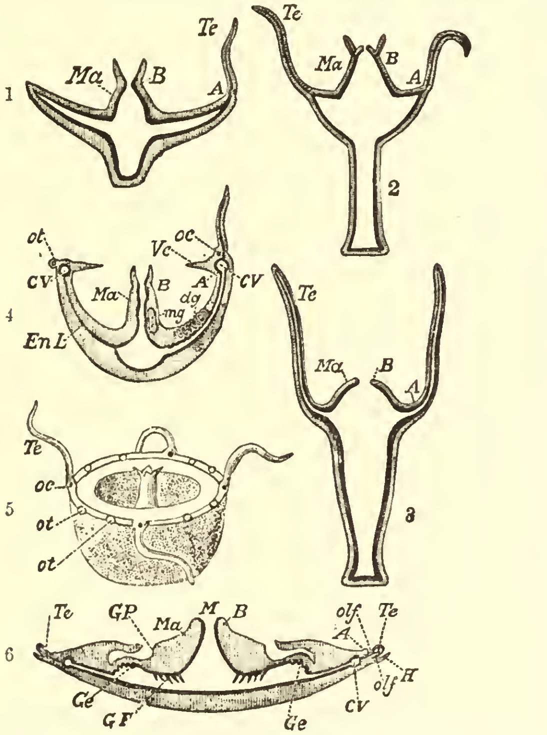


FIG. 16.—Diagrams to exhibit the plan of structure of hydriform and medusiform persons (all except 5 are vertical sections). *A*, base of tentacles, margin of the disc; *B*, oral margin; *Ma*, manubrium; *Te*, tentacle; *CV*, circular vessel; *EnL*, endoderm lamella; *ot*, otocyst; *oc*, ocellus *olf*, olfactory pit; *H*, hood of tentaculocyst; *mg*, genitalia developing in manubrium; *dg*, genitalia developing in the disc (wall of a radiating canal); *GP*, sub-genital pits of the sub-umbrella; *GF*, gastral filaments; *Ve*, velum. 1, Form intermediate between medusa-form and hydra-form. 2, Hydra-form with wide disc, manubrium, and solid tentacles (*Tubularian*). 3, Hydra-form with narrower disc, and hollow tentacles (*Hydra*). 4, Medusa-form with endoderm lamella on the left, the section passing through a radiating canal on the right; a velum, two possible positions of the genitalia, and two kinds of sense-organs are shown (*Hydromedusæ*). 5, A similar medusa-form seen from the surface. 6, Section of *Aurelia aurita*, to show especially the nature of the sub-genital pits, *GP*, outside the genital frills, and the position of the gastral filaments *GF*, as well as the flattened form of the disc.

hydriform to the medusiform phase was loosened in its attachment and about to separate from the colony. The "hastening of events," a well-known feature of organic growth-sequences, would complete the development of the newly sprouting person before the loosened medusa had got well away, and so on with a third, fourth, and even with twenty such successive buds. The separation of the adult form from its fixed larva by fission has been justly compared by Louis Agassiz to the separation of the *Comatula* from its pentacrinoid larval stalk. If the stalk could only produce new *Comatulæ*, the analogy would be complete. *Lucernaria* is in the same way comparable with the stalked crinoids, being an adult form which retains the characters exhibited by the immature phases of its congeners.

The *Scyphomedusæ* do not, however, all exhibit a hydriform phase, and a production of medusæ by the "strobilation" or "metamerizing" of a scyphistoma. Some of them (*Pelagia*) "hasten events" so far that the diblastula never fixes itself, but becomes at once a single medusa, the hydriform phase of the ontogeny being altogether omitted. Certain peculiarities of the medusa's structure, above all the possession of gastral filaments (solid filaments like tentacles projecting in four interradial groups near the genitalia into the enteric cavity), serve to unite *Pelagia*, which has no larval stage, and *Lucernaria* (which is always of intermediate character between hydra-form and medusa-form) with the numerous species which develop by the strobilation of hydriform larvæ.

The second line of descent which has given rise to those *Hydrozoa* known as *Hydromedusæ* not only acquired at the start a different mode of producing medusiform persons, but the medusiform persons acquired characters differing from those of the *Scyphomedusæ* in important (but not fundamental) features. The larval stage in this series developed the property of budding to a very great degree, so as often to form fixed tree-like colonies of considerable size. Then the transformation of the identical colony-forming persons into free-swimming persons was finally and definitively abandoned, and only a late-appearing set of buds proceeded to complete the typical changes and to become medusæ. The earlier-produced buds were thus arrested in development, and became specially modified for the purposes of a fixed life as members of a colony. Thus they acquired the elongate form and the sporadic position of the tentacles which we see in some hydriform persons of the *Hydromedusæ* group (figs. 38 and 40), and were adapted to nutrition solely (hence the term trophosome applied by Allman to such colonies). The characters of the mature generative person, with its power of detachment and free locomotion, being confined to the later buds borne on the sides of the hydriform persons or on special portions of the colony, we find that the former became more and more specialized as *sexual* medusiform persons in proportion as the latter became specialized as *asexual* hydriform persons, and thus it is that we have the remarkable phenomenon of hydriform colonies, developed from the eggs of medusæ, producing as it were crops of medusæ (figs. 34 and 37) which detach themselves and swim away to deposit their eggs (alternation of generations). The *Hydromedusæ* never produce medusæ by strobilation or transverse division of a hydriform person, although in rare cases the cicatrix left by a detached medusa-bud has been observed to sprout and produce a hydriform person. Neither medusiform nor hydriform persons of the *Hydromedusæ* series ever have gastral filaments (unless they are represented by the "villi" of the *Siphonophora* described by Huxley, *Oceanic Hydrozoa*), whilst the medusa-forms always possess a velum and a comparatively simple set (four, six, or eight) of radiating canals in the disc, the remains of the enteric lumen.

The complete differentiation of hydriform and medusiform persons existing on one and the same colony having been attained in the *Hydromedusæ*, further changes of a most remarkable character were brought about in some of the descendants of these forms. The condition which we have so far noted is perpetuated at the present day in *Bougainvillia* (*Eudendrium*), *Campanularia*, and a vast number of the so-called hydroid polyps; others have undergone further adaptational changes. We have to notice at least four important additional modifications independent of one another.

(1.) The hydriform stage was suppressed altogether, and, as in some *Scyphomedusæ*, so here too the diblastula developed directly into a medusa (*Trachomedusæ*, *Narcomedusæ*, and probably some *Leptomedusæ* like *Thaumantias* and *Æquorea*, and some *Anthomedusæ* like *Oceania* and *Turritopsis*).

(2.) The medusiform persons being early produced did not separate themselves from the colony, but the whole colony became free (if it ever were fixed), the medusiform persons carrying the hydriform persons away with them. Thus the highly differentiated swimming and floating colonies of the *Siphonophora* originated.

(3.) The medusiform persons ceased to detach themselves from the fixed hydriform persons or colonies, and developed the ova and sperm within themselves, whilst still small in size and attached to the hydriform stock. Having once abandoned the detached, free-swimming life, the medusæ underwent in different genera a varying amount of degeneration and atrophy, of which we have in existence all

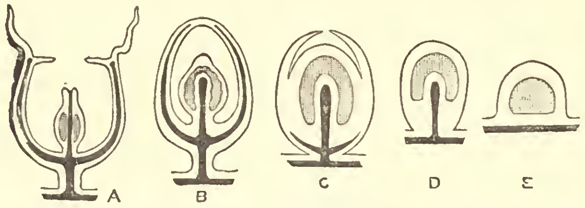


FIG. 17.—Diagrams illustrating the gradual degeneration of the medusa bud into the form of a sporosac. The black represents the enteric cavity and its continuations; the lighter shading represents the genital products (ova or sperm). A, medusiform person still attached by a stalk at the aboral pole to a colony (phanerocodonic gonophor of Allman); B, modified medusiform person, with margin of the disc (umbrella) united above and imperforate (mouthless) manubrium (adelocodonic gonophor of Allman); C, sporosac, with incomplete extension of the enteric cavity into the umbrella,—rudimentary invagination above to form the sub-umbrella cavity; D, sporosac with manubrial portion only of the enteric cavity; E, sporosac without any trace of manubrium.

possible degrees, leading from the fixed "phanerocodonic gonophors" (Allman, bell-like genital buds) of many *Siphonophora* through the "adelocodonic gonophors" (genital buds with the bell no longer open but closed by the union of the margins of the disc) of *Cordylophora* to the sporosacs of *Hydractinia*, and even to the simple genital warts of the little degenerate *Hydra viridis* of fresh waters (see fig. 17, and explanation). By this process a large number of *Hydromedusæ* (figs. 35, 38, 39, 40, and 42) have lost all evidence of the real characters of their medusa-forms, just as others have suppressed the evidence of their hydra-forms by direct development from the egg; and inasmuch as both these processes take place in genera having the closest affinity with genera in which both hydra-form and medusa-form are fully preserved, it is not possible to erect groups similar to the *Haplomorpha* of Carus or the *Monopsea* of Allman for their reception. The difficulty of classification is, however, rendered very great, for a double system becomes necessary, which shall deal with the characters of hydriform and medusiform persons in parallel equivalent series. The difficulty is considerably enhanced when we find that identical medusa-forms may spring from unlike hydra-forms, and, conversely, that closely allied hydra-forms may give rise to very different medusa-forms. The character first noticed by Rapp as distinguishing the hydroid polyps from the coral-polyps, namely, that of developing their genitalia as external bodies (*Exoarii*) instead of internally (*Endoarii*), is seen by the considerations just adduced to be fallacious. The *Hydromedusæ*, it is true, often (not always) develop their generative products from the ectoderm, and the genitalia frequently project as ridges and discharge themselves directly to the exterior in this division. The *Hydromedusæ* contrast in this respect with the *Scyphomedusæ* and *Anthozoa*, which develop their genitalia from the endoderm, and are (to use Rapp's terms) *Endoarii* whilst the former are *Exoarii*. But the bodies mistaken for external generative organs by Rapp and other early observers in many hydroids, and in *Hydra* itself, are aborted degenerate medusæ.

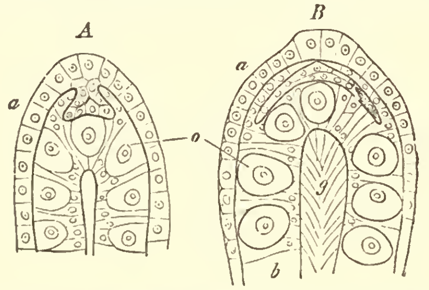


FIG. 18.—Two female sporosacs (degenerate medusæ) of *Hydractinia echinata*. (From Gegenbaur, after Van Beneden.) *a*, ectoderm; *b*, endoderm; *o*, egg-cells; *g*, enteric cavity. In A an invagination of the ectoderm, which is more complete in B, represents the rudiment of the sub-umbrella space.

(4.) A further set of changes, which have affected the original hydriform colonies and their medusa-buds so as to produce new complications of structure among the *Hydromedusæ*, are summed up under the head of "polymorphism." The differentiation of hydriform and medusiform persons is a case of dimorphism; a further distribution of functions, with corresponding modification of form, gives us "polymorphism." Polymorphism is unknown in the *Scyphomedusæ*, and it is chiefly confined to two groups of *Hydromedusæ* (the *Hydrocorallinæ* and the *Siphonophora*). In the hydriform colonies of *Hydractinia* (one of the *Gymnoblastea-Anthomedusæ*) the outer hydriform persons of the colony (fig. 39) differ in form from the rest, and have wart-like tentacles. In the same genus, and also in many *Calyptoblastea*, the hydriform persons which are destined especially to give origin to medusa-buds are devoid of tentacles and mouth, and are known as blastostyles (Allman), (fig. 43). In *Hydrocorallinæ* (fig. 53) elongated hydriform persons (dactylozooids) with no mouth and sporadic tentacles are set in series around a central short mouth-bearing person (gastrozooids) forming the "cyclo-systems" of Mr Moseley (figs. 52 and 55). In the *Siphonophora*, in addition to nutritive (hydriform) persons and generative (medusiform) persons, there may be rows of swimming-bells (medusæ devoid of mouth and of genitalia), covering-pieces (flattened medusæ), and tentacle-bearers (hydriform persons with one long highly-developed tentacle), (see figs. 56 and 57).

Hypothesis of the Individuation of Organs.—The building up of complex individualities, such as a hydrozoon colony, a flowering plant, or a segmented worm or arthropod—in any one of which a number of common units are repeated, but with varied form and function in each part of the compound body—is generally admitted to be explicable in two ways, and which of the two explanations may be adopted in any one case must depend on the ultimate inference from a wide series of observations. The first hypothesis, which undoubtedly applies to the ordinary hydriform colonies of *Hydrozoa*, to the segments of *Tænia*, and to plants formed by the repetition of phyllomes, is that an original unit like those which constitute the composite organism has freely budded, and repeated its own structure in the well-marked units which remain conjoined to form an aborescent or linear aggregate. This is "eumerogenesis," and such aggregates may be termed eumeristic. By a division of labour and consequent modification of form among the units of a eumeristic aggregate, such an aggregate may (in the course of phylogeny) acquire varied shape and definite grouping of its constituent units, and a high specialization as an individual. The high degree of individuation which may be thus attained is due to the more or less complete synthesis of a eumeristic colony. The more highly individuated Chætopods and Arthropods are synthesized linear colonies. The cyclo-systems of the *Hydrocorallinæ* are undoubted examples of synthesized colonies. The second hypothesis is one which is applicable to cases which, in the absence of special evidence to the contrary, might be regarded as highly synthesized colonies. According to this second hypothesis, such highly individuated composite organisms have not (in their phylogeny) passed through a eumeristic phase in which the units were well developed and alike, but the tendency to bud-formation (whether lateral, linear, or radial) has all along acted concurrently with a powerful synthetic tendency, so that new units have from the first made but a gradual and disguised appearance. This is "dysmerogenesis," and such aggregates as exhibit it may be called dysmeristic. In dysmeristic forms the individuality of the primary unit dominates from the first, and the merogenesis (segmentation or bud-formation) can only show itself by partially here and more completely there compelling (as it were) the organs or regions of the body of the primary unit to assume the form of new units. The arms of star-fishes are, when we consider them as derived from the antimera of a Holothurian, explained as examples of dysmerogenesis. So, too, the series of segments constituting a leech, and probably also the segments of a vertebrate. Eumerogenesis and dysmerogenesis are only variations of one process, merogenesis, and no sharp line can be drawn between them. Individuation may appear at *any* period in the phylogeny of a eumeristic aggregate and synthesize its units. On the other hand, individuation is more or less completely dominant *throughout* the history of a dysmeristic aggregate, and is gradually broken down as a more and more complete analysis of the primary unit into new units is effected. It will be observed, however, that in dysmerogenesis, the *form* which individuation tends to preserve is that of the primary unit (notably the case in leeches as compared with the ameristic flukes), whereas when we have eumerogenesis followed by synthesis the resulting form-individuality is something absolutely new. Thus, using the terms eumeromorph and dysmeromorph, we have—(1) synthesized eumeromorph simulates normal dysmeromorph; (2) analysized dysmeromorph simulates normal eumeromorph.

Whether the fixed hydriform colonies of the *Hydrozoa*, with their more or less complete medusiform buds, and further, the floating colonies of *Siphonophora*, with their polymorphous units, are to be regarded as synthesized eumeromorphs or as dysmeromorphs, more or less analysed, is perhaps still open to discussion. The former view (that adopted here) is that held by Allman (*Monograph of the Tubularian Hydroids*, 1874), by Leuckart (1851), by Gegenbaur (*Grundriss*, 1874), by Claus (*Grundzüge der Zoologie*, 1876), and by the Hertwigs (*Organismus der Medusen*, 1878). On the other hand, Huxley (*Oceanic Hydrozoa*, 1856), formerly Gegenbaur (*Zur Lehre der Generations-Wechsel*, 1854), and, more recently, Ed. Van Beneden ("De la distinction originelle du testicule et de l'ovaire," *Bull. Acad. Roy. Belg.*, 1874) have held that the medusiform person is a generative wart which has gradually assumed the characters of a bud, and that the various phases presented by it in different genera are so many more or less successful strivings after complete assumption of the hydra-form (from which the medusa-form is thus secondarily derived). Similarly the variously modified units of the siphonophorous colony have been regarded as the organs of a parent unit which have each more or less completely acquired the form of that parent unit, or, in other words, the colonies in question have been held to be dysmeromorphs. Recently ascertained facts as to the polymorphism of *Hydrocorallinæ*, but more especially the demonstration of the identity of structure of the medusæ of the Scyphomedusan and Hydromedusan groups, and, further, the mode of development of the *Scyphomedusæ* from the scyphistoma and the relations of the generative products to the enteric cavity, combine to render the view that the polymorphous and dimorphous colonies of *Hydrozoa* are synthesized eumeromorphs more probable, in the judgment of the present writer, than that which would explain them as dysmeromorphs.

The term "merogenesis," and its subordinate terms, "eumerogenesis, dysmerogenesis," &c., are applicable to units of the first order, namely, cells, as well as to the "persons" which are built up by them. Ordinary cell-division is an example of eumerogenesis; free-formation of nuclei, as in the fertilized ovum of Arthropods, is dysmerogenesis. A syncytium is usually a synthesized eumeromorph, but may be a dysmeromorph.

Definition of the Hydrozoa.—The *Hydrozoa* are *Cœlentera nematophora*, distinguished from the fellow-group *Anthozoa* (the name applied to *Actinozoa* when the *Ctenophora* are removed from them) by not possessing the latter's constant and sharp differentiation of the arch-enteric cavity into axial digestive and periaxial septate portions, usually by a simpler form of nematocyst, and generally by lower histological differentiation.[1]

The following is a brief summary of the chief characters of the larger divisions of the *Hydrozoa*:—

Sub-class I. SCYPHOMEDUSÆ.—These are *Hydrozoa* which in the adult condition always have four or eight interradial groups of gastral filaments ("phacellæ" of Haeckel) (figs. 16 (6), 23, and 26). The genitalia (ovaria and spermaria) are developed from endoderm, and are always interradial (in the four radii formed after the first four). The hydra-form is not a "hydroid," but a short polyp with broad hypostome—the "scyphistoma," which gives rise to medusa-forms by transverse fission (strobilation), or itself develops genitalia (*Lucernariæ*). Combined visual and auditory organs in the form of modified tentacles (tentaculocysts) to the number of four, eight, or more occur on the edge of the disc (except in *Lucernariæ*, where they are represented by the "colleto-cystophors"). The medusa-form in some cases develops from the egg without the intermediate scyphistoma-stage (*Pelagia*, *Charybdæa*?). The edge of its disc is provided with lappets, which cover the sensorial tentaculocysts (hence *Steganophthalmia* of Forbes), and is not provided with a velum (hence "*Acraspeda*" of Gegenbaur), excepting the rudimentary velum of *Aurelia* (fig. 31) and the well-developed vascular velum (pseudo-velum) of *Charybdæa* (fig. 21). There is no continuous marginal nerve-ring (except in *Charybdæa*), but several separate marginal nerve centres (hence *Toponeura* of Eimer). The

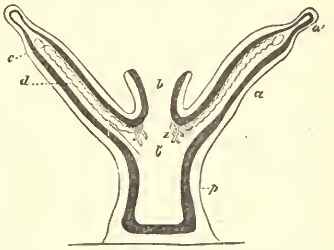


FIG. 19.—Diagrammatic vertical section of a *Lucernaria* in the plane of an interradius. *a*, one of the interradial angles of the disc, giving rise at *a'* to two groups of tentacles adradial in position; *b*, axial enteric cavity; *c*, endoderm; *d*, band-like genital gland (ovary or testis), adradial in position, and attached to the interradial septum which runs along the angular process of the disc, to which the letters *c*, *d* point; *p*, aboral region or "foot"; *z*, the interradial gastral filaments or phacellæ. (After Allman.)

[1] Quite recently the Hertwigs (*Jenaische Zeitschr.*, bd. vi., new series, 1879) have insisted that in the *Hydromedusæ* the genitalia (both ova and testes) are developed from the ectoderm, whilst in the *Scyphomedusæ* and in the *Anthozoa* they develop from the endoderm. On this account they propose to abandon the grouping into *Hydrozoa* and *Anthozoa* of *Cœlentera nematophora*, and suggest two groups, the *Ectocarpeæ* and the *Endocarpeæ*—the former equivalent to *Hydromedusæ*, the latter embracing *Scyphomedusæ* and *Anthozoa*. The *Anthozoa* exhibit a further predominance of the endoderm in its extensive origination in them of muscular fibre, which but rarely and in small quantity develops from endoderm in the *Hydromedusæ* or in the *Scyphomedusæ*. The Hertwigs base their generalization on their own studies of medusæ, but they have ignored the observations of Van Beneden on *Hydractinia* and of Ciamician on various Tubularians, in which the origin of either sperm or ova from endoderm is established. Recently Fraipont has repeated an observation of Van Beneden's on *Campanularia*, and shown conclusively that the ova in that form arise from endoderm. Weismann (*Zoologischer Anzeiger*, May 1880) shows the same for *Plumularidæ* and *Sertularidæ*; the reader is referred to his paper.

diblastula in all cases, as yet observed, is formed by invagination, the blastopore closing up (Balfour).

Fig. 20.

Fig 21.

Fig. 22.

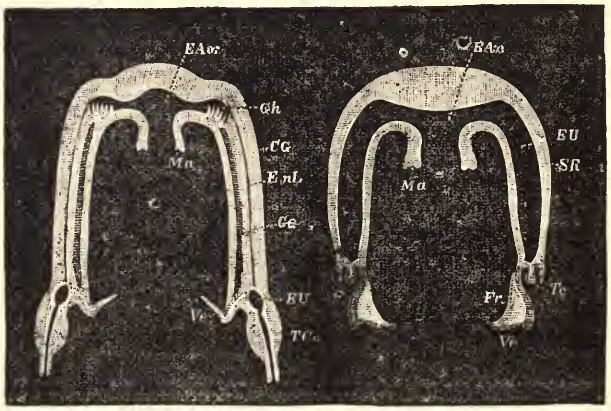


Fig. 23.

Fig. 20.—*Charybdæa marsupialis* (natural size, after Claus). The four annulated tentacles are seen depending from the four lappets placed at the four corners of the quadrangular umbrella. These are interradial. Two of the four perradial enteric pouches of the umbrella, representing radiating canals, are seen of a pale tint. *Fg*, gastral filaments (interradial); *R*, the modified perradial tentacles forming tentaculocysts; *G*, corner ridge facing the observer and dividing adjacent pouches of the umbrella; *GF*, position of one of the genital bands.

Fig. 21.—View of the margin of the umbrella of *Charybdæa marsupialis* (natural size, after Claus). At the four corners are seen the lappets which support the long tentacles, and in the middle of each of the four sides is seen a tentaculocyst. *Vel*, the vascular velum or pseudo-velum, with its branched vessels.

Fig. 22.—Horizontal section through the umbrella and manubrium of *Charybdæa marsupialis* (modified from Claus). *Ma*, manubrium; *SR*, side ridge (perradial); *CR*, corner ridges, separated by *CG*, the interradial corner groove; *Ge*, the genital lamellæ in section, projecting from the interradial angles on each side into *UE*, the enteric pouches of the umbrella; *SU*, the sub-umbrella space.

Fig. 23.—Vertical sections of *Charybdæa marsupialis*, to the left in the plane of an interradius, to the right in the plane of a perradius. *Ma*, manubrium; *EAx*, axial enteron; *Gh*, gastral filaments (*phacellæ*); *CG*, corner groove; *SR*, side ridge; *EnL*, endoderm lamella (line of concrescence of the walls of the enteric cavity of the umbrella, whereby its single chamber is broken up into four pouches); *Ge*, line of attachment of a genital band; *EU*, enteric pouch of the umbrella, in the left-hand figure, points to the cavity uniting neighbouring pouches near the margin of the umbrella and giving origin to *TCa*, the tentacular canal; *Ve*, velum; *Fr*, frenum of the velum; *Tc*, tentaculocyst.

The binary division of the *Hydrozoa* was established by Eschscholtz (*System der Acalephen*, 1829) whose *Discophoræ phanerocarpæ* correspond to the *Scyphomedusæ*, whilst his *Discophoræ cryptocarpæ* represent the *Hydromedusæ*. The terms point to distinctions which are not valid. In 1853 Kölliker used the term *Discophora* for the *Scyphomedusæ* alone, an illegitimate limitation of the term which was followed by Louis Agassiz in 1860. Nicholson has used the term in the reverse sense for a heterogeneous assemblage of those medusæ not classified by Huxley as *Lucernaridæ*, nor as yet recognized as derived from hydroid trophosomes. This use of the term adds to the existing confusion, and renders its abandonment necessary. The term *Discomedusæ* was used for the *Scyphomedusæ* by Haeckel in his *Generelle Morphologie* (excluding *Charybdæa*)—whilst Carus (*Handbuch*, 1867) confines the term "*Medusæ*" to them alone, which is objectionable, since it belongs as justly to the *Hydromedusæ*. Forbes's term for them, *Steganophthalmia*, indicates a true characteristic, failing only in the *Lucernariæ*, but its complementary term *Gymnophthalmia* is inaccurate. Similarly the terms *Acraspeda* and its complement *Craspedota* are inacceptable. Eimer has proposed to use the terms *Toponeura* and *Cycloneura* for the two divisions—but *Charybdæa* appears to break down this division as so many others. The old term *Acalephæ*, which is retained by Gegenbaur in its proper sense for all the *Cœlentera nematophora*, is used as the designation of the *Scyphomedusæ* alone by Claus (*Grundzüge der Zool.*, 1878), which cannot fail to produce confusion. The term *Lucernaridæ*, proposed so long ago as 1856 by Huxley (*Med. Times and Gazette*), most truly indicates the relationships of these organisms which he was the first to recognize, but it seems desirable to restrict this term to the limited order in which *Lucernaria* is placed, and to employ for the larger group—*Scyphomedusæ*—a term which is the true complement of the convenient name assigned to the other division of *Hydrozoa*, viz., *Hydromedusæ*.[1]

Order 1. *Lucernariæ*,—*Scyphomedusæ* devoid of tentaculocysts, with the aboral pole of the body produced into an adhesive disc by which the organism (which possesses the power of swimming by contraction of the circular muscular zone of the hypostome) usually affixes itself. The enteric cavity is divided into four perradial chambers by four delicate interradial[2] septa. The genitalia are developed as four-paired ridges at the sides of the interradial septa on the oral wall of the chambers (fig. 19). No reproduction by fission nor "alternation of generations" is known in the group. At the edges of the disc capitate tentacles are developed in eight adradial[2] groups; between these are modified tentacles in some genera,—the marginal anchors or colleto-cystophors. The canal system which has sometimes been described in them is a product of erroneous observation. A very few genera and species of this order are known. They may be justly called the cœnotype of the medusæ (James Clark), and their relationship to the free swimming forms may be compared, as was done by L. Agassiz, to the relationship of the stalked Crinoids to such forms as *Comatula*. Three species are not uncommon on the British coasts.

By Milne Edwards the animals forming this group were termed *Podactinaria* and associated with the *Anthozoa*. By Leuckart they were termed *Calycozoa*; it is only of late that the closeness of their relationship to the *Scyphomedusæ* has been fully recognized, though long since insisted on by Huxley and by James Clark. Haeckel in his new system of the medusæ (*Sitzungsber. der Jenaische Gesellschaft für Medicin und Naturwiss.*, July 26, 1878) adopts for them the term *Scyphomedusæ* in allusion to their permanently maintaining the distinctive features of the scyphistoma larval form of the *Acraspedæ*, the term which he adopts from Gegenbaur for our *Scyphomedusæ*.

Order 2. *Discomedusæ*.—These are *Scyphomedusæ* developing as sexual medusiform persons by transverse fission from a scyphistoma, or else directly from the egg. They have eight tentaculocysts, four perradial, four interradial, and sometimes accessory ones (adradial). Four or eight genital lobes (ovaria or spermaria or hermaphrodite) are developed from the endoderm forming the oral floor of the central region of the enteric cavity, which is produced into a corresponding number of pouches. The mouth is either a simple opening at the termination of a rudimentary manubrium (sub-order *Cubostomæ*), or it is provided with four or eight arm-like processes (sub-orders *Semostomæ* and *Rhizostomæ*). In the sub-order *Rhizostomæ* (fig. 24, *a*), the

[1] *Scyphomedusæ* (σκύφος, a cup) are medusæ which are related by strobilation to *Scyphistoma*,—a wide-mouthed polyp with four gastral ridges. *Hydromedusæ* are medusæ related to a *Hydra*,—a narrower polyp, devoid of gastral ridges,—by lateral gemmation.

[2] For use of these terms see paragraphs on *Aurelia* below.

edges of the oral opening fuse together at an early age and leave several sucker-like secondary mouths, which were formerly mistaken for independent persons. The central enteric chamber is continued through the disc by a complicated often reticulate system of radiating canals, which excavate the endoderm lamella.

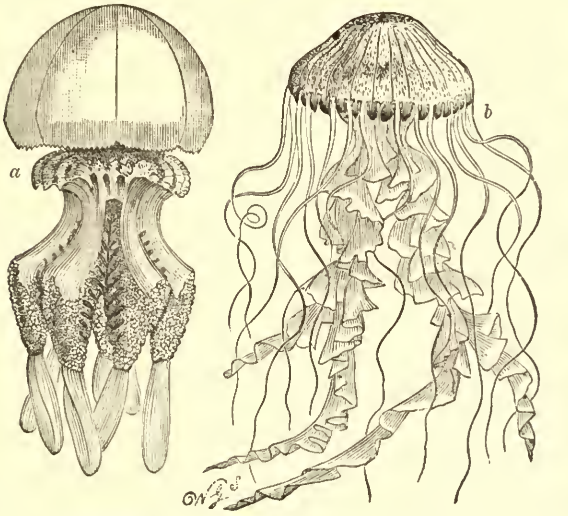


FIG. 24.—*Scyphomedusæ.* a, *Rhizostoma pulmo*; b, *Chrysaora hyosceua*

In the *Semostomæ* and *Rhizostomæ* (not in the *Cubostomæ*) four remarkable (respiratory) sub-genital pits (fig. 28) are hollowed out in the gelatinous substance of the sub-umbrella (oral face of the umbrella). These do not communicate, as

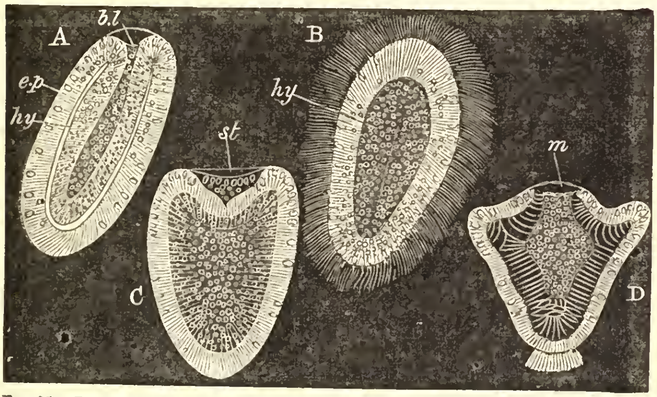


FIG. 25.—Four stages in the development of *Chrysaora*. A, Diblastula stage; B, stage after closure of blastopore; C, fixed larva with commencing stomodæum or oral ingrowth; D, fixed larva with mouth, short tentacles, &c.; *ep*, ectoderm; *hy*, endoderm; *st*, stomodæum; *m*, mouth; *bl*, blastopore. (From Balfour, after Claus.)

has been erroneously supposed, with the genital organs, the products of which normally are evacuated by the mouth. In the Tetragamelian *Rhizostomæ* these pits remain distinct from one another as in *Semostomæ*, but in the Monogamelian *Rhizostomæ* they unite to form one continuous sub-genital cavity placed between the wall of the enteric cavity and the polystomous oral disc. The common English forms, *Aurelia*, *Chrysaora*, and *Cyanæa*, are types of the *Semostomæ*, the somewhat less common *Rhizostoma* of the Monogamelian *Rhizostomæ*, whilst *Nausithoe* and *Discomedusa* represent the simple *Cubostomæ*.

The writer has adopted the term used by Haeckel for this order, and is indebted to his preliminary notices of a large work on the *Medusæ*, now in the press, for outlines of the classification and definitions which have been introduced with modifications in relation to these and the other *Medusæ*. The term *Discophora* is used by Claus (*Grundzüge*) for the *Discomedusæ*. It is quite clear from the varied and inconsistent use by different authors of that term, and also of the terms *Acalephæ* and *Medusæ*, that they must be ejected altogether from use in systematic treatises.

The structure of the common *Aurelia aurita* and its development have recently formed the subject of investigation by Claus, Eimer, and others. As the current accounts

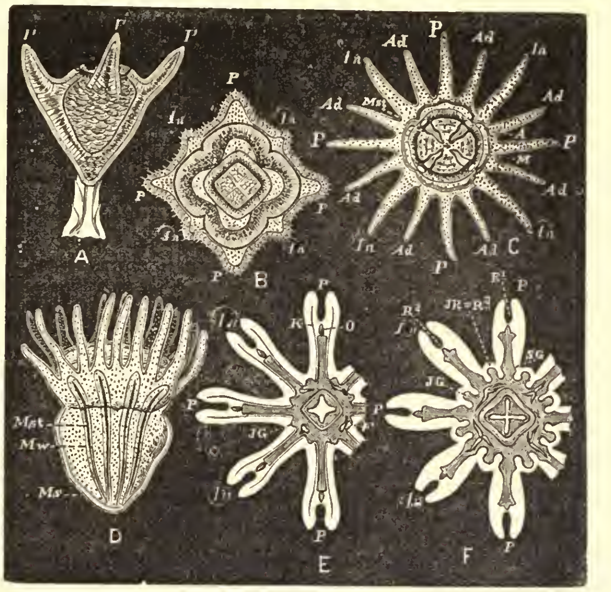


FIG. 26.—Later development of *Chrysaora* and *Aurelia* (after Claus). A, Scyphistoma of *Chrysaora*, with four perradial tentacles and horny basal perisarc. B, Oral surface of later stage of scyphistoma of *Aurelia*, with commencement of four interradial tentacles. The quadrangular mouth is seen in the centre; the outline of the stomach wall, seen by transparency around it, is nipped in four places interradially to form the four gastric ridges. C, Oral surface of a sixteen-tentacled scyphistoma of *Aurelia*. The four gastric interradial ridges are seen through the mouth. D, First constriction of the *Aurelia* scyphistoma to form the pile of ephyræ or young medusæ (see fig. 27). The single ephyra carries the sixteen scyphistoma tentacles, which will atrophy and disappear. The four longitudinal gastric ridges are seen by transparency. E, Young ephyra just liberated, showing the eight bifurcate arms of the disc and the interradial single gastral filaments. F, Ephyra developing into a medusa by the growth of the adradial regions. The gastral filaments have increased to three in each of the four sets. *A*, margin of the mouth; *Ad*, adradial radius; *F*, gastral filament; *In*, interradial radius; *JG*, adradial gastral canal; $JR=R^3$, adradial lobe of the disc; *K*, lappet of a perradial arm; *M*, stomach wall; *Mst*, muscle of the gastral ridge; *Mw*, gastral ridge; *Ms*, mesoderm; *O*, tentaculocyst; *P*, perradial radius; R^2, interradial radius; R^3, adradial radius; *SG*, commencement of lateral vessel.

in text-books are very inadequate, a short sketch of the morphology of that form is appended here.

From the egg, according to the researches of Claus (whose figures, here reproduced, refer more especially to the closely allied genus *Chrysaora*, up to the completion of the scyphistoma), a single-cell-layered blastula develops which forms a diblastula by invagination (fig. 25, A, B, C). The orifice of invagination closes up, and the ciliated "planula" (as this stage used to be termed in all *Cœlentera*), after swimming around for a time, fixes itself, probably by the blastoporal pole. The true mouth then forms by inruption at the opposite pole. Two tentacles now grow out near the mouth opposite to one another (fig. 25, D), and are followed by two more (fig. 26), these indicating the four primary radii of the body which pass through the angles of the four-sided mouth, and are termed *perradial*. Meanwhile the aboral pole narrows and forms a distinct stalk, which in *Chrysaora* secretes a horny perisarc (fig. 25,

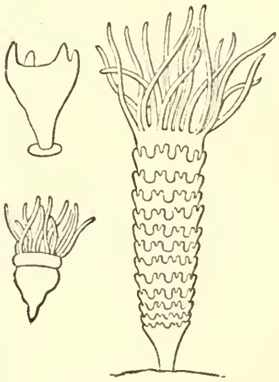


FIG. 27.—Development of *Aurelia*. Above to left, young scyphistoma with four perradial tentacles. Below to left, scyphistoma with sixteen tentacles and first constriction. To the right, strobila condition of the scyphistoma, consisting of thirteen metameric segments; the uppermost still possesses the sixteen tentacles of the scyphistoma; the remainder have no tentacles, but are ephyræ, each with eight bifid arms (processes of the disc). Each segment when detached becomes an ephyra, such as that drawn in fig. 26, E, F. (From Gegenbaur.)

D). Four new tentacles, those of the intermediate or secondary radii, now appear between the first four, and are termed *interradial*. At the same time four longitudinal ridges grow forward on the wall of the enteric cavity (fig. 26). These interradial ridges have sometimes

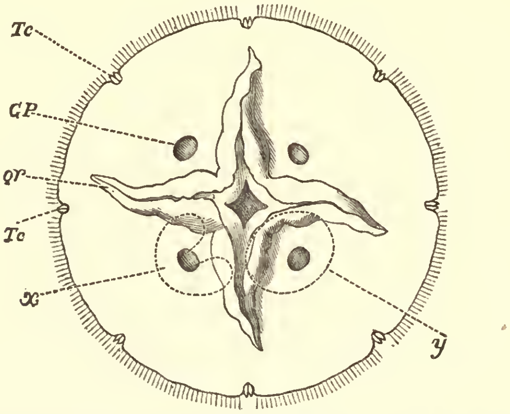


FIG. 28.—Surface view of the sub-umbrella or oral aspect of *Aurelia aurita*, to show the position of the openings of the sub-genital pits, *GP*. In the centre is the mouth, with four perradial arms corresponding to its angles (compare fig. 26). The four sub-genital pits are seen to be interradial. *x* indicates the outline of the roof (aboral limit) of a sub-genital pit; *y*, the outline of its floor or oral limit, in which is the opening (compare 6 of fig. 16).

been erroneously described as containing each a longitudinal canal connected with a circular canal at the base of the tentacles. They are in reality solid, as is the margin of the hypostome from which the tentacles spring. It is in connexion with these four ridges that the gastral filaments will subsequently appear, as also the genital organs either along their middle line or adradially to them. The ridges correspond to the mesenteries of the *Anthozoa*. Eight additional tentacles placed one on each side of the perradial tentacles (or of the interradial, according as we may choose to regard the matter) next appear, and are distinguished as *adradial*. All the tentacles reaching an equal size, we obtain the appearance seen in fig. 26, when the young scyphistoma is looked at from above. Looked at from the side, with its wide hypostome and short vertical axis, the scyphistoma differs widely from an ordinary hydra-form, and approaches the medusa-form, to which its four longitudinal gastral ridges further assimilate it. The little creature is now about an eighth of an inch in height; in other genera, but not in *Chrysaora*, it may now multiply by the production of a few buds from its fixed basal disc. After nourishing itself for a period, and increasing to four or five times the size just noted, the vertical axis elongates and a series of transverse constrictions appear on the surface, marking off the body of the scyphistoma into a series of discs (figs. 26 and 27), each of which by the development

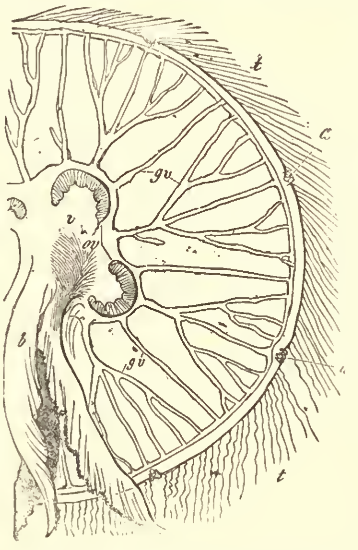


FIG. 29.—Half of the lower surface of *Aurelia aurita*. The transparent tissues allow the enteric cavities and canals to be seen through them. *a*, marginal lappets hiding tentaculocysts; *b*, oral arms; *v*, axial or gastric portion of the enteric cavity; *gv*, radiating and anastomosing canals of the enteric system; *ov*, ovaries. The gastral filaments near to these are not drawn. (From Gegenbaur.)

of tentacles and completion of the constriction will become a separate medusa (in its young state called "ephyra"). The tentacles of the *Aurelia* and the structure of the margin of its hypostome are very different from those of the scyphistoma. They are exhibited in their earliest condition (when the *Aurelia*-medusa is first liberated from its attachment and is an ephyra) in fig. 26, E, F. The margin of the hypostome is drawn out into eight arms (which are not to be confused with tentacles); the end of each arm is bifid, carrying a pair of lappets—the marginal lappets which persist in the adult (see figs. 30 and 31). Between the lappets is placed a short and peculiar tentacle, the tentaculocyst or sense-organ. The eight arms of the disc and their tentaculocysts are perradial and interradial. As the organism grows, a set of eight adradial tentacles appear in the notches between the eight arms, but never attain any relatively large size in *Aurelia*. The asteroid arm-bearing

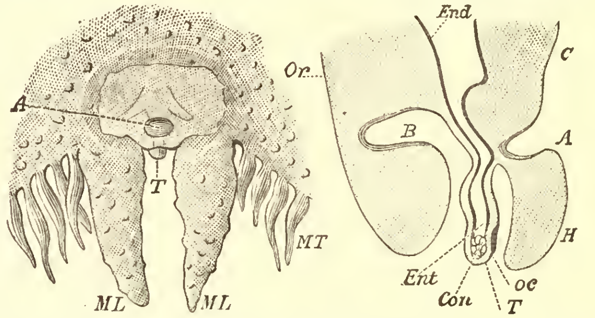


FIG. 30.—Tentaculocyst and marginal lappets of *Aurelia aurita*. In the left-hand figure—*ML*, marginal lappets; *T*, tentaculocyst; *A*, superior or aboral olfactory pit; *MT*, marginal tentacles of the disc. The view is from the aboral surface, magnified about 50 diameters. In the right-hand figure—*A*, superior or aboral olfactory pit; *B*, inferior or adoral olfactory pit; *H*, bridge between the two marginal lappets forming the hood; *T*, tentaculocyst; *End*, endoderm; *Ent*, canal of the enteric system continued into the tentaculocyst; *Con*, endodermal concretion (auditory); *oc*, ectodermal pigment (ocellus). The drawing represents a section, taken in a radial vertical plane so as to pass through the long axis of the tentaculocyst. (After Eimer.)

character of the margin of the disc is soon obliterated by the relative growth of the intermediate adradial areas, which become quite filled up, so that in the adult the tentaculocyst is carried in a notch instead of on a prominence, and is concealed by the two lappets (figs. 28 and 30). The margin of the disc between adjacent pairs of lappets gives rise to a fold which grows inwards (toward the mouth) during an early stage (fig. 31), and numerous small tentacles (the fringe) appear along the margin of the disc, which soon equal in size the first adradial tentacle. The ingrowing fold is the velum or "pseudo-velum," and never increases in size, so that in the adult it is not observable. The tentacles also remain very small and fine in *Aurelia*, forming a continuous fringe along the edge of the disc, interrupted only by the eight notches for the tentaculocysts (fig. 29).

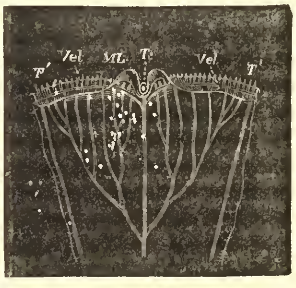


FIG. 31.—Part of the margin of the disc of a young *Aurelia*, to show the rudimentary velum, *Vel*, extending from the marginal lappets, *ML*, on either side; *T'*, the small tentacles fringing the disc.

The sixteen tentacles of the scyphistoma are necessarily attached to the most anterior of the pile of medusæ; they atrophy, but to what extent they may be metamorphosed to form the parts of the ephyra or young medusa has not been determined. The scyphistoma, having given rise to its pile of ephyræ, may (in some genera, *Aurelia*?) redevelop its own kind of tentacles below the constriction marking off the last ephyra. Hence scyphistoma tentacles appear sometimes at the top and sometimes at the bottom of the pile, which has led to diverse accounts of the mode of development of the ephyræ.

Whilst changes are going on in the configuration of the margin of the disc of an ephyra on its way to the perfect form of the adult *Aurelia*, the enteric cavity has also undergone most important changes. Foremost in importance is the development of a single gastral filament on each of the four gastral ridges which necessarily are present in the transverse slice (so to call it) of a scyphistoma, which becomes an ephyra (fig. 26). These rapidly increase in number as the ephyra grows. Further, the enteric cavity at first follows the outline of the ephyra, sending a process into each arm, but then by adhesion of its walls is converted into a four-lobed central chamber, a marginal canal, and an endoderm lamella. A system of canals, the arrangement of which is seen in figs. 29 and 31, subsequently opens out again certain lines and tracts of the conjoined endoderm walls.

In the adult *Aurelia* we find the mouth surrounded by four large arm-like perradial processes (figs. 25 and 29) (not tentacles), and leading through a short manubrium into a flattened four-lobed chamber, the lobes being interradial, and having on their oral floor numerous gastral filaments (rich in thread cells) (6 in fig. 16). Each pouch or lobe gives off a canal, which runs towards the circular canal at the margin of the disc, but breaks up into three or four secondary canals on its way. Between the pouches come off eight other "radiating" canals (adradial), which do not branch, but go straight to the circular canal.

The oral floor of the concavity of each lobe of the enteric cavity is occupied by a horse-shoe-shaped frill (fig. 29, *ov*), either testis or ovary (the sexes being in separate individuals). The open arms of the horse-shoe are turned towards the centre of the disc, and the folds of the genital frill are so deep as to show themselves on the outer ectodermal wall of the disc. Here, however, there is a very remarkable arrangement, which has rarely, if ever, been correctly described and figured in our common *Aurelia*. The gelatinous substance of the disc is hollowed out on that part of the oral face corresponding to the position of the genital frills, so as to form four separate extensive pits or chambers. Each of these sub-genital pits has in *Aurelia* a small round opening on the oral face of the disc (fig. 28, GP), but is otherwise entirely closed, having no communication with the genital tissues, from which it is separated by a delicate layer of ectoderm (6 in fig. 16). The pits probably serve to admit water for respiratory purposes into close proximity with the genital tissues.

The whole enteric surface, including canals, is ciliated, whilst the ectoderm is not ciliated, but provided with groups of nematocysts.

The tentaculocyst in the adult *Aurelia* is relatively an extremely minute body, completely hidden by the two large marginal lappets (fig. 30, T). Above it (that is, on the aboral surface, as the *Aurelia* swims) is a deep pit (A), Schäfer's fovea nervosa superior, sunk in a sort of bridge which connects the two lappets and overhangs the tentaculocyst. A similar pit (the fovea inferior) exists on the oral surface. These have been recognized by Claus, Eimer, and the Hertwigs as olfactory organs. The tentaculocyst is seen in section in fig. 30 (right-hand figure), which exhibits its central cavity continuous with the enteric cavity, its ectodermal pigment spot (eye), and its endodermal mass of concretions (auditory organ).

The chief muscular mass of *Aurelia*, except that of the oral arms, is a circular zone on the oral face of the disc. The muscular fibres are not distinct cells, but transversely-striated processes of the epidermic cells (epidermo-muscular cells) (fig. 9). In the "arms" of other medusæ, and presumably of *Aurelia*, the muscular fibre is formed by independent nucleated cells (fig. 9).

The nerve-epithelium from the olfactory pits of *Aurelia* is drawn in fig. 14. Starting from this and from the cells of the tentaculocysts are nerve-fibres, which spread themselves on the surface of the circular muscular zone in the neighbourhood of the tentaculocysts, and these are connected each and separately with large isolated nerve-ganglion cells (fig. 15). The nerve-fibre is continued beyond the cell, and in some instances has been traced into a broadened expansion lying on a muscular fibre (Schäfer). The nerve-ganglion cells lie very superficially immediately below the flat epithelium of the body surface and between it and its muscular processes.

The ova and spermatozoa of *Aurelia* develop in the genital frills from endoderm cells in separate individuals. They pass to the exterior through the mouth.

Order 3. *Conomedusæ*,—*Scyphomedusæ* with only four tentaculocysts, and these perradial. A broad velum (so-called pseudo-velum) of complete circular form is present, differing from that of the *Hydromedusæ* in the fact that it is penetrated by canals of the enteric system (*Charybdæa*). The whole umbrella is bell-shaped. The genital organs are four pairs of lamelliform ridges (fig. 22) which are attached to the four narrow interradial septa that divide the large enteric cavity of the umbrella into four perradial gastro-canal pouches. The lamelliform genital glands hang freely in these pouches. At the edge of the umbrella are four interradial lappet-like prolongations of the gelatinous substance of the disc, which support each a long tentacle (fig. 20). The nerve-ring is complete, like that of the *Hydromedusæ*.

There is now no doubt that *Charybdæa*, which has been placed in each of the two large divisions of the *Hydrozoa*, must be classed with the *Scyphomedusæ*. The recent investigations of Claus (*Arbeiten aus dem Zool. Institut zu Wien*, Bd. i. Hft. ii., 1878), as well as those of Haeckel and Fritz Müller, lead to this conclusion. The term *Conomedusæ* is adopted from Haeckel, who places here, besides *Charybdæa* and *Tamoya*, other forms, a fuller description of which may be expected in his forthcoming *System der Medusen*. In many respects—its quadrangular form, its marginal lappets, its broad enteric pouches in place of fine canals, its vascular velum, and its highly complicated tentaculocysts (fig. 13, B)—*Charybdæa* is peculiar. The simplicity of the enteric system and the arrangement of the genital glands brings it near to *Lucernaria*. The existence of four interradial groups of gastral filaments, and the disposition of the paired genital glands at the sides of the interradial septa, determine its position to be among the *Scyphomedusæ*. Its development is not known. Figs. 20 to 23 illustrate the structure of *Charybdæa*.

Order 4. *Peromedusæ*,—*Scyphomedusæ* with four interradial tentaculocysts. The enteric system consists of three divisions,—an aboral main stomach with four interradial gastral ridges and filament groups; a mid-stomach, which communicates by means of four perradial slits with a very large ring-sinus (occuping two-thirds of the umbrella); and thirdly, an oral portion or pharynx, with four wide perradial pouches. The genital organs are four pairs of sausage-shaped interradial ridges lying on the oral floor of the ring-sinus.

This is a new group founded by Haeckel, of which we have at present no further details.

Sub-class II. HYDROMEDUSÆ.—These are *Hydrozoa* devoid of gastral filaments; the sexual persons are always medusiform, the genital glands are developed sometimes from ectodermal cells, sometimes from endoderm, and are always perradial (in the radii of the first order). The medusiform persons always possess a muscular non-vascular velum (hence *Craspedota*) and a complete nerve-ring (hence *Cycloneura* of Eimer). The marginal sense-organs are either ocelli or otocysts or tentaculocysts. The diblastula, in all cases as yet observed, is formed by delamination (Balfour). The sexual medusiform persons may develop directly from the egg, but more usually the egg gives rise to a hydriform person—the hydroid—which differs from a scyphistoma in its elongate vertical axis, the indefinite number (often also position) of its tentacles, and its frequent formation of a colony of large size by lateral budding. By lateral budding (not by

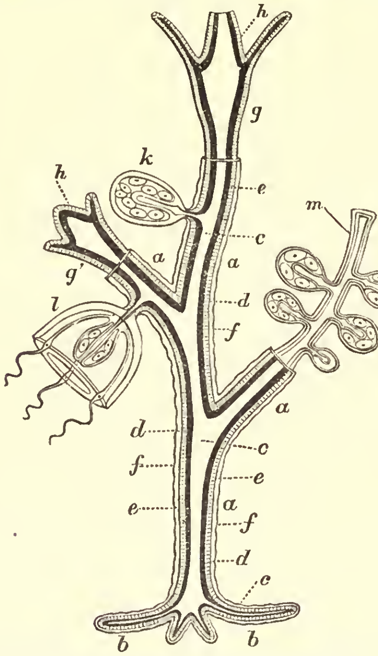


Fig. 32.—Diagram showing possible modifications of persons of a gymnoblastic *Hydromedusa*. *a*, hydrocaulus (stem); *b*, hydrorhiza (root); *c*, enteric cavity; *d*, endoderm; *e*, ectoderm; *f*, perisarc (horny case); *g*, hydranth (hydriform person) expanded; *g′*, hydranth (hydriform person) contracted; *h*, hypostome, bearing mouth at its extremity; *k*, sacciform gonophor (sporosac) springing from the hydrocaulus; *k′*, sporosac springing from *m*, a modified hydriform person (blastostyle): the genitalia are seen surrounding the spadix or manubrium; *l*, medusiform person or medusa; *m*, blastostyle. (After Allman.)

metameric fission) medusiform persons which alone develop sexual glands are produced on the hydriform colonies;

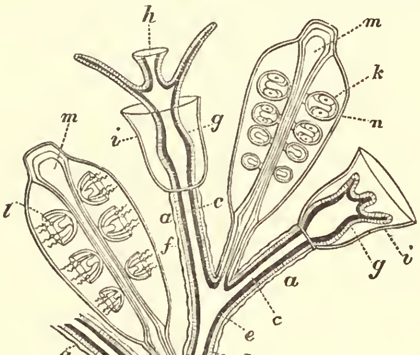


Fig. 33.—Diagram showing possible modifications of the persons of a Calyptoblastic *Hydromedusa*. Letters *a* to *h* same as in fig. 32. *i*, the horny cup or hydrotheca of the hydriform persons; *l*, medusiform person springing from *m*, a modified hydriform person (blastostyle); *n*, the horny case or gonangium enclosing the blastostyle and its buds. This and the hydrotheca *i* give origin to the name *Calyptoblastea*. (After Allman.)

these may separate from the colony, or may be retained in a more or less degenerate form adherent to it, as generative buds or warts.

The medusiform persons of this group are the *Discophoræ cryptocarpæ* of Eschscholtz, the *Craspedota* of Gegenbaur (1854), and the *Hydromedusida* of Kölliker (1853)—the last two authors at that time separating the hydriform persons as *Hydroidea*. Louis Agassiz (1860) includes both sets of persons under the term

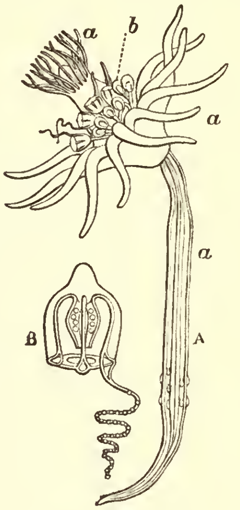


Fig. 34.

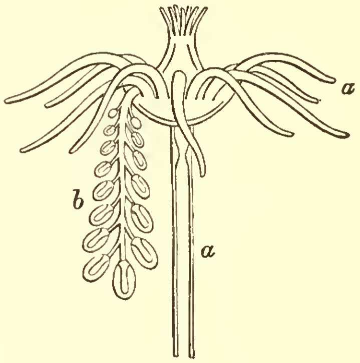


Fig. 35.

Fig. 34.—Diagram of *Corymorpha*. A, a hydriform person giving rise to medusiform persons by budding from the margin of the disc; B, free swimming medusa (*Steenstrupia* of Forbes) detached from the same, with manubrial genitalia (*Anthomedusæ*) and only one tentacle. (After Allman.)

Fig. 35.—Diagram of *Tubularia indivisa*. A single hydriform person *a* bearing a stalk carrying numerous degenerate medusiform persons or sporosacs *b*. (After Allman.)

Hydroida (together with *Lucernaria*), which also is the term adopted by Allman in his beautiful monograph (1871–74). J. V. Carus, amending the limitations given by Carl Vogt, was the first to use the term *Hydromedusæ* in the sense here adopted (*Handbuch der Zoologie*, 1863), and it is now employed in the same sense by Gegenbaur (*Elements of Comparative Anatomy*, London, 1878), namely, to embrace both the cryptocarpous medusæ of Eschscholtz and the

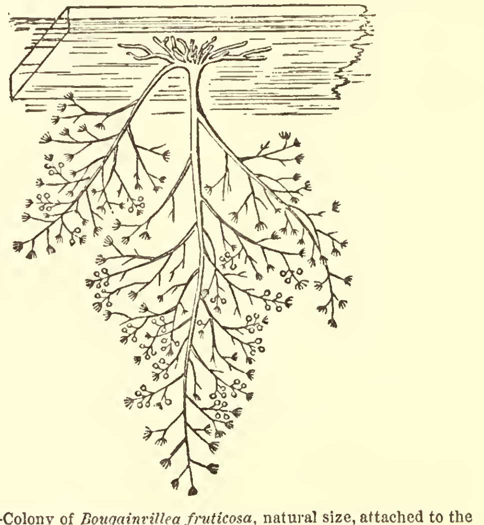


Fig. 36.—Colony of *Bougainvillea fruticosa*, natural size, attached to the underside of a piece of floating timber. (After Allman.)

hydroids related to them. The term *Hydromedusæ* is used unwisely by Claus (*Grundzüge d. Z.*) for the whole group of *Hydrozoa*. It has been the practice of some authors to give a double classification of the group—one based on the characters of the medusiform persons, the other on that of the hydriform persons. In the present article a double name will in some cases be assigned to a group—but the attempt is made to bring both sets of persons under one system.

Order 1. *Gymnoblastea-Anthomedusæ*.—These are *Hydromedusæ* which all, as far as is known, pass through a hydriform phase, but in which the medusiform persons may either reach full development or exhibit the extremest degeneration (*Hydra*). The ectoderm of the hydriform persons may secrete a horny tubular protective case (perisarc), but this does not form cups for the reception of the tentacular crown nor cases enclosing groups of medusiform buds (gonangia). The fully-developed medusiform

FIG. 37.—Portion of colony of *Bougainvillea* (*Endendrium*) *fruticosa* (*Anthomedusæ-calyptoblastea*) more magnified. (From Lubbock, after Allman.)

persons never possess otocysts nor tentaculocysts, but always ocelli at the base of the tentacles. The latter are usually four or six, corresponding to the same number of simple radial enteric canals, but may be more numerous or reduced to one or to two; rarely they are branched (*Cladonema*).

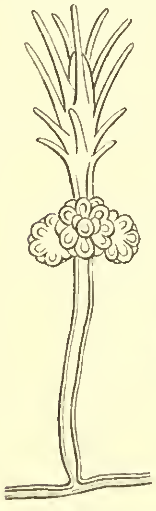


Fig. 38.

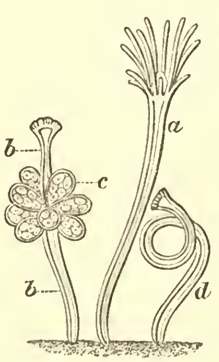


Fig. 39.

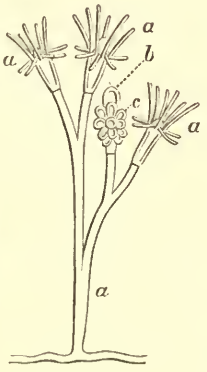


Fig. 40.

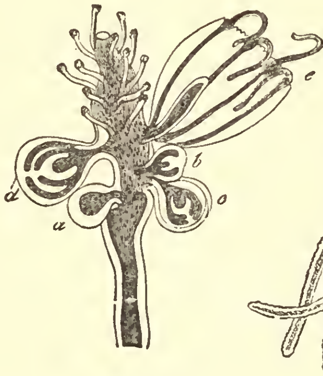
FIG. 38.—Diagram of *Clava*, showing a hydriform person surrounded by a verticil of degenerate medusiform persons (sporosacs). (After Allman.)

FIG. 39.—Diagram of a colony of *Hydractinia*, showing four forms of persons. *a*, hydriform person; *b*, modified hydriform person, or blastostyle, bearing *c*, degenerate medusiform persons or sporosacs; *d*, modified hydriform person situated at the margin of the colony (dactylozooid). (After Allman.)

FIG. 40.—Diagram of a colony of *Dicoryne*, showing three forms of persons *a*, normal hydriform person; *b*, modified bud-bearing hydriform person (blastostyle); *c*, degenerate medusiform persons (sporosacs). (After Allman.)

The sexual glands are placed in the wall of the manubrium, either equally distributed all round it or in four separate perradial groups, which are often divided into eight adradial groups by the perradial longitudinal muscles.

This is a very well defined group, since the *Gymnoblastea* of Allman, based on the characters of the hydriform persons—also known as *Tubulariæ* and *Gymnotoka*—correspond exactly with the *Anthomedusæ* of Haeckel's new system. *Hydra* is included here, though placed in a separate order by Allman. Some of the leading forms of hydriform and medusiform persons are given in the cuts (figs. 34 to 42). The greatest range in the amount of degeneration of the medusiform persons is seen even in genera of the same family—*e.g.*, *Turris* and *Clava*—the former producing free medusæ, the latter sessile sporosacs. The *Oceanidæ* of Gegenbaur (excluding the *Williadæ*, which Haeckel assigns to the next group) correspond on the whole to the medusa-forms of this order.



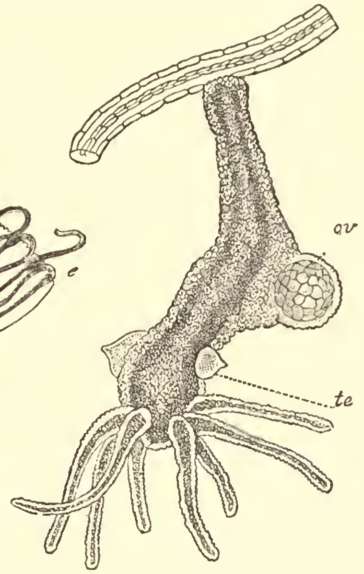
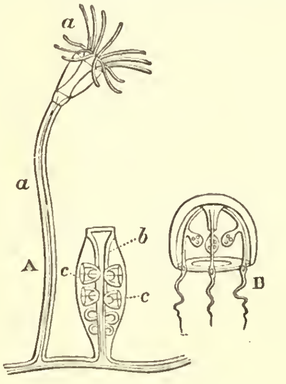


Fig. 41. Fig. 42.

FIG. 41.—Hydriform person of *Syncoryne*, with medusiform persons budding from it, and shown in various stages of development, *a*, *b*, *c*, *d*, *e*. (From Gegenbaur, after Desor.)

FIG. 42.—*Hydra viridis*. *ov*, ovary; *te*, testis.

Order 2. *Calyptoblastea-Leptomedusæ*.—These are *Hydromedusæ* of which the hydriform phase is known in a large number of cases, whilst of others only the medusa-forms are known; none are *known* to develop directly from the egg to the medusa-form. As in the preceding group, the medusiform persons may reach full development or



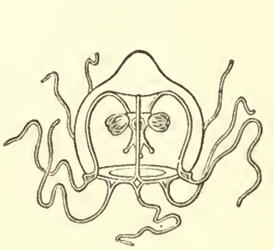


Fig. 43. Fig. 44.

FIG. 43.—Diagram of a colony of *Campanularia*, showing four forms of persons. A, portion of a fixed colony; *a*, hydriform person; *b*, bud-bearing hydriform person (blastostyle); B, free-swimming colony, being a sexless medusiform person (blastochеme of Allman), with modified medusiform persons budding from its radiating canals, as sporosacs. (After Allman.)

FIG. 44.—Medusiform person (*Lizzia*), one of the *Anthomedusæ*, detached from a hydroid colony of the family *Endendridæ*. Ocelli are seen at the base of the tentacles, and two medusiform buds on the sides of the manubrium. (After Allman.)

exhibit themselves as degenerate sexual sacs on the hydriform colonies. The ectoderm of the hydra-forms always secretes a perisarc which forms a cup-like protection (hydrotheca) to the tentacle-crown, and which also encloses the group of medusa-buds in peculiar horny cases (gonangia). The fully-developed medusiform persons (fig. 47) either have no otocysts, but only ocelli (*Ocellatæ*), or they have otocysts (fig. 11) (ectodermal sacs), four, eight, or over a hundred, not homologous with tentacles, and sometimes in addition ocelli (*Vesiculatæ*). The radial enteric canals are usually four or eight in number, but may be more numerous, whilst the marginal tentacles of the disc are either few or

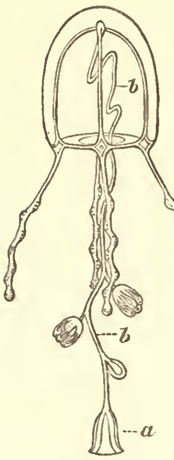


Fig. 45.

Fig. 46.

Fig. 45.—Medusiform person (*Sarsia*), one of the *Anthomedusæ*, detached from a hydroid colony of the family *Corynidæ*. *b*, the long manubrium, bearing (as an exception) medusiform buds; *a*, mouth.
Fig. 46.—Medusiform person, one of the *Anthomedusæ*, detached from a hydroid colony of *Syncoryne*. Ocelli are seen at the base of the tentacles, and also (as an exception) groups of medusiform buds.

very numerous. The genital glands always are placed in the course of the radial canals of the disc (not in the manubrium), and stand out as groups of wart-like processes on the sub-umbrellar surface (fig. 43). Their mode of discharge is uncertain.

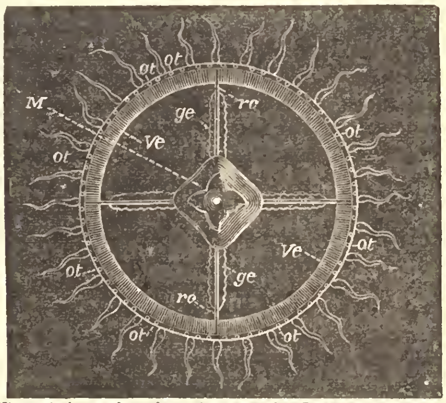


Fig. 47.—View of the oral surface of one of the *Leptomedusæ* (*Irene pellucida*, Haeckel), to show the numerous tentacles and the otocysts. *ge*, genital glands; *M*, manubrium; *ot*, otocysts; *rc*, the four radiating canals; *Ve*, the velum.

The *Calyptoblastea* of Allman, *Skenotoka* of Carus, and *Campanulariæ* of authors form a well-marked group of hydroids which, when they give rise to free medusæ, give rise to those termed *Leptomedusæ* by Haeckel, corresponding to the *Thaumantiadæ* and *Eucopidæ* of Gegenbaur's system. The calyptoblastic hydroid *Leptoscyphus*, which, according to Allman, gives rise to a *Lizzia*-like medusa (*Anthomedusæ*), is the only recorded exception to this correspondence. The *Æquoridæ* and other medusæ of similar structure have not been traced into connexion with any hydriform trophosome, but we are not justified therefore in concluding that they develop directly from the egg without hydriform phase. The chief point distinguishing the *Leptomedusæ* as a lot from the *Anthomedusæ* is the development of the generative bodies in the radial canals. This position is similar to that occupied by the same organs in *Trachomedusæ* and *Scyphomedusæ*. Allman, however, considers the genital glands of the *Leptomedusæ*, not as mere glands like those of *Aurelia* or *Charybdæa*, but as a series of buds—a generation of aborted medusæ or sporosacs. In consequence he terms the medusa of the *Leptomedusæ* a blastocheme (or bud-producer), as distinguished from a gonocheme (or genital-producer). In support of this view, Allman (*Monograph*, 1874) adduces the various remarkable cases of production of buds by medusæ which have been recorded (fig. 44, 45, 46), and, further, the very striking similarity between the structure of a lobe of the genital gland of *Obelia* and a sporosac such as we find in *Hydractinia*. It seems necessary to accept Allman's view on this matter, unless we are prepared to abandon the homology of sporosacs with medusæ in the case of hydriform persons.

The colonies of hydriform persons of the present group differ *inter se* according to the arrangement of the cups or hydrothecæ. In *Plumularidæ* they are sessile, and all on one side of a branch; in *Sertularidæ* they are sessile, and alternately placed on either side; in *Campanularidæ* each cup is raised on a pedicel or stalk. The medusiform persons sometimes remain abortive and sessile in their gonangia.

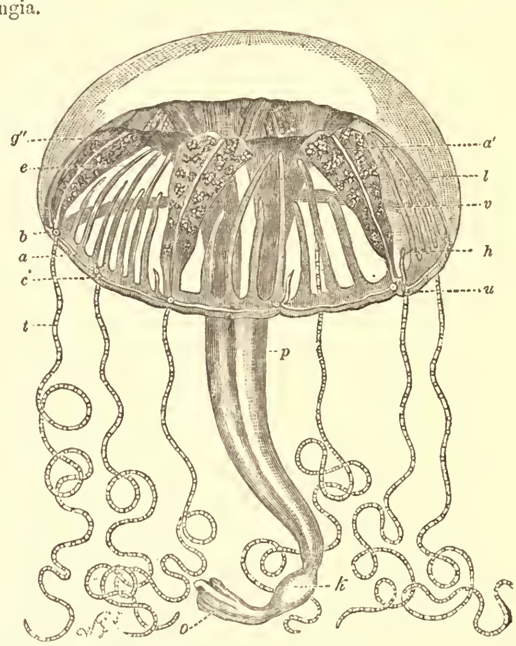


Fig. 48.—*Carmarina* (*Geryonia*) *hastata*, one of the *Trachomedusæ*. (After Haeckel.) *a*, nerve-ring; *a'*, radial nerve; *b*, tentaculocyst; *c*, circular canal; *e*, radiating canal; *g''*, ovary; *h*, peronia or cartilaginous process ascending from the cartilaginous margin of the disc centripetally in the outer surface of the jelly-like disc; six of these are perradial, six interradial, corresponding to the twelve solid larval tentacles, resembling those of *Cunina*; *k*, dilatation (stomach) of the manubrium; *l*, jelly of the disc; *p*, manubrium; *t*, tentacle (hollow and tertiary, *i.e.*, preceded by six perradial and six interradial solid larval tentacles); *u*, cartilaginous margin of the disc covered by thread-cells; *v*, velum.

Order 3. *Trachomedusæ*,—*Hydromedusæ* which have as sense-organs tentaculocysts. The otoliths (fig. 12) are

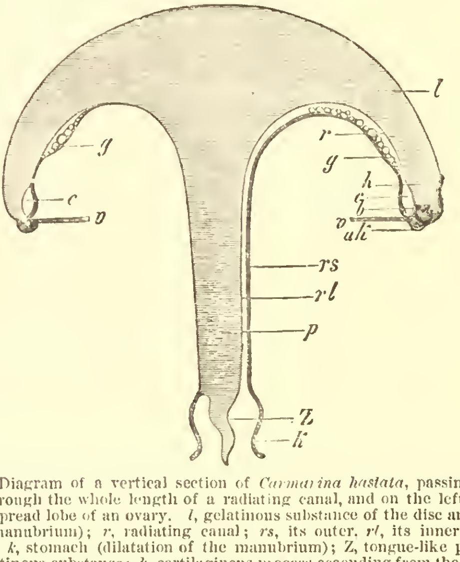


Fig. 49.—Diagram of a vertical section of *Carmarina hastata*, passing on the right through the whole length of a radiating canal, and on the left through the outspread lobe of an ovary. *l*, gelatinous substance of the disc and gastric stalk (manubrium); *r*, radiating canal; *rs*, its outer, *rl*, its inner wall; *g*, ovaries; *k*, stomach (dilatation of the manubrium); Z, tongue-like process of the gelatinous substance; *h*, cartilaginous process ascending from the marginal ring at the site of a tentaculocyst; *c*, circular canal; *b*, tentaculocyst; *v*, velum; *uk*, cartilaginous marginal ring. (From Gegenbaur.)

formed by endodermic cells as in *Scyphomedusæ*, and ocelli may or may not be present on the tentaculocyst.

The genital glands have the form of wide outgrowths or lamelliform enlargements in the course of the radial canals (figs. 48, 49). No hydriform phase is known in any member of this group, and one at least (*Geryonia*) has been observed to develop from the egg directly into the medusa-form.

Order 4. *Narcomedusæ.*—These have the same characters as the *Trachomedusæ*, excepting that the genital glands are in the wall of the manubrium or in pocket-like radial outgrowths thereof (figs. 50 and 51). Further, the marginal tentacles of the disc possess peculiar "roots," which can be traced upwards into the gelatinous substance of the body. No hydriform phase has been observed in this group, whilst *Ægina* and *Æginopsis* have been shown to develop directly from the egg to the medusa-form.

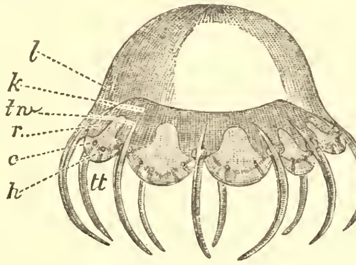


FIG. 50.—*Cunina rhododactyla*, one of the *Narcomedusæ*. *c*, circular canal; *h*, "otoporpæ" (ear-rivets) or centripetal process of the marginal cartilaginous ring connected with tentaculocyst; *k*, stomach; *l*, jelly of the disc; *r*, radiating canal (pouch of stomach); *tt*, tentacles; *tw*, tentacle root. (After Haeckel.) The lappets of the margin of the disc, separated by deep notches, above which (nearer the aboral pole) the tentacles project from the disc (not marginal therefore), are characteristic of many *Narcomedusæ* and *Trachomedusæ*. Cartilaginous strands (the mantle rivets or peroniæ) connect the tentacle root with the solid marginal ring.

The two orders *Trachomedusæ* and *Narcomedusæ* are established by Haeckel in his new "system" for the peculiar forms classed by Carus as *Haplomorpha*, and by Allman as *Monopsea*. These latter names have reference to the fact that no hydriform phase is *known* to occur in the life-history of these organisms, a fact which is not peculiar to them, and, if it should prove to be not universal amongst them, would by no means invalidate their claim to a distinct position on the grounds afforded by the characters above given. They are remarkable for a certain hardness and stiffness of the gelatinous substance of the disc, or at any rate of the cellular axis of the tentacles, on account of which the orders are contrasted by Haeckel as *Trachylinæ* with *Anthomedusæ* and *Leptomedusæ*, which are

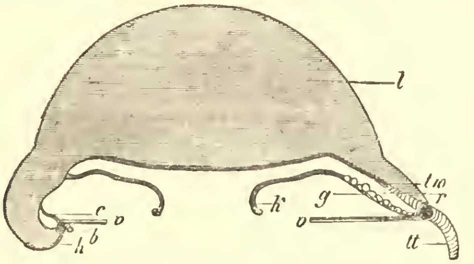


FIG. 51.—Diagram of a vertical section through a young *Cunina rhododactyla*, passing on the right side through a radiating pouch. *b*, tentaculocyst; *c*, circular canal; *g*, ovary; *h*, marginal cartilage and connecting process springing from a tentaculocyst (otoporpa); *k*, stomach; *l*, jelly of the disc; *r*, radiating canal or pouch; *tt*, tentacle (solid, cartilaginous); *tw*, tentacle root; *v*, velum. (From Gegenbaur.)

termed *Leptolinæ*; a curious parallelism as to the position of the genitalia exists between *Anthomedusæ* and *Narcomedusæ* on the one hand and *Leptomedusæ* and *Trachomedusæ*, on the other. The orders present a very high degree of development, both in coarser and histological differentiation. At one time it was supposed, in accordance with Haeckel's observations, that *Geryonia* (*Carmarina*, fig. 48), one of the *Trachomedusæ*, gave rise by buds from its enteric walls to young *Cuninæ* (*Narcomedusæ*, fig. 50), but this has been explained by the observations of Franz Schulze and of Uljanin as due to parasitism, young *Cuninæ* in the condition of ciliated *Planulæ* entering the mouth and enteric chamber of the *Carmarina*. The same explanation probably applies (Claus) to the supposed internal buds of *Cunina* observed by Gegenbaur, Fritz Müller, and Metschnikow. The process is sufficiently remarkable according to the last observer, for the first generation of buds produce a second generation by external gemmation, before attaining the characters of the parent *Cunina*. The anatomy of these forms is fully given in Haeckel's memoirs in the *Jenaische Zeitschrift*, vols. i. and ii., 1864–66; also further details as to *Carmarina* are given in Eimer's *Medusen*, 1878.

Order 5. *Hydrocorallinæ.*—These are *Hydromedusæ* in which the hydriform phase forms large colonies, presenting a copious calcareous deposit in the ectodermal tissue (cœnosteum of Moseley), leaving only the hydranths or tentacular region free from such hardening. The medusiform persons are, at present, only known in the degenerate form of sporosacs, which occupy cavities (ampullæ of Moseley) in the hardened base of the colony (*Stylasteridæ*). No such cavities have been detected in others (*Milleporidæ*), which may, therefore, give rise to complete medusiform persons.

FIG. 52.—Portion of the calcareous corallum of *Millepora nodosa*, showing the cyclical arrangement of the pores occupied by the "persons" or hydranths. Twice the natural size. (From Moseley.)

In all a marked polymorphism has been observed (fig. 53), consisting in the differentiation of longer tentacle-like persons (dactylozooids) and shorter mouth-bearing persons (gastrozooids). The persons of both kinds are either scattered irregularly or the dactylozooids are arranged around the gastrozooids in cyclosystems of greater or less definiteness, or in distinct rows (fig. 55). The position of these two kinds of hydriform persons is marked by definite groups of pits (cyclosystems) in the dried calcareous skeleton of the colonies, which simulate the calycles of the stony corals (*Anthozoa*).

FIG. 53.—Enlarged view of the surface of a living *Millepora*, showing five dactylozooids surrounding a central gastrozooid. (From Moseley.)

Louis Agassiz was the first to recognize the true nature of the *Milleporidæ*, and his imperfect observations have been fully confirmed and greatly extended by Mr Moseley (*Phil. Trans.*, 1878) who added the *Stylasteridæ* previously regarded as *Anthozoa* to the category of calcigenous hydroids, and founded the order of *Hydrocorallinæ*. The *Stylasteridæ* differ from the *Milleporidæ* in possessing a calcified axial style at the base of the dilated portion of each gastrozooid, and further in the ascertained development of sporosacs, and in the greater complication of their cyclosystems. These forms are abundant in tropical seas, and contribute with the *Anthozoa* and Corallines to the formation of coral reefs. *Allopora* and *Stylaster* occur off the Norwegian coast. The woodcuts illustrating the structure of this group are borrowed from Mr Moseley's *Notes of a Naturalist on the "Challenger."*

The nearest allies of the *Hydrocorallinæ* are such polymorphic *Gymnoblastea* as *Hydractinia* (fig. 39); the definite division of labour and the polymorphism in the former, together with their calcigenous peculiarity, entitle them to rank as a distinct order.

Order 6. *Siphonophora.*—These are *Hydromedusæ* in which hydriform persons alone (*Velella*) or hydriform persons and sterile medusiform persons are united, under many special modifications of form, to constitute floating colonies of very definite shape and constitution. In addition to these are developed medusiform sexual persons which usually are sporosacs and only exceptionally attain full development so as to be liberated from the colony as free-swimming medusæ (*Velella*, as *Chrysomitra*; *Physalia*, only liberating female medusæ). The medusiform persons, where sufficiently developed, exhibit the velum characteristic of *Hydromedusæ*; the larger mouth-bearing hydriform persons, which are sometimes the only representatives of their kind, are remarkable for differentiation into four regions,—a proboscis, a stomach, a basal ring, and a short stalk on which the *single* tentacle of great length is situated (fig. 56, *f*). In the sub-order *Physophoridæ* (fig. 57, C) the persons are united by a short or long and spiral stem, terminated at one end by a flask-like air-sac (pneumatocyst); below the air-sac a biserial or multiserial range of swimming-bells (nectocalyces = medusæ with suppression of manubrium, tentacles, and sense-organs) are placed. Covering pieces (hydrophyllia, reduced medusæ) and dactylozooids are affixed to the succeeding region of the stem, and alternate in definite order with the mouth-bearing hydriform persons (polyps or nutritive persons) and generative medusiform persons. In the sub-order *Physalidæ* the stem is converted into an air-sac, enormously enlarged, and the necto-

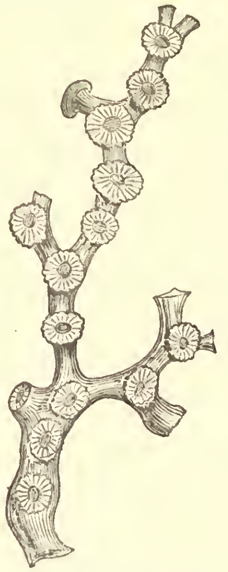


Fig. 54.—Portion of the corallum of *Astylus subviridis* (one of the *Stylasteridæ*), showing cyclosystems placed at intervals on the branches, each with a central gastropore and zone of slit-like dactylopores. (After Moseley.)

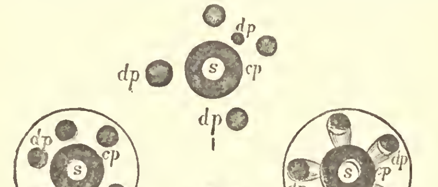


Fig. 55.—Diagrams illustrating the successive stages in the development of the cyclosystems of the *Stylasteridæ*. 1, *Sporadopora dichotoma*. 2, 3, *Allopora nobilis*. 4, *Allopora profunda*. 5, *Allopora miniacea*. 6, *Astylus subviridis*. 7, *Distichopora coccinea*. *s*, style; *dp*, dactylopore; *gp*, gastropore; *b*, in fig. 6, inner horseshoe-shaped mouth of gastropore. (After Moseley.)

calyces and hydrophyllia are absent. In the sub-order *Calycophoridæ* the air-sac is not developed, the nectocalyces are in a biserial group, or reduced to two or to one. Dactylozooids are wanting. The modified persons (appendages, Huxley) arise from the stem in groups, and can be withdrawn into the cavity of a swimming-bell (fig. 57, B). Each group consists of a nutritive person, with long tentacle, of generative medusoids, and usually also an umbrella-shaped or funnel-like covering piece. The latter separate in some *Diphyidæ*, and lead an independent life as *Eudoxiæ*.

In the suborder *Discoidæ* the stem is converted into a flattened disc with a system of canalicular cavities. Above this lies the air sac, a flattened reservoir of cartilaginous consistence. The hydriform persons depend from the disc, centrally a large nutritive person surrounded by smaller similar persons carrying at their bases the generative medusoids; near the edge of the disc are dactylozooids. The medusoids develop into complete medusiform persons, and develop the genital products after liberation from the colony, when they are known as *Chrysomitra*.

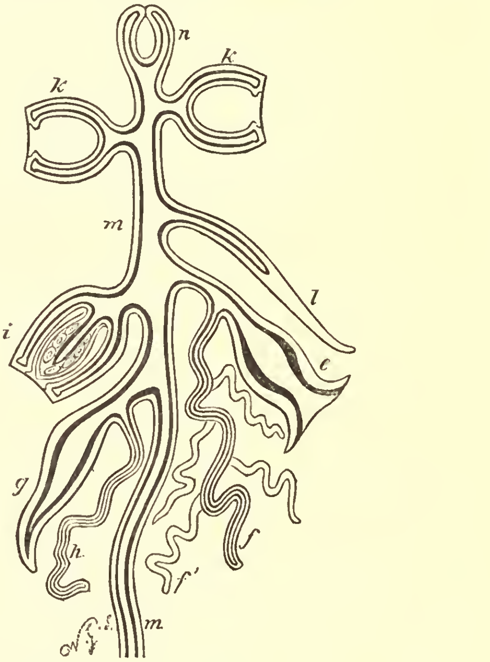


Fig. 56.—Diagram showing possible modifications of medusiform and hydriform persons of a colony of *Siphonophora*. *n*, pneumatocyst; *k*, nectocalyces (swimming bells); *l*, hydrophyllium (covering-piece); *i*, generative medusiform person; *g*, dactylozooid with attached tentacle, *h*; *e*, nutritive hydriform person, with branched grappling tentacle, *f*; *m*, stem. The thick black line represents endoderm, the thinner line ectoderm. (After Allman.)

The *Siphonophora* alone, amongst the colonies formed by *Hydrozoa*, exhibit a high degree of division of labour and consequent individuation. The mode of origin of such colonies has been discussed above. The locomotive habit, as contrasted with the sessile habit of other colonies, is no doubt correlated with the sharply defined individuality which they attain (compare *Cristatella* among *Polyzoa*). *Velella* and *Physalia* are occasionally seen on the southern and western shores of England, but as a rule the *Siphonophora* are met with only in the open ocean and in the Mediterranean. By some authorities the *Siphonophora* are assigned a distinct position among the *Hydrozoa*, side by side with the *Hydromedusæ* and *Scyphomedusæ*; their interpretation as floating colonies of *Hydromedusæ*, an interpretation necessitated by the structure of their medusiform persons, forbids their separation from that group.

Fossil Hydrozoa.—The researches of Moseley have necessitated a redistribution of the group of *Anthozoa* known as the *Tabulata*. Among these appear to be a few *Hydrocoralline*, which occur in the fossil state. The Palæozoic forms known as graptolites are by some authors assigned to the *Hydrozoa*, but the grounds for placing them in this position are very slight, owing to the imperfect nature of the remains. A discussion of the small amount of structure which they present would be out of place here.

Remarkable *Scyphomedusæ* have been obtained from the Solenhofen slates (Jurassic); excepting these, no noteworthy extinct *Hydrozoa* are known (see Haeckel in *Zeitsch. wiss.*

Zool., vols. xv., xix., and *Jenaische Zeitsch.*, vol. viii., 1874).

Relationship of the Ctenophora to the Hydrozoa.—The remarkable medusa-form recently described by Haeckel (*Sitzungsber. Jenaische Gesellsch.*, 1878) as *Ctenaria ctenophora*, and classed by him amongst the *Anthomedusæ*, seems to furnish a very direct transition from the structure of a medusa to that of such a ctenophor as *Cydippe* (*Pleurobrachia*). The woodcut and appended explanation (fig. 58) copied from Haeckel's memoir will render the relations of the two forms clear. *Ctenaria* has the margin of its disc narrowed so as to give the organism a spherical form. The approximated margins bound an orifice leading to the sub-umbrella space. This orifice corresponds to the so-called mouth of a *Cydippe*. Further, *Ctenaria* has two, and only two, long-fringed tentacles, like those of *Cydippe*, and each springing from a pocket as in that genus, and on the surface of its spheroidal umbrella eight rows of differentiated ectodermal cells, which though not ciliated correspond closely in position with the eight ctenophoral ambulacra of *Cydippe*. The disposition of the enteric canal-system of *Ctenaria* is, as shown in the cut, also transitional in the direction of *Cydippe*. Apart from the existence of *Ctenaria*, the homologies suggested by Haeckel between *Hydromedusæ* and *Ctenophora* are such as to commend themselves very strongly to acceptance. (E. R. L.)

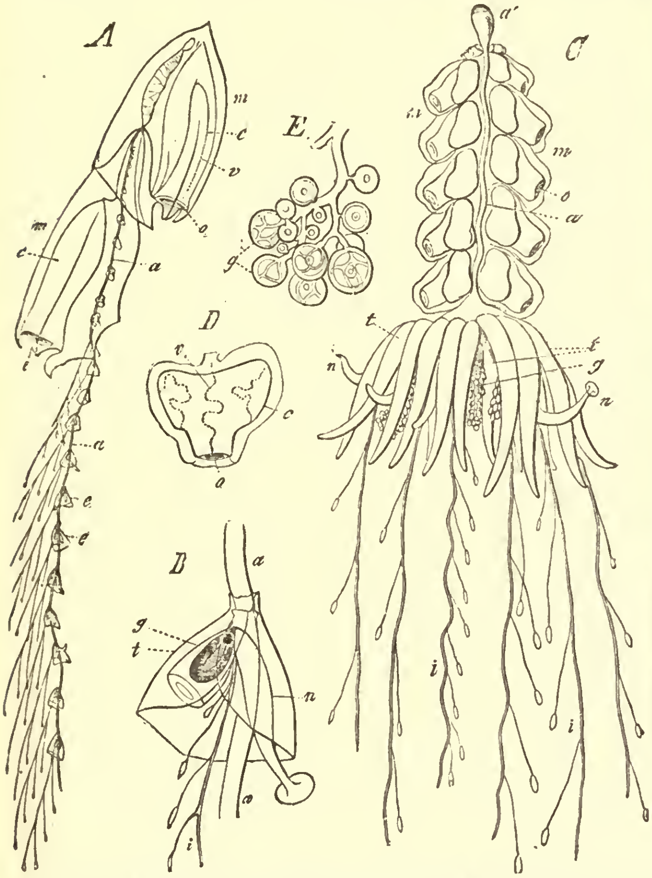


FIG 57.—Floating colonies of *Siphonophora*. *A*, *Diphyes campanulata*. *B*, A group of appendages from the stem of the same *Diphyes*. *C*, *Physophora hydrostatica*. *D*, Separate nectocalyx of the same. *E*, Cluster of female sporosacs (aborted medusæ) of *Agalma sarsii*. *a*, stem or axis of the colony; *a'*, pneumatocyst (air-bladder); *m*, nectocalyx; *c*, sub-umbrellar cavity of nectocalyx; *v*, radiating canals of the umbrella of the nectocalyx; *o*, orifice formed by the margin of the umbrella; *t*, hydrophyllia in *B*, dactylozooids in *C*; *n*, stomach; *i*, tentacles; *g*, sporosacs. (From Gegenbaur.)

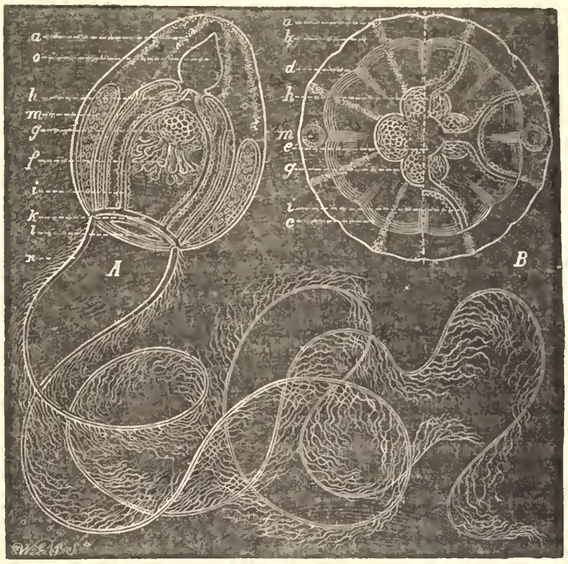


FIG. 58.—*Ctenaria Ctenophora* (Haeckel), one of the *Anthomedusæ*, connecting that group with the *Ctenophora*. *A*, lateral view of the entire medusa; *B*, two horizontal views, that to the left representing the surface of the aboral hemisphere, that to the right a section passing nearly equatorially. *a*, the eight (ciliated?) rows of thread-cells, adradial in position, and corresponding to the eight ctenophoral zones of *Pleurobrachia*; *b*, jelly of the umbrella; *c*, circular muscle of the sub-umbrella; *d*, longitudinal muscles of the sub-umbrella; *e*, stomachal dilatation of the enteric cavity; *f*, the sixteen oral tentacles; *g*, the four perradial generative glands in the stomach wall (manubrium); *h*, the four perradial primary radiating canals; *i*, the eight adradial bifurcations of the preceding; *k*, ring canal in the margin of the umbrella; *l*, velum; *m*, the two lateral tentacle pouches; *n*, the two lateral unilaterally fringed tentacles; *o*, the apical cavity (infundibulum) above the stomach. The canal system, with its four primary and eight secondary rami agrees in *Ctenaria* and *Pleurobrachia*. The mouth of the latter is homologous with the margin of the umbrella of the former. The mouth of *Ctenaria* is homologous with the junction of the so-called funnel of *Pleurobrachia* with its so-called digestive cavity. This last is the homologue of the sub-umbrellar cavity of *Ctenaria*. The apical opening or openings of the funnel of *Ctenophora* is paralleled, by the stalk canal of medusæ, whilst the agreement between the tentacles and their pouches in *Ctenaria* and *Pleurobrachia* is complete.

HYDRUNTUM. See OTRANTO.

HYÈRES, a town of France, in the department of Var and arrondissement of Toulon, about 3 miles from the coast of the Mediterranean. It is connected by a branch line with the railway from Toulon to Cannes, and by diligences with the neighbouring towns. The town proper is situated on the south-eastern side of a steep hill (650 feet high) which forms one of the last buttresses of the Maurettes, a group of picturesque hills covered with olive, pine, and cork trees, and underwood of myrtles and other shrubs. In front, towards the south and south-east, a fertile plain, once famous for its orange groves, and now mainly occupied by vineyards and farms, stretches to the sea, while towards the south-west, across a narrow valley, rises a cluster of low but well-clad hills. The older part of the town, still on its eastern and northern sides surrounded by its ancient and dilapidated wall, is a labyrinth of steep dirty streets; but the new quarters which have grown up at the foot of the hill have handsome boulevards and villas, many of them with beautiful gardens full of semi-tropical plants. Of best note among the objects of interest at Hyères are the house (Rue Rabaton, No. 7) where Massillon was born; the cathedral or church of St Louis, a low building of the 12th century (restored in 1840), which belonged to the Cordeliers; and the ancient castle, crowning the highest part of the hill. The Place des Palmiers takes its name from the seven palm trees planted there in 1834. On the plain between the town and the sea are large nurseries, an excellent jardin d'acclimatation, and the famed kitchen gardens which supply Paris with early fruits and vegetables and with roses in winter. There are extensive salt-beds on the peninsula of

Giens, which juts due south into the Mediterranean, where salt is made by the exposure of the sea-water to the sun. Up to the 14th century Hyères was a larger and more important town than Toulon; and in the 16th century it became famous as a winter resort. Catherine de' Medici at one time thought of making it the seat of a royal residence. At present the more brilliant social attractions of some of the neighbouring watering-places of the Riviera divert the more fashionable visitors from Hyères. In climate it differs little from its more favoured compeers. From the east and north-east winds it is completely sheltered, but it lies open to the ravages of the mistral. The population in 1872 was returned at 5881 for the town and 11,212 for the commune; in 1876 the corresponding figures were 6797 and 12,289. The islands of Hyères (the Stœchades—αἱ Στοιχάδες νῆσοι—of the classical geographers), otherwise called Les Îles d'Or, lie to the east of the peninsula of Giens, and form a protection to the roads of Hyères, one of the great rendezvous of the French fleets. The principal islands are Porquerolles, which rises to a height of 600 feet, Port-cros, and Titan. The population is scanty. A marquisate of the Îles d'Or was created by Francis I.

See Alphonse Denis, *Promenades pittoresques à Hyères*, 1842; Eugène Farenc, *Les récits du touriste Provençal*, 1859; Aufauvre, *Hyères et sa vallée*, 1862; Joanne, *Hyères et Toulon*, 1870; Lenthéric, *La Provence maritime*, 1880.

HYGIENE is the science, PRACTICAL HYGIENE the art, of preserving health. The name has been adopted from the French, from which language it has also been introduced into most other tongues; it is derived from the Greek ὑγίεια or ὑγεία, health. Writings on health are among the oldest in the world, for the subject has engaged the attention of the profoundest thinkers and the most renowned leaders of men. We have only to point to the elaborate directions in the Mosaic laws for the preservation of health through scrupulous attention to cleanliness, the isolation of the sick, and extreme care in the use of wholesome articles of food and drink. Throughout the whole of their history the Jews enjoyed a remarkable immunity from epidemic disease, the most of the instances in which such disease occurred being represented as those in which they departed from the law and doubtless relaxed the wholesome vigilance enjoined by it. In mediæval and modern history they have often, even down to our own time, been spared the ravages of epidemics, when their Christian neighbours were perishing around them. Ignorant superstition often gave rise to the idea that they had poisoned the wells, and they fell victims to the fanaticism of the times. It is highly probable that the periodical cleansing of their dwellings, involved in the thorough search for the leaven which preceded the yearly passover (*Mishna*, Pesachim, i. 11), had a notable influence in preventing that continuous deposition of organic matter, which is no doubt one most powerful factor in the production of zymotic disease. On the other hand, the filthy habits of the Christian populations offered a premium to plagues of every kind; for there is no parallel in ancient history to the terrible invasions of disease which from time to time ravaged Europe down to quite recent times.

It is the province of hygiene to seek out and determine the causes of disease, and to formulate rules for their prevention and removal. It may thus be called also preventive medicine, although this term does not quite express all that must be included. The progress of hygiene, such as it was, rested for many ages upon an empirical basis, and indeed to a large extent this is still the case. The subject has, however, in later times at least, been studied to considerable advantage, although much remains to be done. Two centuries ago the mortality of London was 80 per 1000—at the present day it is under 23. A century ago ships could barely keep the sea for scurvy, whilst jails and hospitals were in many cases the hotbeds of fatal disease; now those conditions are rectified, or at least the means of rectifying them are known. Thirty years ago the English troops at home died at the rate of 20 per 1000—now their death-rate is less than one-half of this. A knowledge of the causes and modes of propagation of disease being necessary in order to provide rules for its prevention, it is obvious that hygiene must be largely dependent upon the advances made in pathology and ætiology; hence the impossibility of any very marked progress in former times, by reason of the imperfection of the collateral sciences, and the want of the appliances more recently made available for inquiries of such a difficult and recondite character. Within this century, however, and especially within the last forty or fifty years, it has been possible to follow out the subject on a more strictly scientific basis, and so to lay a foundation, at least, on which to build a structure, which may one day entitle hygiene to a place among the more exact sciences.

The special subjects which hygiene embraces are the following:—I. Those which concern the surroundings of man; such as meteorological conditions, roughly included under the head of climate; the site or soil on which his dwelling is placed; the character, materials, and arrangement of his dwelling; the air he breathes; the cleansing of his dwelling, and the arrangements for the removal therefrom of excreta and other effete matters.

II. Those which concern the personal care of health; such as the food he eats and the water and other beverages he drinks; clothing; work and exercise; personal cleanliness; special habits, such as the use of tobacco, narcotics, &c.; control of sexual and other passions.

III. Certain points not directly included in the above; such as the management of infancy; the prevention of disease; the hygiene of the sick-chamber; and the disposal of the dead.

It is obvious that it is impossible to draw any hard and fast line in these divisions, and that they must constantly run into and overlap each other. Such a division, however, gives a general idea of the scope of the science, and a brief consideration of the different sections will enable us to furnish a slight sketch of the nature of the subject.

1. *Meteorological* or (so-called) *climatic* conditions. Here temperature and humidity are the two points that obviously present themselves for consideration, but it is very difficult indeed to separate their influence from those of soil or site. It is also certain that much that has been attributed to climate is really due to other causes. It may be laid down as a general principle that, if moderate care be taken, man may preserve his health in almost any part of the world, although it must be admitted that in some places, such as hot and moist climates, disease causes appear to be more easily called into action than under colder or drier conditions. Some diseases, such as yellow fever, appear to require a certain temperature for their development and propagation; others, such as enteric (commonly called "typhoid") fever, appear to exist indiscriminately under any meteorological conditions; others, such as cholera, although undoubtedly originating in hot and moist countries, appear capable of being propagated in most parts of the world. In some cases great heat and dryness arrest disease, as used to be observed in Egypt, where the plague was commonly said to cease after St John's day. During the hot harmattan wind of the west coast of Africa small-pox is arrested, and successful vaccination becomes impossible. To the sick or delicate, meteorological conditions are of great importance, but this part of the subject belongs more to the treatment of disease than to general hygiene. To the healthy, meteorological conditions, however much they may affect personal comfort, are of comparatively little moment as

regards health, so long as reasonable care is observed. In a healthy body an adaptation to circumstances rapidly takes place, and an equilibrium is soon established. Thus, it used to be supposed that great heat increased the temperature of the body, but later observations have shown this to be erroneous, and that the balance is soon re-established by the process of transpiration;—should this, however, be arrested, then a rise of temperature may take place, and disease of a febrile character be established.

2. The *soil* or *site* of the dwelling is, however, of greater moment, and much that has been attributed to climate has been more truly due to locality. Soils are generally divided into moist and dry, permeable and impermeable, and again subdivided according to formation, composition, slope, &c. Healthy soils are those which are dry and permeable, or which have such a slope as renders drainage easy; on the other hand, soils which are flat, moist, and impermeable are generally unhealthy. Soils containing much organic matter are to be avoided, such as alluvial soils generally, as well as all marshy districts. The air in soils is generally more or less impure, hence the unadvisability of occupying dwellings below the ground level or situated immediately on its surface. The water in the soil is a question of great importance, apart from the mere moisture. At varying distances from the surface, but everywhere, there exists a great subterranean lake or sea, known as the *ground-water* or *water-table*, which is constantly in motion, both vertically and horizontally. Its horizontal movement is towards the nearest water-course or towards the sea; its vertical movement is determined by rainfall chiefly. Much importance has been attached to it, and the following points may be considered as accepted by most hygienists :—(1) a permanently high ground-water, that is, within 5 feet of the surface, is bad, while a permanently low ground-water, that is, more than 15 feet from the surface, is good; and (2) violent fluctuations are bad, even with an average low ground-water; a comparatively high ground-water with moderate and slow fluctuations may be healthy. According to the school of Pettenkofer, it is the ground-water which determines the spread of certain forms of disease, such as cholera and enteric fever. A previously high level, succeeded by a fall, with a certain height of temperature in the soil-air, is the condition believed by them to be the one most favourable for disease production. Healthy soils are the granites, metamorphic rocks, clay-slate, limestone, sandstone, chalk, gravel, and sand; unhealthy are—clay, sand and gravel with clay subsoil, alluvial soil, and marsh-lands, with the exception of peatlands. Among the unhealthy soils ought also to be included all "made" soils, particularly those that are formed so often in towns from rubbish of all sorts. Such soils ought not to be occupied as building sites for at least two years.

3. The sanitation of *dwellings* involves numerous points. The site has been considered in the previous section, but the importance of excluding soil emanations must be insisted upon. The placing of a dwelling in any spot of ground tends to exert an extractive force upon the soil, because the air of the dwelling is almost always warmer than the external air, and there is therefore a constant danger of sucking up the more or less impure soil-air into the dwelling. Not only is this a recognized source of disease, but fatal cases of direct poisoning have sometimes resulted, as when coal-gas has escaped into the soil below or near a dwelling. An impervious foundation is therefore necessary, although this precaution is too often neglected, even in high-class dwellings. Houses ought to be so arranged that they may receive plenty of light, not merely for work or convenience, but as a matter of health. Sunlight, for full health, is as necessary as air, and this is now so strongly recognized in America that in many of the hospitals in that country rooms are provided where patients may take a "sun-bath."

The materials of which houses are built are various. Wooden dwellings have advantages, but there is always the danger of fire. Brick or stone is most commonly used, but very good dwellings may be made of concrete or even of mud. Probably the best material is good, sound, well-burnt brick. Dryness must be secured by means of damp-proof courses along the foundations, hollow walls, and cementing or slate-hanging externally. Non-absorbent surfaces internally are important, although some writers, such as Pettenkofer, &c., have been inclined to attribute the unhealthiness of dwellings to the impermeability of the walls obstructing air change. But where air can pass, organic matter can lodge and become a source of danger. It is better, therefore, to have non-absorbent surfaces as much as possible, and to provide for ventilation in other ways. Paint that can be washed is therefore better than paper; if the latter is used it had better be glazed. Care should be taken to scrape off all old papers beneath, as they and the paste used with them tend to decompose and become injurious to health. Ceilings ought to be impervious as well as walls, and floors ought to be made of well-fitting seasoned wood, caulked, and oiled or varnished so as to make them water-tight.

Proper cubic space is a matter of great importance, for upon it depends the renewal of air. The air of an air-space can seldom be changed oftener than three times an hour, hence the space ought to be large enough to allow of such rate of change providing enough of air for respiratory purposes. The furniture of rooms, especially sleeping rooms, ought not to be too massive; whilst curtains and hangings too often form traps for dust and organic matter.

The warming of houses is important, and is generally badly and wastefully done. The open fire-place has great advantages, but it is in many cases insufficient. Where any general system is employed it is better to warm the air in the room itself, as by pipes conveying hot water or steam, than to warm it before delivery. Overheated rooms are a source of ill-health. For sitting-rooms 60° to 65° is quite enough; for a study or work-room 60° is sufficient, even in some cases less than this. A sleeping-room need never be above 60°, often with advantage below it. Fresh air ought not to be sacrificed to temperature, except under extreme circumstances. Dwellings should not be occupied for some time after building, till they are thoroughly dry. Rheumatism, chest diseases, &c., are very apt to arise from neglect of this precaution.

Scrupulous attention to cleanliness is necessary in dwellings, and there is wisdom in their periodical vacation for a certain time, so as to let them lie fallow, as it were, and interrupt the continuity of deposit of organic matter. Dwellings ought to be scattered over as wide an area as possible, for statistics show that sickness and death-rate are often inversely proportional to the amount of area per head occupied by a community. The area per head in London is estimated at double that of Paris and many other cities, whilst at the same time its death-rate is smaller than that of any other large city in Europe.

4. *Air* is the prime necessity of life. Food or water may be abstained from for a considerable time, and we may thus have an opportunity of replacing either should we doubt its purity or wholesomeness, but the atmosphere around us we must breathe or die. Hence the paramount necessity for having it pure. But, although this is apparently so obvious, attention to its importance has been very generally omitted. Air consists of a mechanical mixture of oxygen and nitrogen, in the proportion of nearly 21 per cent. of the former to 79 of the latter, with small quantities in addition of carbonic acid, moisture, organic matter,

&c. By respiration and combustion air becomes vitiated, the oxygen diminishing and the carbonic acid and organic and suspended matter increasing. Within certain limits the amount of carbonic acid is in itself immaterial to health, but it is important as a measure of the amount of organic matter, which is really the dangerous impurity. Air vitiated by respiration is also much more dangerous than when the carbonic acid is partly the result of combustion. It is now pretty generally admitted that air cannot be considered as really good and fit for respiration in which the respiratory impurity reckoned as carbonic acid much exceeds two parts in 10,000 by volume. On the other hand, if air can be kept down to this point, the condition may be looked upon as satisfactory. The amount of impurity given off by living beings varies of course with size, weight, age, sex, and work, but it may be allowed that under ordinary circumstances it amounts to about six cubic feet of carbonic acid per head in ten hours during repose. This requires an hourly supply per head of 3000 cubic feet of fresh air for its dilution, and this amount should be largely increased during work or in sickness (see HOSPITAL). The diseases which have been shown to arise from the effects of vitiated air are widely prevalent, including such as consumption and other forms of scrofulous disorders, bronchitis and pneumonia, sore throat, &c. Crowded and ill-ventilated places also tend to increase the virulence and the rapidity of spread of the various communicable diseases.

5. *Cleansing*, including the removal of slops, excreta, &c., forms one of the most important and also most difficult of questions. The main principle is that all should be immediately and effectually removed from the house and its neighbourhood, and that there should be no possibility of reflux of foul air from drain or cesspool. The system of water-carriage is certainly the cleanest and most convenient, especially among large communities, but other systems find advocates. In villages and isolated houses the earth system and other dry methods have many advantages. The question of the disposal of sewage is a very large one, into which it is impossible to enter here. Hitherto all or almost all the material has been wasted by being poured into rivers or the sea, the streams being thus polluted and the shores rendered offensive. The object to be aimed at is to utilize a product of undoubted fertilizing influence, without endangering the health of the community. The diseases to be apprehended from imperfect methods of sewage removal are enteric fever, cholera, diphtheria, sore throat, and an aggravation of most other diseases, especially those of an eruptive character. Ashpits ought to be especially attended to, their neglect being attended with much danger.

6. *Water-supply*, although included under the head of food and beverages, merits special consideration, so important is its relation to health, both directly as a drink and indirectly with reference to its many other uses. It is required for drinking, cooking, the cleansing of person, clothes, and dwelling, and the flushing of closets, sewers, and drains. The hygienic requirements are that water should be good in quality and sufficient in quantity. Good water should be clear, colourless, quite free from suspended matter, of a good lustre, and should have a pleasant sparkling taste, the latter qualities being due to the carbonic acid and atmospheric air dissolved in it. In its chemical composition it ought to be as free as possible from organic matter. The evidence in favour of communication of disease by means of drinking water is now very extensive, and we may cite diarrhœa, dysentery, ague, enteric fever, and cholera as among the diseases which may be conveyed through this channel. Numerous parasites also find their way into the human body by this means. Hard water is objectionable for cooking and washing, nor can it be recommended for drinking, although some insist upon a certain amount of hardness being essential. In the case of water being impure, boiling, distilling, or filtering may be resorted to. The two former are the most efficacious, but the last has advantages of convenience if properly carried out. Charcoal filters, if properly cleansed, or renewed sufficiently often, are useful, but it is better to have a material that purifies without risking any deterioration of the water itself. Such filters as the spongy iron and the carferal effect this. All filters, however, require the medium to be cleansed or renewed periodically. In a house the chief dangers are from dirty cisterns and from pipes being connected with drains and closets. All supply should be on the constant system, and no pipe supplying a closet should be resorted to for drinking purposes. All overflow pipes should deliver in the open air. The quantity of water required per head may be stated at a minimum of 12 to 16 gallons per diem where there is no general system of drainage, and about 25 gallons with drainage. In towns more than this is necessary, and from 30 to 50 gallons are desirable. In sickness generally double the amount is necessary that is required in health. The source of the water ought to be pure,—springs, deep wells, and upland surface water being the best. Shallow wells and rivers to which sewage gains access are most to be avoided.

7. For *food* and *beverages* the reader is referred to the article DIETETICS.

8. *Work and Exercise.*—The kinds of work performed by man are of course very various, but they may be reduced more or less to a uniform standard, which is usually reckoned as so many tons (or pounds) raised through one foot, or, tersely, as foot-tons or ton-feet. A fair day's work is generally taken at 300 foot-tons, a laborious day's work at 450, and the maximum to be expected, except under very special conditions, at 600. For this work a certain time should be allowed, as the strain increases (almost in a geometrical ratio) with the velocity. Usually speaking 50 foot-tons an hour is a fair amount, and this ratio is equal to a walk of three miles for an average man. The amount for mental work has not been accurately calculated, but it may be safely assumed that a man of sedentary occupation ought to take exercise of a physical kind varying from 50 to 100 foot-tons per diem. In all cases his food ought to be proportioned to his work, for it is now recognized that man is a machine, whose work depends upon the energy derived from the food he eats.

9. *Clothing and Personal Cleanliness.*—Clothing should fulfil the functions of preserving warmth in cold weather, providing covering without being too oppressive in hot weather, keeping out wet in wet weather, and yet allowing sufficient transpiration for health. At the same time it ought to admit of frequent change and cleansing. Dr Parkes has pointed out that it is probably due in some measure to cleaner habits with reference to clothing that the diminution of typhus fever should have been so marked in recent times. Personal cleanliness is also a matter of great importance, a daily general bath being advisable for every one. For animals as well as human beings it has been shown that cleanliness is conducive to improved appetite and general health. Filth is one of the prime factors in the production and propagation of most of the devastating plagues known to mankind.

10. *Prevention of Disease.*—This is a large question, on which we can only briefly touch. Much depends upon our knowledge of ætiology or the remote causes of disease. The best rule for preventing disease is to follow out carefully the principles of general hygiene, laid down with reference to pure air, pure water, proper food, cleanliness, &c. Some diseases may be more specially provided against, such as paroxysmal fevers by the use of quinine, and small-pox by vaccination, but for the great majority of diseases

no such special preventive is known. Some diseases, such as typhus fever and plague, are successfully combated by scattering the population over a large area and inducing the freest ventilation, and to all diseases this plan may be applied with more or less effect. In those diseases which are known to be communicable, such as scarlet fever, isolation of the patients is an effectual means of arresting the spread; but the poisons of others, such as measles and hooping-cough, are so subtle that isolation can only be looked upon as a measure of doubtful success. Much stress has been laid upon *disinfection* as a means of preventing disease, and if properly carried out it has some efficacy. But it is a mistake to place too implicit reliance upon it as ordinarily practised. In dealing with clothing, bedding, &c., the best method is the application of heat, at or above the boiling-point of water, which may be done by means of dry heat, superheated steam, or boiling water. In fumigating places, burning sulphur or the vapour of chlorine or nitrous acid is used, but to be effectual the air must be rendered for the time irrespirable. The solid and liquid disinfectants (so-called) are chloride of lime, the permanganates, carbolic acid, and a great many similar substances, many of which have been made the subjects of patents. A large number of them are merely deodorants. It may be stated generally that disinfectants are useful as adjuncts to other hygienic measures, but that they cannot replace them, except to a small extent, and in a very imperfect way.

11. *Disposal of the Dead.*—The most frequent plan is interment in the earth, but it may well be a question if this be the best plan; it has certainly led to much evil when carried out near habitations. Two other plans have been suggested, viz., burial at sea (suggested by the late Dr Parkes) and cremation. The former is hardly likely to be resorted to, but the latter would be effectual in preventing the evil consequences of ordinary interment. At the same time the danger that it might too effectually conceal much secret crime has to be taken into account.

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HYGINUS, Caius Julius, a native of Spain, and the freedman of Augustus, by whom he was made chief of the Palatine library. He is said to have fallen into great poverty in his old age, and to have been supported by one C. Licinius. He was a voluminous author, and his works included topographical and biographical treatises, commentaries on Cinna and on Virgil, and disquisitions on agriculture, bee-keeping, and the military art. All of these are lost. But there have come down under his name two school treatises on mythology, which have produced much discussion. They are entitled (1) *Fabularum Liber*, containing 277 mythological legends, and valuable for the use made of the Greek tragedians; and (2) *Poeticon Astronomicon Libri IV.*, an astronomical treatise of little value. Both are abridgments; both are by the same hand; but from the "tyro-like mistakes" in both they have been thought unworthy of the librarian of Augustus. It is not, however, impossible that they are early compositions of his, written before he had gained full command of the Latin language. A suggestion has also been made (Bursian in Fleckeisen's *Jahrbuch*, xciii. p. 773) that a work of Hyginus, named *Genealogiæ*, was abridged by a grammarian of the latter half of the 2d century, who appended a treatise on the whole mythology arranged according to mythological views. This text-book, retaining the name of Hyginus, would be used in the schools, and would be from time to time altered and augmented. But in these, as in the many other opinions that have been advanced, there is nothing beyond conjecture.

HYGINUS (surnamed Gromaticus, from *gruma*, a surveyor's measuring rod), a writer on land surveying and castrametation, who flourished in the reign of Trajan (98–117 A.D.). There survive fragments of a comprehensive treatise *De munitionibus castrorum* or *De castrametatione*, and of a work *De limitibus constituendis*, which may be found in Lachmann's edition of the works of the Roman Gromatics (1848), i. 108–134.

HYGROMETRY. In the British Islands all are familiar with the arid character of the east winds of spring, and not a few are only too painfully aware of the discomfort experienced while under their influence; and all are likewise familiar with the opposite state of the atmosphere, most frequently and unmistakably occurring also with east winds, when every object feels damp and clammy to the touch, and horses on the streets are seen each with a steaming cloud of dense mist around it. In certain other climates, such as are met with in India and South Africa, these effects are greatly intensified, so that on the one hand the ivory scales of thermometers, quill pens, and other objects curl up, articles of furniture open at the joints and split up, and the grass which covers the soil is reduced to a state of tinder; and on the other hand, everything becomes so permeated with moisture that, even in the interior of houses, furniture, books, and wearing apparel become sodden with wet. These different effects depend on the states of the air as regards the quantity of aqueous vapour diffused through it taken in connexion with the temperature, these varying from the completest possible saturation of the air, which is of occasional occurrence in the rainy season of some tropical climates, to that extreme desiccation of the air which sometimes happens in Great Britain in spring, but more completely and frequently in such dry summer climates as that of the Punjaub.

A large number of substances, such as sugar, flour, and bread, possess the property of absorbing moisture, and most gases, as well as air, absorb and retain aqueous vapour. The term *hygrometry* is employed to signify the measurement of the degree of dampness of substances, and to denote the processes by which their humidity is ascertained. The term, however, may be considered as restricted to the humidity of the atmosphere, owing to the paramount importance of that branch of the subject, and the slight and unsatisfactory knowledge we yet possess of the laws of hygrometry of other substances.

All organic substances contain pores for the conveyance of their juices, and are influenced by the accession of moisture, some of them very markedly so. Every species of wood is liable to these hygrometric changes, the amount of contraction and expansion being much greater across the grain of the wood than lengthways. Hence the panels of doors are fitted into grooves so as to allow of shrinkage, for, if secured at the edges, the panels must inevitably split. The hair of animals is also eminently hygrometric, curling and uncurling as the air becomes drier or moister, and it is because of the peculiar sensations accompanying these hygrometric changes that the cries and behaviour of many of the lower animals furnish valuable prognostications of weather changes. Similarly many manufactured objects, such as paper, cordage, &c., vary in weight, bulk, form, and elasticity with the varying degrees of humidity of the air, and other interesting prognostics have been drawn from these hygrometric changes.

In the earlier stages of the investigation of the hygrometry of the air, the hygrometric properties of several substances were made use of as instruments of observation. Of these may be named the twisted Indian grass (*Oobeena*

Hooloo), employed by Captain Kater on account of its remarkable property of twisting and untwisting according to the dampness of the air; a slip of whalebone cut across the fibres, used by De Luc; and the hygrometer of Saussure, which was formed of a hair from which the oily matter had been previously removed, and which stretches when moist and contracts when dry. Experience has, however, shown that none of these hygrometers are satisfactory instruments, seeing they give inconsistent results, and are liable when in use to great and uncertain changes. Hence, while they serve to give the roughest idea of the state of the air as regards moisture, they have fallen into disuse as accurate instruments of observation of the hygrometry of the atmosphere. But in the intensely cold climates of Russia and Siberia, the hair hygrometer still continues to be used as an instrument of observation; and when we consider the tediousness and difficulty of making hygrometric observations with the hygrometer in most general use when the temperature of the air descends below the freezing-point of water, the hair hygrometer should perhaps be considered as good an instrument as is available to put into the hands of ordinary observers in times of low temperature.

The most accurate hygrometers are those which are constructed, not as the above, on the principle of absorption of vapour, but on the principles of condensation or evaporation. The well-known fact that the temperature of a wet body is lower than that of a dry one when under the same atmospheric conditions was applied by Sir John Leslie to measure the humidity of the air. Leslie's hygrometer (fig. 1), which is an adaptation of his differential thermometer, is formed by uniting two tubes having a ball blown on the end of each, into which some coloured sulphuric ether has been previously introduced. When both bulbs are at the same temperature, the fluid stands at the zero of the scale, but when one of them is covered with wetted paper or muslin the instrument shows the depression of temperature of the wetted bulb. In order to ascertain the quantity of moisture corresponding to the reading of a Leslie's hygrometer, we must deduct from the total quantity of moisture which the air of the temperature at the time of observation is capable of holding the deficiency due to the degree of cooling shown by the hygrometer.

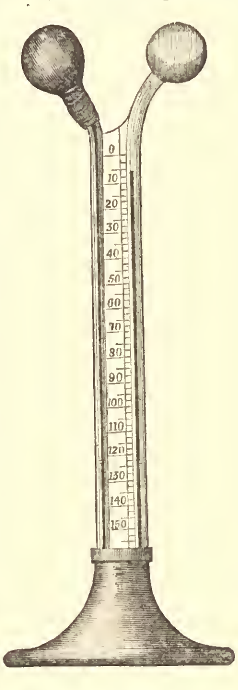


Fig. 1.—Leslie's Hygrometer.

As no air is ever absolutely dry, but contains more or less moisture, it is evident that if any mass of air be cooled sufficiently it may be made to deposit its moisture. A familiar example of the condensation of vapour is seen in the formation of dew on a tumbler filled with cold water and brought into a warm room. This dew is caused by the deposition of moisture from the air in contact with the cold surface of the glass, which is cooled down below the point of saturation. The temperature of the glass at the instant dew begins to form on its surface is termed the dew-point, which corresponds with the point of saturation of the air.

Daniell's and Regnault's hygrometers are constructed on the principle of this simple phenomenon, various contrivances being used for lowering the temperature quickly to any point that may be desired, and for observing with requisite precision the temperature at which the dew begins to form. In both cases ether is employed to lower the temperature.

Daniell's hygrometer consists of a glass tube bent at right angles at two points with a bulb at each extremity, one bulb being of black and the other of clear glass, the latter covered with muslin. The liquid within the bulbs is ether, which at the time of being sealed is made to boil for the purpose of expelling the air. If the temperature of the two bulbs be made to differ from each other, all the ether is transferred from the warmer to the colder bulb. In making an observation the whole of the ether is first transferred to the black bulb, and ether is then dropped on the muslin covering outside the clear bulb. This ether quickly evaporates, and in doing so rapidly lowers the temperature of the clear bulb so that the ether inside the black bulb distils over into the clear bulb. The result is a lowering of the temperature of the black bulb, and, as soon as this falls to the temperature of the dew-point of the air where the experiment is conducted, a ring of vapour begins to be formed outside the black bulb, more or less dulling its surface. At this instant a thermometer placed inside the tube with its bulb immersed in the ether filling the black bulb is read, and the reading gives the dew-point of the air at the time.

Regnault's hygrometer is a little more complicated than Daniell's, but its indications are much more trustworthy. It consists (fig. 2) of a glass tube or capsule A, having on the bottom and a little way up a highly polished silver surface, and closed by a cork with two holes. Through one of these holes the stem of a thermometer B passes, having its bulb at the bottom of the silvered capsule, while through the other hole passes a narrow metallic tube C, one end of which opens close to the bottom of the capsule, and the other end may, if desired, be connected with an aspirator or air-pump. In making an observation as much ether is introduced into the capsule A as will cover the bulb of the thermometer, and then by transmitting air through the tube C the ether vapour is withdrawn from the capsule A through another tube D. By this means the temperature of the ether is very rapidly reduced, and since the whole mass of the ether is agitated by the air-bubbles which rise through it from the bottom of the capsule, the cooling of the ether is equal throughout. The thermometer is then read quickly, but to ensure an accuracy to the tenth of a degree a second and a third experiment, conducted more slowly, should be made. As showing the rapidity with which observations can be made with this hygrometer, Henry F. Blanford on one occasion made six observations in six minutes in the dry climate of Secunderabad, when the temperature of the air was 93°, the dew-point 51°, and the relative humidity consequently 24°. The temperature of the air at the time of observation may be ascertained in the usual way, or by means of the thermometer E, if care be taken that its temperature is unaffected by the proximity of the person of the observer.

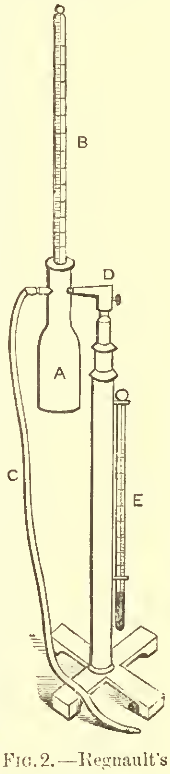


Fig. 2.—Regnault's Hygrometer.

Owing to the expense and great trouble attending the use of hygrometers which give the dew-point directly by condensation, another hygrometer has come into extensive use by which the dew-point is determined indirectly by evaporation. This is August's hygrometer, sometimes called

Mason's hygrometer, but more generally known as the dry and wet bulb hygrometer, which has the strong recommendation of being self-acting, and requiring only the readings of the two thermometers in making air observations. This hygrometer (fig. 3) consists of two thermometers *a* and *b* similar to each other in all respects except that one of them has a piece of muslin tied closely over the surface of its bulb *c*, and kept constantly wet by a few threads of cotton which connect it with the water in the vessel *d*. The water then which rises from the vessel by capillary attraction spreads over the muslin, and evaporates from its surface with more or less rapidity according to the dryness or moistness of the air; and the greater the dryness of the air the greater is the difference between the observed readings of the dry and the wet thermometers.

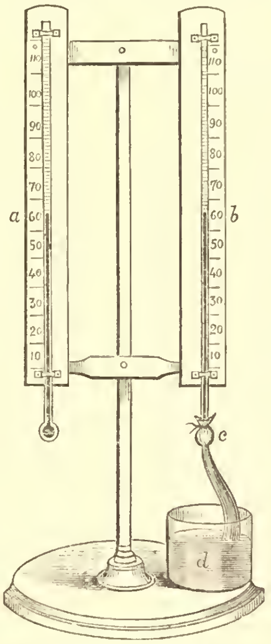


Fig. 3.—Dry and Wet Bulb Hygrometer.

The formula for deducing the hygrometric state of the air from these two observations has been investigated by Professor Apjohn (*Trans. Roy. Irish Acad.*, vol. xvii.), and has been already described (see Atmosphere, vol. iii. p. 32). As it is very troublesome to go through the calculations for each fresh observation, tables have been prepared which give the dew-point by inspection. The best of these tables in English measures are those of Glaisher, fifth edition, constructed empirically from direct experiments carried on at Greenwich, combined with Regnault's last revised tables relating to aqueous vapour. There can be but one opinion as to the great service rendered to meteorology by Glaisher in the preparation of these tables, which give results approximately correct for high and moderate humidities and for situations at no great height above the sea; in other words, they may be regarded as accurate for at least such conditions as are presented by the climates of the British Islands. They are, however, insufficient, owing to the comparatively large errors attending their use, for the reduction of observations made in elevated situations and in such arid states of the atmosphere as are of frequent occurrence in India and South Africa. The preparation of such tables remains still a serious desideratum in meteorology; and another desideratum equally important is the introduction of a simple, handy, and accurate method of observing the hygrometry of the air when its temperature descends below the freezing-point of water, some method which would involve only a minimum of manipulative skill and trouble in making an observation. See Atmosphere. (A. B.)

HYMEN, or Hymenæus, was originally the name of the song sung at marriages among the Greeks. As usual the name gradually produced the idea of an actual person whose adventures gave rise to the custom of this song. He occurs often in association with Linus and Ialemus, who represent similar personifications, and is generally called a son of Apollo and a Muse. In Attic legend he was a beautiful youth who, being in love with a girl, followed her in a procession to Eleusis disguised as a woman, and saved the whole band from pirates. As reward he obtained the girl in marriage, and his happy married life caused him ever afterwards to be invoked in marriage songs. At other times the tale is of an opposite character; Hymen was unfortunate either by dying on his marriage day or in some other way, and he was invoked to propitiate him and avert a similar fate. He occurs often in the train of Aphrodite, along with Eros, Himerus, Pothus, &c. According to Orphic legend he was restored to life by Asclepius.

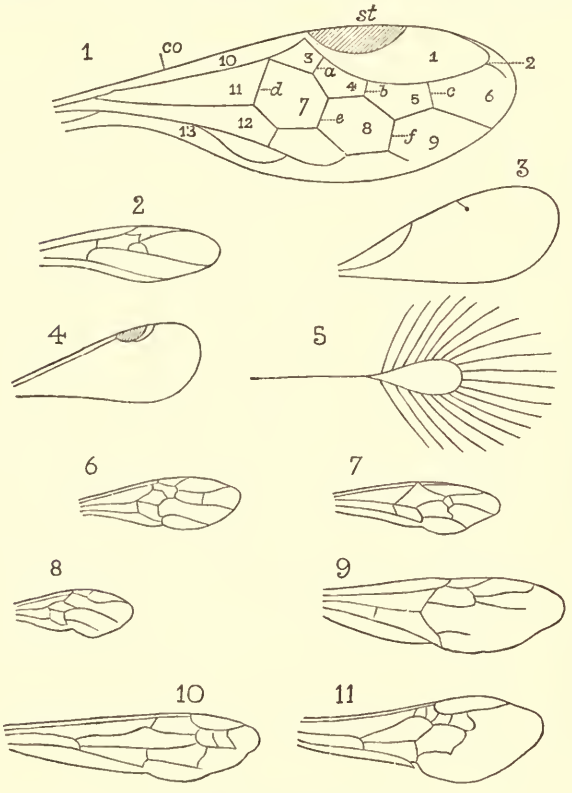
HYMENOPTERA (the *Piezata* of Fabricius, *Hautflüger* or *Aderflüger* in German), an order of *Insecta* (so named from their wings being joined, as hereafter described) containing the insects commonly called bees, wasps, ants, ichneumons, gall-flies, saw-flies, and others less known which have received no English names. The main characteristics of the order are these:—the possession of four wings, of which the anterior are always larger than the posterior, always of the same texture, and mostly with nervures arranged in regular patterns; a dense hard skin, smooth, shining, or very hairy; a mouth always provided with mandibles adapted for biting, though the other mouth parts may be so modified as to serve for mastication, or for the sucking, or rather lapping, of liquids. The female is provided with an anal instrument connected with oviposition, and sometimes serving for defence, in which case it is in communication with a poison gland. They undergo a regular transformation, and have larvæ provided with legs on the thorax and abdomen, or on the former part only, or (as is more often the case) entirely footless.

General characteristics.

The wings have few nervures, and may be even entirely devoid of them; when present they proceed from the base of the wing, or from the costa (the part which bounds the wing in front) towards the apex, which they may or may not reach. Connected with the lateral nervures are others (recurrent nervures) which unite them together, and form in this way regular cellules. The first two lateral nervures (those nearest the top) are the most important, and are called the "marginal" and "submarginal" respectively. The cellules which they form by means of the cross or recurrent nervures are called the "marginal" and "submarginal cellules." Not unfrequently there is, towards the apical third of the costa, a thickened spot (considered by some to act as a counterpoise when the insect is flying) termed the "stigma" or "pterostigma." It is not always present, however, and when present may be very small, or, as in *Pachylostica*, very large and projecting. In a similar way the hind wing may contain lateral and cross nervures, but they are fewer in number and in importance, and may be entirely absent, although present in the larger pair. The arrangement of the nervures in the *Hymenoptera* undergoes, in the various families, great diversity; and, what is of great importance in classification, their form, in the different families, and even genera, is, within certain limits, remarkably constant. On this account great attention has been paid to them; and each nervure and cellule has received a distinct name. The use of the nervures and cellules does not lead to the formation of artificial groups; for we find that the existence of a particular arrangement of the nervures in a hymenopterous insect denotes the presence of other characters. Each family indeed has its own form of wing, as will be seen from the accompanying figures. The relative value, however, of the neuration in classification is not always the same. It is of much greater importance, for instance, with saw-flies than with bees. The wings are usually shorter than the body, and may be so short as to be useless for flight; they may be even entirely absent. Apterous species are found in almost all the families. In most cases it is the females only which are thus deprived of the power of flight. But the opposite of this may exist; as, for instance, with a curious species of *Chalcididæ* which lives in the nest of bees as a parasite. With ants, again, the neuters are always wingless; and the females lose their wings when they commence the formation of a colony. It is worthy of remark, too, that some *Chalci-*

Wings.

didæ and *Oxyura*, which are normally winged, occasionally appear in an apterous or semi-apterous condition. On the anterior margin of the hind wings are placed a number of very minute hooks, which fit into a thickened rim on the posterior margin of the front wings, so that the two become united, and strike the air as one whole. The wings are usually transparent, and, in certain arrangements of the light, are seen to be highly iridescent. Occasionally they are coloured in patches, or are entirely black or blue; in the latter case, they are not unfrequently of a thickish texture and have a metallic lustre, as, *e.g.*, in *Hylotoma*. The smaller forms (*Chalcididæ* and *Oxyura*) have few or no nervures. Some of these have the wings deeply fringed;



Wings of Hymenoptera.

1. Tenthredinidæ (*Hylotoma*)—1, marginal; 2, appendicular; 3, 4, 5, 6, submarginal; 7. 8, 9, discoidal; 10, costal; 11, 12, branchial; and 13, lanceolate cellules; *a*, *b*, *c*, submarginal nervures; *d*, basal nervures; *e*, *f*, recurrent nervures; *st*, stigma; {*co*, costa. 2. Cynipidæ (*Cynips*). 3. Chalcididæ (*Perilampus*). 4. Oxyura (*Codrus*). 5. Oxyura (*Mymar*). 6. Braconidæ (*Bracon*). 7. Ichneumonidæ (*Trogus*). 8. Chrysididæ (*Cleptes*). 9. Formicidæ (*Formica*). 10. Diploptera (*Vespa*). 11. Anthophilia (*Apathus*).

and *Mymar* and *Flabrinus* have the wings as it were cleft and stalked; that is to say, there is a long, thin stalk projecting from the thorax for a certain distance; then it dilates into a number of deeply fringed branches (see fig. 5).

Head. The head is seldom broader than the thorax. It is usually of a more or less globular shape, but may be much flattened and long. The compound eyes are placed along the sides, while the simple eyes, or ocelli, are arranged in a triangle on the vertex. Certain ants and *Chalcididæ* are blind. Others have eyes, but want the ocelli. The mouth organs are, except with bees, adapted solely for mastication or for prehension; while, in addition to performing these functions, wasps use them for building up or digging out their nests in the ground or wood. Some worker ants and other aculeates (especially males) have the mandibles enormously developed. *Blastophaga*, an insect found in figs, has a curious mandible, remarkable, not in itself, but by having attached to it an appendage whose use is supposed to be to clean away the juice of the fig from the mouth. The maxilla and labium are provided with jointed palpi. The number of joints in the maxillary palpi is usually five, but may be more or less than that; the labial palpi are two- to four-jointed. It is with bees that the mouth parts (and especially the ligula) have their greatest development and specialization. With them the various parts (except the mandibles) are elongated to form a sucking tube, by means of which they lap up the nectar of flowers.

The form of the antennæ is very variable. They may Anten have three (*Hylotoma*) to sixty joints (ichneumons); may be very long and thin as in ichneumons, or scarcely projecting beyond the head as in *Perga*; of uniform thickness, or distinctly clavate as in *Cimbex*; bare, or very hairy. Then they often differ very much in the males. *Lophyrus* (*Tenthredinidæ*) and many *Chalcididæ* have them pectinated in various degrees; they are deeply forked in *Schizocera*; and many others have them covered with long hair, although they are quite bare in the other sex. In some families the number of joints varies very much, but most *Aculeata* have the same number, namely, 13 in the male and 12 in the female. These appendages serve as sense organs, especially for the discovery of food, and, in the male, for finding the female. At any rate an ichneumon (for instance) when searching for a larva in which to lay its eggs (and this has especially been noticed with those which oviposit in concealed larvæ) keeps them in a state of continuous trembling motion, and males have also been observed to do the same when searching for the females.

The three divisions of the thorax—pro-, meso-, and meta- Thora thorax—have pretty much the same relative proportions in all the families. The prothorax is small. The upper part is strongly articulated to the mesothorax, while the lower is freer; and it is by means of this lower part that the head is united to the thorax. The metathorax is very large, as might be expected, from its having to take such an important part in flight. As for the scutellum it varies more than any other portion of the thorax. Mostly it is flat, or at least only slightly raised above the mesonotum; but in the smaller groups (*Oxyura*, *Chalcididæ*, *Cynipidæ*) its form is sometimes very curious. In *Ægilips* (*Cynipidæ*) and *Agriotypes* (*Ichneumonidæ*) it is produced into a sharp more or less curved spine; in *Eucœla* it is cup-shaped, that is to say, it is raised up, and has the centre hollow. It undergoes, however, its greatest development with some *Chalcididæ*. In *Chirocerus*, for example, it is lengthened so much that it reaches the middle of the abdomen. The metathorax is never very large, nor does it exhibit any marked peculiarities.

The legs show the same manifold diversity in form that Legs. we found to exist with the other appendages. The basal parts—the coxæ and trochanters—are not usually of any size, except in the lower tribes, *e.g.*, *Chalcididæ*. In classification the trochanters are of value, for we find with the *Aculeata* they are joined to the femora by a single joint, whereas in all the other *Hymenoptera* there are two joints. Hence the bees, wasps, &c., form the division *Monotrocha*; and the ichneumons, saw-flies, &c., are denominated *Ditrocha*. Some *Chalcididæ* have the femora greatly thickened, and toothed on the under side;[1] but as a rule it does not show any striking peculiarity unless it be with some male insects. As might be expected from their more intimate connexion with the habits of the insects, the tibiæ and tarsi vary according to the uses they are put to, apart from locomotion. With bees (at least with the non-parasitic species) they are employed to carry the pollen necessary for the nourishment of the young; for this purpose they are

[1] The enormous development of the hind femora in *Chalcis* and *Leucaspis* does not appear to give these insects extra leaping power. Other *Chalcididæ* which have not thickened femora can leap considerable distances.

provided with hairs, or the apex of the tibiæ and base of the tarsi are flattened out to form a plate on which the pollen is stored for its easier and more economical conveyance to the hive. They are richly spined in the sand-wasps, and are thus useful to the animals in digging out the nests which they form in the earth. At the base of the tibiæ are placed two spurs (calcaria), which, however, may be absent. Finally the tarsi are provided with plate-like processes termed patellæ, which may be very largely developed, especially with males; and the front pair may terminate in large jointed raptorial claws, as is the case with *Chelogynus* (*Oxyura*).

men. The abdomen may be united to the metathorax in two ways: it may be joined to it by its entire width, or by a narrow pedicle only. In the former case the thorax and abdomen form as it were one whole, so that the body has the appearance of being composed of only two parts; whereas in the other section the three divisions, head, thorax, and abdomen, are clearly separated, or specialized. It is only the *Siricidæ* and *Tenthredinidæ* which have the abdomen united by the whole width. Thus the order becomes divided into two well-marked divisions, one represented by the *Tenthredinidæ* (having the abdomen sessile) and the other by the *Aculeata*, *Ichneumonidæ* (having it appendiculated). The abdomen shows little variation in structure or form in the *Tenthredinidæ*; but does so to a large extent with the others. Usually more or less globular and rounded, and not of any great length compared to the head and thorax, it is often very much compressed and sabre-like, as in *Ophion*, or very long and thread-like as in *Pelecinus*; then it may be joined to the thorax in such a way as to be semi-sessile, or by a very long, thin, thread-like pedicle (*Pelopæus*, many *Chalcididæ*, and *Cynipidæ*). Between these two extremes there are all gradations, the form of the abdomen depending on the habits of the insect, upon its manner of self-defence or of oviposition. As regards the number of the segments, it varies. It is 8 with the *Tenthredinidæ* and with the *Siricidæ*, but in other groups it is less. Through one or other of the basal segments being greatly developed, and the terminal ones correspondingly reduced in size, some groups appear to have only 3 or 4 (*Chrysididæ*). The *Aculeata* have always the same number, namely, 7 in the males and 6 in the females. Some bees (*Cœlioxys*) and *Chrysididæ* have the abdomen armed with spines or teeth at the apex.

pro-ctive ans. The male and female organs are situated at the end of the abdomen. They are rarely conspicuous externally with the males; but in some females they are of great length, and may indeed exceed considerably the length of the body. However different in the various groups of *Hymenoptera* the organs connected with the laying of the eggs may be, they are fundamentally constructed on the same plan in all of them, no matter how different they may appear or how various the ways in which they may be used. A typical ovipositor in the *Hymenoptera* may be described as being composed of three bristle-like organs,—one placed above, and the others below. This upper bristle is channelled throughout, and has (when in use) the others pressed to it in such a way that the three together form a narrow tube, through which the egg passes. The two lower bristles are toothed at the lower end. These three parts are enclosed between a couple of two-jointed valves, situated at their base, which serve them as supports. Thus the ovipositor consists of five different parts. It exists under two forms. In the bees and wasps (*Aculeata*) it takes the form of a sting, or weapon of defence; and it is connected with a gland secreting a poison (the principal constituent being formic acid) which the insect injects by means of the sting into any thing that attacks it. Besides this defensive (or offensive) use to which it is put, it is employed by the sand-wasps to benumb the larvæ and other insects or spiders with which they store their nests for the use of their young, in such a way that they remain to all intents and purposes lifeless, yet still keeping fresh, until such time as the wasp-larvæ escape from the eggs and are ready to feed on them. In the rest of the order—with ichneumons, saw-flies, &c.—it is not used as an instrument of defence (some ichneumons, indeed, will attempt to pierce the hand with it when caught, but they are never able to do any harm); it is simply an instrument for laying the eggs, and is not connected with a poison gland, or at any rate with a gland secreting a poison similar to that of a wasp. A poison gland exists, for instance, with saw-flies, but its purpose and also the manner of its use are different from what they are in the case of the aculeates. Its function is to act on the plant in which the eggs are laid,—either to raise galls in which the larvæ will find food and shelter, or to prevent the hole made by the ovipositor for the reception of the egg from closing in on the egg, and thereby crushing it; for we find that eggs laid, for example, on leaves are not closely pressed by the substance of the leaf, but have a more or less open space surrounding them.

From the observations of Kraepelin on the development of the ovipositor, it seems clear that the grooved central bristle and the two basal sheaths arise in the larva from papillæ situated on the under side of the ninth abdominal segment, while the two lateral (or rather lower) bristles have their origin in similar papillæ on the eighth. It would appear also highly probable that the parts are true appendages of the abdominal segments, rather than modified portions of the body walls.

The ovipositor is either hidden (as is mostly the case) or may be exserted to a greater or less extent. Its length varies with the habits of the species; that is to say, the longer it is, the deeper, in wood, or in any other substance, does the larva, on which the ichneumon is a parasite, live. Species with long ovipositors occur in all the parasitic families, except the *Oxyura* and *Chrysididæ*. With the last-mentioned family it is tubular. It is strangely modified with the saw-flies. With them it forms a veritable sawing apparatus (hence the name of these insects), being broad, plate-like, and toothed in various ways and degrees according to the habits of the insects; according as the eggs are laid in leaves or in bark it is slender and thin or broad and thick. In the pupa state *Hymenoptera* with long ovipositors have them curled up on, and closely pressed to, the back. It is a curious circumstance that this embryonic condition of the ovipositor is retained in the perfect state by a few forms, as, *e.g.*, *Leucaspis*.

As remarked at the beginning of this article, the *Hymenoptera* go through a regular metamorphosis—appearing in four distinct forms. The egg is generally longer than it is broad, and rounded at both ends. The skin is always thin, never sculptured, and rarely coloured; the only instance of colour in any of their eggs known to the writer being in those of certain saw-flies which are more or less greenish, and this colour may have been imbibed from the leaf. Many parasitic species (*Ophion*, *Cynips*, *Mymar*) have pedunculated eggs,—eggs provided with a long pedicle or stalk, by means of which they are attached to the plant or insect, as the case may be. A *Tryphon*, for example, attaches her stalked eggs to the larva's skin; it hangs by the stalk; and when the young tryphon-larva's development in the egg is matured it leaves it by the lower end, and then proceeds to bore its way into the inside of its victim. A curious phenomenon has been observed to take place in hymenopterous eggs shortly after being laid; it is that they swell up (perhaps by imbibing moisture, although this cannot be the sole cause of the swelling) to double or more than double the size they were when laid. The number of eggs laid by a female varies of course with the species. Colonial species lay the greatest number; but with them the eggs are not laid all at once, as is the case with solitary species. Some social forms lay comparatively few eggs, while, on the other hand, many saw-flies and ichneumons must lay some hundreds. Solitary bees and wasps do not lay many; but it must be remembered that the storing of food and the building and digging of the nest are works of labour and time. Metamorphoses. The egg.

The larvæ. The larvæ are of two sorts. Those of species with a petiolated abdomen are white, footless grubs, incapable of any extended motion; nor is this necessary, for they have not to seek their food, which is provided for them by their mothers,—either collected and stored up for them in nests made by the female, as with bees and wasps, or by the eggs being placed in the bodies of other insects on which they live as parasites, or in galls upheaved on plants. It is, however, of interest to note that, while the larva after leaving the egg shows no trace of legs, yet they were present when it was in the egg. This shows clearly that the legs were lost through disuse. And this view is confirmed by the fact that the larvæ of the lowest division of the *Hymenoptera*, those with a sessile abdomen, have jointed thoracic legs, and often abdominal legs as well, while they, for the most part, lead a free existence. In the lowest group of this division, the *Siricidæ*, as well as in those *Tenthredinidæ* most nearly allied to them, the larvæ have only the thoracic or true legs. They live either boring in wood, as *Sirex*, or in stems of plants, as *Cephus*, or in leaves rolled together by silken threads, as *Lyda*. Except *Lyda*, *Cephus*, and *Xyela*, all the saw-fly larvæ have the usual thoracic and a variable number of false or abdominal legs, which are in fact merely prolongations of the ventral surface of the body, as with many phytophagous *Coleoptera*; nor have they anything like the claspers of lepidopterous caterpillars. With their similar habits and the presence of these ventral legs, saw-fly larvæ have a considerable resemblance to the caterpillars of *Lepidoptera*, but they may be known from them in two ways,—by always having more than five pairs of ventral legs (eight in *Cimbex*, seven in *Nematus*, and six in some *Hylotomides*), and never having more than two ocelli—one on each side of the head—instead of six on each side as in *Lepidoptera*. As with lepidopterous caterpillars, green is the prevailing colour of saw-fly larvæ. They agree with them, too, in their general habits: they live on the leaves of various plants, devouring them in different ways, roll down leaves, raise galls, and mine leaves. It is interesting to note further that, as with lepidopterous caterpillars, larvæ which are innoxious and eaten by birds are either entirely green, or green with black, pink, or white stripes along the sides and back, while noxious larvæ—those with bad smells or secretions which render them unpalatable to birds—have bright contrasting colours with irregular markings, tubercles, &c., and they feed exposed, so that they may be readily seen and avoided. Some hymenopterous larvæ before becoming pupæ moult a certain number of times. According to Packard, a *Bombus* casts off its skin ten times; *Tenthredinidæ* do it five times; but many (all parasitic, and most aculeates) do not moult until they become pupæ; nor do they empty the contents of the stomach till then. The period during which a hymenopteron remains in the larva state is seldom long; it may be eight or nine days, or a month or two, but this depends on the season of the year; for many larvæ, which have not been able to reach maturity in the autumn, remain in the same condition until the following spring, when they pupate. In order that this period may be passed in quietness, a cocoon is usually spun by the larva. For this purpose it is provided with a spinning apparatus, and a gland for secreting the silk required for the construction of the cocoon. With the *Aculeata* it is thin and almost transparent; it is of a firmer consistency with ichneumons, and is often coloured black, brown, or grey. *Microgaster* and other *Braconidæ* spin their cocoons in company, and often around the dead body of the larva which they have devoured. They may be placed together without any regularity, or closely pressed in regularly arranged rows like the cells in a hive. Some ichneumons suspend their cocoons from twigs, &c., by means of a silken thread. Generally the cocoon is single, but certain saw-flies (*e.g.*, *Cimbex*) spin double ones,—a thin inner one (which may be separated from the outer one by a considerable space) placed inside an outer, harder, and more tenacious covering. A cocoon, however, is not always spun. *Cynipidæ* never spin one, nor apparently do *Chalcididæ* nor some ants, *e.g.*, *Myrmica*. The empty skin of the caterpillar which they have devoured is utilized by some ichneumons instead of a cocoon; galls serve the same purpose with others; while *Emphytus* and other *Tenthredinidæ* bore into pithy stems, where they pass into pupæ without any other protection. Finally, others make a cell in the earth for the same purpose.

The pupa. The pupa resembles very closely the perfect insect, save that the wings are not developed, although visible as pad-like structures along the sides. The legs and antennæ are laid along the front of the body, enclosed in thin pellicles. In certain *Chalcididæ* (*Eulophus*) the pupa is of that form called "coarctate"; that is to say, the entire body is enveloped in a case which conceals its form, and this case is hard and of some thickness, instead of being a mere thin transparent skin. When the insect leaves this pupal covering the latter retains its form intact. Most pupæ are white. Many saw-fly pupæ are green, with orange spots on the abdomen. A few *Braconidæ* (*Apanteles*) have orange-coloured pupæ.

In the pupa state *Hymenoptera* remain but a short time,—as a rule, not more than seven to ten days. They are not entirely quiescent in this condition, but have considerable power of motion, especially if exposed to the light, or disturbed in any way. As the insect gradually reaches maturity, the pupa becomes more or less black,—at first on the back of the thorax, then on the abdomen and limbs. When maturity is gained, the insect splits the pellicles which so closely envelop its body; the limbs are freed; the wings spread out and lose their flabby consistency; the nervures become hard and firm; the insect moves about, ejects from the anus a coloured liquid, and enters on its new mode of existence.

The sexes. Hymenopterous insects procreate by the union of the two sexes. This takes place usually in the sunshine. Sometimes the connexion does not last more than a few seconds, and is not preceded by any preliminary courting. On the other hand many bees remain united for hours, and the genital parts of the male get torn and ruptured, so that it dies immediately after. Some species of *Chalcididæ* have been observed coquetting together for more than an hour before uniting. Generally copulation takes place on the ground; but a few forms pair on the wing. The male *Anthophora*, for instance, carries the female with him into the air for the marriage flight. This is the reason why the male *Anthophora* is larger than the female, instead of being smaller, as is usually the case.

While, as has been said, *Hymenoptera* reproduce by the union of the two sexes, yet parthenogenesis or virgin reproduction is of not uncommon occurrence, and has been observed in all the families whose development for more than one generation can be traced with sufficient facility and accuracy. We meet with this phenomenon under (broadly speaking) two or three phases. Many females, if they cannot get access to males, will readily lay eggs, which are fertile and give issue to larvæ; but these larvæ, when they reach maturity, yield invariably males. Any one can test this for himself with the too common gooseberry grub, *Nematus ribesii*. The same thing occurs with wasps, ants, and bees. With saw-flies, again, there are some species whose males are quite unknown, although the species have been caught and bred from the larvæ in hundreds, *e.g.*, *Eriocampa ovata*. Others have males, but they are extremely rare, *e.g.*, *Nematus gallicola*. It has been shown, too, that the species just mentioned and some others (*Phyllotoma nemorata*, *Pœcilosoma pulveratum*, &c.) with males unknown readily lay fertile eggs. The queen bee can lay eggs which will produce males or females, by opening or closing the spermatic sac, and letting the eggs come in contact or not with the spermatic fluid. In the former case females will be the result, in the latter males. Worker bees, wasps, and ants deposit eggs which produce, however, only males. A still more curious phenomenon in connexion with the reproduction of some gall-insects (*Cynipidæ*) requires to be mentioned. In early spring will be found on oak leaves and flowers soft, juicy, greenish, globular pea-shaped galls. Out of these come in summer the gall-flies represented by both sexes. In the autumn (also on oak leaves) are found those curious flat brownish galls commonly called "oak spangles," which by many are taken for fungi, and have indeed been described as such. These "spangle galls" retain very much the same form during the autumn and winter; then in March they swell up and become juicy, and a larva makes its appearance; this soon becomes a pupa and finally a fly, but only in one sex, the female. It was long supposed that these two insects had no relationship with each other, that they belonged in fact to two distinct genera, for not only did the galls differ, but the insects themselves differed in the form of the body, the wings, &c. But it has recently been shown by Dr Adler that the two are forms of the same species, that there is an alternation of a spring bisexual form, with an autumnal unisexual one.

A dimorphism of another kind exists among the social bees, wasps, and ants. An ordinary colony of these insects consists of three sorts of individuals. There is the large female which founded the colony; then there are the workers or neuters, undeveloped females on whom the work of the colony depends; and, lastly, there are the males. It is with ants that the workers are most profoundly modified. They are wingless, and there may be in a colony several sorts, each kind performing different duties, and having the body modified in accordance with the work it has to do. Those which act as soldiers (when a special kind is set apart for this work), for instance, have the mandibles enormously developed; another set may secrete honey for the benefit of the others, &c.

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The *Hymenoptera* must be regarded as one of the most beneficial and useful to man of the insect orders. The produce of the hive bee—wax and honey—has been employed by man since the earliest ages, and forms an extensive article of commerce. The curious structures raised by *Cynipidæ* on the oaks of eastern Europe—galls—have long been used in the manufacture of ink. But, whatever the bee may have done in contributing to our luxuries, and the gall-fly in rendering easier the advance of knowledge, these are small benefits compared to the indirect advantages we derive from the labours of the parasitic species through the havoc they make among the insects which devour the produce of our fields and gardens, and too often destroy the labours of the farmer and gardener. When we remember that there are vast numbers of insects which destroy plants; that many of these are so minute and obscure in their mode of life as to escape ordinary observation, save when the injury is done; and that others appear in enormous numbers,—it becomes evident that an insect which causes the death of a single caterpillar does good service, since that caterpillar would have (if left undisturbed) given, in all probability, origin to an imago which might give birth to hundreds of others. It is this which the ichneumons do,—they destroy the larvæ of plant-devouring insects. Another division of *Hymenoptera* does equally good service. It has been shown by modern researches that without the aid of bees many flowers would never yield seed. Many plants cannot fertilize themselves, so that if bees did not carry the pollen from one plant to another, and thus effect fertilization, no seed would be produced. The red clover, for instance, would never produce seed if it were not for the humble bees fertilizing it in their visits in search of honey. It must, however, be confessed that some *Hymenoptera* do very considerable damage to vegetation, especially saw-flies and ants. Of injurious saw-flies the most destructive are *Eriocampa adumbrata*, on fruit trees; *Nematus ribesii*, which is so destructive to the gooseberry and red currant; *Athalia spinarum*, at one time so destructive to the turnip (probably when it first took to feeding on it); and *Cephus*, in the stems of corn. The damage done by ants in Europe is small; but in the tropics the leaf-cutting ants do enormous damage by cutting down the leaves of trees (especially cultivated ones), which they convey into their nests, where they are used (according to Belt) to rear fungi upon which the ants feed.

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The *Hymenoptera* are almost exclusively dwellers on land, and are essentially sun-loving insects. Two or three only live an aquatic or quasi-aquatic mode of life. Sir John Lubbock discovered two minute species of *Oxyura* (*Polynema*) which descend into the water for the purpose of depositing their eggs in the eggs of aquatic insects. They use the wings as oars to swim in the water, and can remain in it for two hours. An ichneumon (*Agriotypes*) has long been known to live as a parasite in the bodies of caddis-worms; and it has been observed to go down into the water to find the worms, which are said, when infested by the ichneumons, to anchor themselves by means of a silken thread.

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Many *Hymenoptera* give origin to sounds. The humming of bees is one of the most familiar and delightful of country sounds. It is not yet quite clearly understood how it is caused, but there is evidence enough to show that the buzzing originates by the air impinging against the lips of the metathoracic and abdominal stigmas; although it is possible, too, that the rapid vibration of the wings (224 per second with the *Bombus muscorum* and 440 with the honey bee) may also have something to do with the production of sound, for a bee can give out differently pitched notes according to its mood, as it is pleased or angry. Besides the buzzing sounds, a few other species chirp by means of the abdominal segments. *Mutilla* stridulates by drawing in and out the raised striated surface of the third under the edge of the elongated second segment. The workers of *Myrmica* stridulate in pretty much the same way.

Internal anatomy.

The internal anatomy of the *Hymenoptera* presents some interesting features. Their organs of secretion are numerous. The poison is secreted in two long ramose tubes; and from them it goes into a sac situated near the base of the sting. Wax is made in some of the abdominal segments.[1] The salivary glands in the hive bee (worker) are very large and complicated. They are three in number, two (an upper and a lower) placed in the head, and the other in the front region of the thorax. Each gland is different, and has excretory ducts of its own. In the queen bee these are not nearly so much developed as in the worker, and they are even less in the drones. Many saw-fly larvæ secrete fluids for purposes of defence. Some species of *Tenthredo* secrete a blackish liquid, which they eject from the mouth; *Perga* throws out a gummy matter from the same orifice, and *Cimbex* an acid liquid from lateral pores. Then there are the silk-secreting glands which most larvæ possess. The urinary vessels are always present, and may be as many as 150. According to Von Siebold, the aculeates have a long intestine and a stomach with many convolutions, while they are short in the terebrant forms. The tracheæ are well developed. Many dilatations are given off from the main stems, a pair at the base of the abdomen being exceptionally large. In connexion with the female organs of generation, it is worthy of remark that sebaceous glands and a copulatory pouch are absent in the *Aculeata*, although present in the other section. The ovaries are two in number, and consist of a number (it may be as many as a hundred) of distinct many-chambered tubes. Each tube in *Athalia*, for instance, contains 7 eggs, and, as there are 18 of such tubes in each ovary, there will be thus 250 eggs in all. In *Platygaster* the ovary is of a very exceptional nature, inasmuch as the egg tube is a close sac, so that it is burst when the egg is laid.

Specialties in development.

The most noteworthy and exceptional features in the developmental history of the *Hymenoptera* are those shown by some very minute species of *Oxyura*, which live in the bodies of *Diptera* (*Cecidomyia*), and in the eggs of beetles and dragon-flies. After the eggs of *Platygaster* have undergone segmentation, and the embryo has been formed, there leaves the egg a larva of a very unusual form. It is broad and rounded at the head, but contracted towards the tail, which terminates in four spined, bristle-like appendages, so that the larva has a considerable resemblance to a copepod. It is provided with a mouth and hook-like mandibles, by the aid of which it anchors itself inside the body of its host (the larva of a *Cecidomyia*); there are a rudimentary stomach and antennæ, but no trace of nerves, tracheæ, or organs of circulation. Soon it changes its form: the tail with its bristles is thrown off; it becomes shaped somewhat like a hen's egg; the nervous, circulatory, and reproductive organs become visible, while the alimentary organs show an advance in structure. This second

[1] The wax is secreted on the ventral surface of the hive bee, but on the dorsal surface with the stingless bee of America (*Melipona*).

larva is succeeded by a third, which differs from it in being longer and thinner, while the various organs have reached a further stage of advancement in complexity of structure. The after course of its development does not differ from that of other *Hymenoptera*. *Polynema* and *Mymar* (egg-parasites) go through somewhat similar changes in their early embryonic life.

Classification.

Classification.—As regards the classification of the *Hymenoptera*, the order divides itself naturally into two great divisions, as has been already indicated. The *Aculeata* form a division distinguished alike by the form of the sting, with its connected poison-bag, and by the trochanter being joined to the femur by a single joint. The other division (that usually called *Terebrantia* or *Ditrocha*) has a double joint to the trochanter, and the ovipositor is never used as a weapon of offence.

The *Ditrocha* are again divided into two sections, well distinguished by the form of the abdomen, by the larva, and by habits: the one (the *Securifera*) has the abdomen sessile, the larvæ have legs, and they are phytophagous; while the other (the *Spiculifera*) has the abdomen petiolated, the larvæ are apodal, and they are (except part of the *Cynipidæ*) animal feeders. The *Securifera* are further distinguished from all others by the form of the ovipositor, which forms either a short "saw," as in the *Tenthredinidæ*, or a stout exserted "borer," as in the *Siricidæ*; and they have another peculiarity in having at the bottom of the anterior wing a cellule, termed the "lanceolate cellule" (see fig. 1, above), which is found in no other family, and is of great use in classification. The *Securifera* embraces the families *Tenthredinidæ* and *Siricidæ* (by some *Cephus* is made into a third family, while by others it is placed among the *Tenthredinidæ*, owing to its agreeing with the saw-flies in the form of the thorax and ovipositor, and by others with the *Siricidæ*, because it has only one spine in the anterior leg, while the saw-flies have two). The species of *Siricidæ* are few in number, and have a very wide distribution. They are larger than any *Tenthredinidæ*, and are indeed among the giants of the order. All live in wood, especially in *Coniferæ*, and have occasionally done great damage to the forests in Germany. As they are easily imported along with timber, they very often make their appearance in out-of-the-way places and frighten ignorant people, although, of course, they are perfectly harmless.

The *Spiculifera* contain the families *Cynipidæ*, *Chalcididæ*, *Proctotrypidæ*, *Evanidæ*, *Braconidæ*, and *Ichneumonidæ*.

The *Cynipidæ*, or gall-flies, are small insects, rarely exceeding two lines in length. The antennæ are straight, inserted in the middle of the face; the joints are variously shaped, and do not exceed 16 in number. The thorax is large; the scutellum always forms a conspicuous object, and its form is very varied. The abdomen is much compressed, especially with the males; curled up over the apical segments is the long thin bristle-like ovipositor. A few species are apterous. There is always a radial cellule in the anterior wing, but few nervures and there is never a stigma. What distinguishes the *Cynipidæ* more especially is their habit of raising galls on plants to serve as food and lodgings for their young.[1] These galls have the most diversified shapes, and are raised on all parts of a plant—the buds, leaves, roots, flowers, and fruit all being used by the gall insects. A gall may serve to shelter a solitary larva, or it may be so large as to contain many hundreds. The oak is the principal tree used by the *Cynipidæ*; next is the rose, upon which is found the well-known "bedeguar gall" of *Rhodites rosæ*, once used medicinally; the maple, poppy, bramble, hawkweed, and some other plants have likewise their galls. All *Cynipidæ*, however, are not gall-makers. One group deposit their eggs in the galls raised by the true gall-makers, when they are soft and young, and the larva of the cuckoo-fly lives on the gall at the expense of the legitimate owner, which is killed by the more energetic intruder. Another group contains pure animal feeders, parasites which live at the expense of other insects (especially plant lice).

Closely allied to the *Cynipidæ* is the family *Chalcididæ*, an immense tribe of very minute insects with brilliant metallic green bodies. Their wings have few nervures, and they never form closed cellules, but a stigma is always present. The antennæ are always elbowed; they have never more than 13 joints, and may have as few as 6. With the males they are sometimes flabellate, or covered with tufts of hair. Generally the ovipositor is short and concealed, but it may be exserted and much longer than the entire body. In either case it issues from the lower side of the belly. Apterous and semi-apterous species are not uncommon. In habits the *Chalcididæ* are very diversified. They are parasites on insects of all orders and in all stages. While no definite line can be drawn, yet particular groups in the mass confine their attacks to certain families of insects. Thus *Leucaspis* and *Chalcis* are attached to bees and other nest-building aculeates, the long-tailed *Torymides* to oak and other galls, the *Encrytides* to *Homoptera* (*Coccus* especially). Species of *Isosoma* appear to be herbivorous, and one in America is destructive to corn, by raising gall-like structures at the joints and thus causing the plant to wither. Giraud has likewise described *Isosoma* to be a vegetable feeder, at any rate during a considerable portion of its life, as well as another species (*Aulogymnus aceris*) which lives in galls on the maple. Those curious forms, *Sycophaga* and *Blastophaga*, which live in figs, appear undoubtedly to feed on their seeds.

The species of *Proctotrypidæ* (called also *Oxyura*), unlike those of the *Chalcididæ*, are dull-coloured insects, usually entirely black, or at best relieved by brown or red. They are distinguished from the last family by the non-elbowed antennæ, which are 8- to 13-jointed. The wings in the smaller forms may be without nervures, while in the higher they are much more developed than in the *Chalcididæ*. The edges of the wings are deeply fringed with some species; and other species have dense patches of hair on the thorax and abdomen. One group bears raptorial claws on the front tarsi; and, in connexion with this structure, it is worthy of notice that the late A. H. Haliday observed one species to kill and deposit in an empty straw a caterpillar, apparently for the purpose of laying its eggs in it; so that in habits it approximates to the fossorial *Hymenoptera*, which some of them undoubtedly do in structure. The *Oxyura* are parasites. Some are attached to gall insects, others to aphides, while *Diptera* and eggs of insects of all orders afford nourishment to many.

The insects usually called "ichneumons" belong to two families —the *Ichneumonidæ* and *Braconidæ*. Both are readily distinguished from the families already mentioned by the wings being well provided with nervures, which form regular cellules, by the greater number of joints in the antennæ, and generally by their much greater size. The only radical distinctions between the groups are that the *Ichneumonidæ* have two recurrent nervures, and a little joint in front of the second antennal joint, whereas this is absent in the *Braconidæ*, which have besides only one recurrent nervure. In habits there is no broad distinction between them. They are parasites on insects of all orders. The *Evanidæ* are a small and somewhat heterogeneous assemblage of insects, which do not agree very well in their structure; but the typical species may be known by the abdomen being inserted in the middle or above the middle of the metathorax. As far as is known the family are parasitic on cockroaches, and appear to be not very numerous in species.

In some respects the *Chrysididæ* are intermediate between the *Aculeata* and the *Terebrantia*, for they have the single-jointed trochanter of the former, while in the structure of the ovipositor, in having the antennæ 13-jointed in both sexes, as well as in habit, they agree with the latter. They are exceedingly brilliant insects; their bodies are metallic, with shining green, purple, or golden hues. The abdomen hangs as it were from the thorax, and is somewhat concave on the under side. It can be bent under the thorax, so that the insect can roll itself up into a ball, which is its way of protecting itself when attacked—its hard metallic coat of mail being impregnable against the mandibles of other insects. These insects differ from other terebrant *Hymenoptera* in the structure of the abdomen, for it has never more than four segments visible in the female and five in the male, while the ichneumons have always more. The terminal segments form a tube, which is used in oviposition. In habits the *Chrysididæ* do not differ from the ichneumons, being parasites. They prey principally on bees and wasps, whose nests they enter when the owners are absent, and should they be discovered their hard skin saves them from serious injury. Indeed the only portions of their bodies which can be mutilated are the wings. St Fargeau observed a bee do this to a chrysis; she bit off the four wings, but did not thereby save her young, for as soon as the bee left, the now wingless parasite crawled into the nest and laid her eggs therein.

As has been stated, the *Aculeata* are distinguished from all other *Hymenoptera* by having a sting, a single-jointed trochanter, and the antennæ with 12 joints in the female and 13 in the male. They differ, too, in habits from the *Terebrantia*, for, although many of them are parasites, their parasitism is unlike that of the ichneumons. Parasitic *Aculeata* earn their bread differently: they enter the nests of other aculeate species and lay their eggs in the food stored up there for the benefit of the young of the builder, which are starved or destroyed by the more vigorous larva of the parasite. In order to carry out their ends with greater ease, some parasites mimic the forms of the species upon which they prey. Thus *Apathus rupestris* is coloured exactly like *Bombus lapidarius*, its host. On the other hand the species of *Nomada*, an extensive genus of parasitic bees, do not resemble in the least the bees on which they prey; they have instead gaudily coloured, hairless bodies. One of the most interesting chapters in the history of the *Aculeata* is their nest building. The nests are built in all sorts of places and of all kinds of materials.

[1] There is a radical distinction between the gall-making *Cynipidæ* and the gall-making saw-flies. The latter feed on the gall itself, so that in course of time it becomes reduced to a mere bladder; and the gall is fully formed before the larva leaves the egg. On the other hand, the development of *Cynips* and the growth of the gall go on at the same time,—the reason of this being that it feeds only on the juice of the gall, which hardens and dries very soon after it makes its appearance, so that necessarily the larva has to feed up rapidly. After the gall has dried the larva occupies a cell of harder matter than the rest of the gall, not much larger than its own bulk.

Many, like *Andrena*, dig in light soils a burrow, consisting of a narrow passage going down some inches, and having at each side of it at intervals cells in which the food is stored. Wood is used by others to form somewhat similar cells, which may be lined with pieces of leaves or flowers. The stems of brambles are utilized by a large number of species of bees and fossorial *Hymenoptera*. *Osmia* uses empty shells for its habitation. Then others build up nests. *Chalicodoma* and other bees, with many wasps, construct cells by cementing together bits of mud and clay. Social wasps form their large nests of paper made of masticated wood; humble bees and the hive bee do so by a secretion called wax. Some ants build up from the ground, of leaves, &c., nests shaped like a hay-stack, which in size they may almost equal. An Indian species builds, at the ends of branches of trees, large nests of dead and living leaves matted together with a white web. Finally, the thorns of *Acacia* are hollowed out by others to serve as a residence.

The *Aculeata* may be divided into five families—the *Formicidæ*, or ants, *Mutillidæ* (commonly called "solitary ants"), *Fossores* (sand-wasps, &c.), *Diploptera*, or true wasps, and *Anthophila*, or bees. The ants are, as a rule, social insects, and their workers differ from those of wasps and bees in being always wingless.[1] What morphologically more especially distinguishes ants from other aculeates is the structure of the abdomen, which at the base (on the peduncle or petiole) is provided either with a flattened plate-like projection or with two nodes. In the former case, there is, as in *Formica*, only a rudimentary sting, while in the latter there is an efficient one, as in *Myrmica*; but there are exceptions to both rules. A few ants are solitary and parasitic in habits, and in this case the female is wingless. Closely allied to the ants are the *Mutillidæ* (by some authors the two are placed in one group, *Heterogyna*), which, however, differ from them in being solitary, in having neither a scale nor node, while the tibiæ are spined, and the tarsi ciliated. It is only the males which are winged, and they have the abdomen spined and curved at the apex. They are brightly coloured insects, and are very numerous in species. So far as is known they are parasites on humble bees. The group of *Fossores* is a very extensive one. Their habits are very interesting and varied even in the same genus. They are carnivorous, storing up (after having benumbed but not killed) caterpillars, beetles, flies, aphides, &c., in cells formed or dug out of wood or of bramble stems, in the ground, or built up of mud or sand. Some build no nests, and store up no food for their young, but live, cuckoo fashion, on other *Fossores* or bees. In general structure the *Diploptera* do not differ essentially from the *Fossores*; but they may be readily known from them by the wings being folded longitudinally in repose, while the eyes are reniform and reach to or near to the base of the mandibles. They differ too from the *Fossores* in some of them being social, as is the case with *Polistes* and *Vespa*. In habits the solitary wasps agree more or less with the *Fossores*. While the above-mentioned tribes are carnivorous, the bees, on the other hand, are entirely vegetable feeders, living on the pollen or nectar of flowers. As might be expected, we find with them certain peculiarities of structure in connexion with their habits. The great business of a bee is the storing up of food, for its own use or (and more especially) for that of its young. To do this to the best advantage certain parts of the body are adapted for the carrying home of pollen. This is done more especially on the legs. The basal joint of the tarsus is, for this purpose, flattened and compressed, and covered (at least on the inner side) with hair. This then, is a character which distinguishes them from all other aculeates. The least specialized bees carry home the pollen loose, but *Apis* mixes it into a paste in the field. To serve the same end the mouth parts are profoundly modified for the lapping of nectar. Many bees are parasites on other bees. These want the pollen collecting apparatus, and many of them have bright-coloured hairless bodies, as already remarked.

[Distribu-] The earliest *Hymenoptera* known belong to the upper Oolitic formation; but, as they are *Apidæ*, it is certain that the order must have appeared much earlier in time than that. At the present day, representatives of the order are found in all parts of the world, even as far north as 78° to 83° N. lat., where *Bombi* and ichneumons were found by the naturalists attached to the Arctic expedition of 1875–76. Many genera in all the families have a very wide distribution, *e.g.*, *Ophion* and *Pimpla* among the ichneumons, *Odynerus* with the wasps, *Megachile* with bees. Humble bees and saw-flies are characteristic of temperate, if not northern, latitudes; *Mutilla* of warm regions, although it also appears in arctic regions. *Vespa* is more limited in its range than the solitary wasps (*Odynerus*, &c.), being absent from Africa, Australia, and South America. Many individual species have a very extensive range. This has been brought about in some cases by the aid of man. In this way many pests have been carried over the globe, *e.g.*, *Nematus ribesii*, the gooseberry grub, which is now spreading over the American gardens; *Eriocampa adumbrata*, the slug worm of British fruit trees, has reached New Zealand; while, among ants, the house ant of Madeira (*Pheidole pusilla*) is now cosmopolitan. Many species are common to the Palæarctic and Nearctic regions, *e.g.*, *Megachile centuncularis*, *Vespa vulgaris*, *Hemichroa rufa*. Others have a wider geographical range. The ant *Solenopsis geminata*, for instance, is found in India, the Eastern Archipelago, South America, and the Hawaiian Islands. *Hylotoma pagana*, again, occurs in the Southern States of America, and all over Europe, and extends to India and Japan.

There being no complete list of *Hymenoptera*, it is not easy to give the number of described species, but probably it is not much over 17,000. The actual number, however, must be very much greater; probably it will be found to reach 70,000 or 80,000; for in those countries where anything like the same attention has been paid to them as to beetles they are nearly as numerous; and in no country have they received so much attention as *Coleoptera*. As regards the number of British species, there are recorded in the catalogues published by the Entomological Society of London, in 1871–2, 378 *Aculeata*, 1654 *Ichneumonidæ* and *Braconidæ*, and 325 *Oxyura*; while 325 saw-flies were catalogued in 1878—in all about 2700. Besides these there are about 150 *Cynipidæ*, and upwards of 1200 *Chalcididæ* have been described by Francis Walker; but that number may safely be reduced to 600 or 700. Number of species.

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H Y M N S

1. *Classical Hymnody.*

THE word "hymn" (ὕμνος) was employed by the ancient Greeks to signify a song or poem composed in honour of gods, heroes, or famous men, or to be recited on some joyful, mournful, or solemn occasion. Polymnia was the name of their lyric muse. Homer makes Alcinous entertain Odysseus with a "hymn" of the minstrel Demodocus, on the capture of Troy by the wooden horse. The *Works and Days* of Hesiod begins with an invocation to the Muses to address hymns to Zeus, and in his *Theogonia* he speaks of them as singing or inspiring "hymns" to all the divinities, and of the bard as "their servant, hymning the glories of men of old, and of the gods of Olympus." Pindar calls by this name odes, like his own, in praise of conquerors at the public games of Greece. The Athenian dramatists (Euripides most frequently) use the word and its cognate verbs in a similar manner; they also describe by them metrical oracles and apophthegms, martial, festal, and hymenæal songs, dirges, and lamentations or incantations of woe.

[1] The wings, however, may be distinguished in the pupæ of the neuters, thus showing clearly that they have been lost through disuse.

Hellenic hymns, according to this conception of them, have come down to us, some from a very early and others from a late period of Greek classical literature. Those which passed by the name of Homer were already old in the time of Thucydides. They are mythological poems (several of them long), in hexameter verse,—some very interesting. That to Apollo contains a traditionary history of the origin and progress of the Delphic worship; those on Hermes and on Dionysus are marked by much liveliness and poetical fancy. Hymns of a like general character, but of less interest (though these also embody some fine poetical traditions of the Greek mythology, such as the story of Tiresias, and that of the wanderings of Leto), were written in the 3d century before Christ, by Callimachus of Cyrene. Cleanthes, the successor of Zeno, composed (also in hexameters) an "excellent and devout hymn" (as it is justly called by Cudworth, in his *Intellectual System*) to Zeus, which is preserved in the *Eclogæ* of Stobæus, and from which Aratus borrowed the words, "For we are also His offspring," quoted by St Paul at Athens. The so-called Orphic hymns, in hexameter verse, styled τελεταί, or hymns of initiation into the "mysteries" of the Hellenic religion, are productions of the Alexandrian school,—as to which learned men are not agreed whether they are earlier or later than the Christian era.

The Romans did not adopt the word "hymn;" nor have we many Latin poems of the classical age to which it can properly be applied. There are, however, a few,—such as the simple and graceful "Dianæ sumus in fide" ("Dian's votaries are we") of Catullus, and "Dianam teneræ dicite virgines" ("Sing to Dian, gentle maidens") of Horace,—which approach much more nearly than anything Hellenic to the form and character of modern hymnody.

2. *Hebrew Hymnody.*

For the origin and idea of Christian hymnody we must look, not to Gentile, but to Hebrew sources. St Augustine's definition of a hymn, generally accepted by Christian antiquity, may be summed up in the words, "praise to God with song" ("cum cantico"). Bede understood the "canticum" as properly requiring metre; though he thought that what in its original language was a true hymn might retain that character in an unmetrical translation. Modern use has enlarged the definition: Roman Catholic writers extend it to the praises of saints; and the word now comprehends rhythmical prose as well as verse, and prayer and spiritual meditation as well as praise.

The modern distinction between psalms and hymns is arbitrary (see PSALMS). The former word was used by the LXX. as a generic designation, probably because it implied an accompaniment by the psaltery (said by Eusebius to have been of very ancient use in the East) or other instruments. The cognate verb "psallere" has been constantly applied to hymns, both in the Eastern and in the Western Church; and the same compositions which they described generically as "psalms" were also called by the LXX. "odes" (*i.e.*, songs) and "hymns." The latter word occurs, *e.g.*, in Ps. lxxii. 20 ("the hymns of David the son of Jesse"), in Ps. lxv. 1, and also in the Greek titles of the 6th, 54th, 55th, 67th, and 76th (this numbering of the psalms being that of the English version, not of the LXX.). The 44th chapter of Ecclesiasticus, "Let us now praise famous men," &c., is entitled in the Greek πατέρων ὕμνος, "The Fathers' Hymn." Bede speaks of the whole book of Psalms as called "liber hymnorum," by the universal consent of Hebrews, Greeks, and Latins.

In the New Testament we find our Lord and His apostles singing a hymn (ὑμνήσαντες ἐξῆλθον), after the institution of the Lord's Supper; St Paul and Silas doing the same (ὕμνουν τὸν θεόν) in their prison at Philippi; St James recommending psalm-singing (ψαλλέτω), and St Paul "psalms and hymns and spiritual songs" (ψαλμοῖς καὶ ὕμνοις καὶ ᾠδαῖς πνευματικαῖς). St Paul also, in the 14th chapter of the first epistle to the Corinthians, speaks of singing (ψαλῶ), and of every man's psalm (ἕκαστος ὑμῶν ψαλμὸν ἔχει), in a context which plainly has reference to the assemblies of the Corinthian Christians for common worship. All the words thus used were applied by the LXX. to the Davidical psalms; it is therefore possible that these only may be intended, in the different places to which we have referred. But there are in St Paul's epistles several passages (Eph. v. 14; 1 Tim. iii. 16; 1 Tim. vi. 15, 16; 2 Tim. ii. 11, 12) which have so much of the form and character of later Oriental hymnody as to have been supposed by Michaelis and others to be extracts from original hymns of the Apostolic age. Two of them are apparently introduced as quotations, though not found elsewhere in the Scriptures. A third has not only rhythm, but rhyme. The thanksgiving prayer of the assembled disciples, recorded in Acts iv., is both in substance and in manner poetical; and in the canticles, "Magnificat," "Benedictus," &c., which manifestly followed the form and style of Hebrew poetry, hymns or songs, proper for liturgical use, have always been recognized by the church.

3. *Eastern Church Hymnody.*

The hymn of our Lord, the precepts of the apostles, the angelic song at the nativity, and "Benedicite omnia opera," are referred to in a curious metrical prologue to the hymnary of the Mozarabic Breviary, as precedents for the practice of the Western Church. In this respect, however, the Western Church followed the Eastern, in which hymnody prevailed from the earliest times.

The peu

Philo describes the "Therapeutæ" of the neighbourhood of Alexandria as composers of original hymns, which (as well as old) were sung at their great religious festivals,—the people listening in silence till they came to the closing strains, or refrains, at the end of a hymn or stanza (the "acroteleutia" and "ephymnia"), in which all, women as well as men, heartily joined. These songs, he says, were in various metres (for which he uses a number of technical terms); some were choral, some not; and they were divided into variously constructed strophes or stanzas.

Eusebius, who thought that the Therapeutæ were communities of Christians, says that the Christian practice of his own day was in exact accordance with this description. Gibbon considered it to be proved, by modern criticism, that the Therapeutæ were not Christians, but Essene Jews; but he recognized in their customs "a very lively image of primitive discipline;" and he states that the Christian religion was embraced by great numbers of them, and that they were probably, by degrees, absorbed into the church, and became the fathers of the Egyptian ascetics. Apollos, "born at Alexandria," may possibly have been one of them.

Ant pho sing

The practice, not only of singing hymns, but of singing them antiphonally, appears, from the well-known letter of Pliny to Trajan, to have been established in the Bithynian churches at the beginning of the 2d century. They were accustomed "stato die ante lucem convenire, carmenque Christo, quasi Deo, dicere *secum invicem*." This agrees well, in point of time, with the tradition recorded by the historian Socrates, that Ignatius (who suffered martyrdom about 107 A.D.) was led by a vision or dream of angels singing hymns in that manner to the Holy Trinity to introduce antiphonal singing into the church of Antioch, from which it quickly spread to other churches. There seems to be an allusion to choral singing in the epistle of Ignatius himself to the Romans, where he exhorts them, "χορὸς γενόμενοι" ("having formed themselves into a choir"), to "sing praise to the Father in Christ Jesus." A statement of Theodoret has sometimes been supposed to refer the origin of antiphonal singing to a much later date; but this seems to relate only to the singing of Old Testament Psalms (τὴν Δαυιδικὴν μελῳδίαν), the alternate chanting of which, by a choir divided into two parts, was (according to that statement) first introduced into the church of Antioch by two monks famous in the history of their time, Flavianus and Diodorus, under the emperor Constantius II.

Other evidence of the use of hymns in the 2d century is contained in a fragment of Caius, preserved by Eusebius, which refers to "all the psalms and odes written by faithful brethren from the beginning," as "hymning Christ, the Word of God, as God." Tertullian also, in his description of the "Agapæ," or love-feasts, of his day, says that, after washing hands and bringing in lights, each man was invited to come forward and sing to God's praise something either taken from the Scriptures or of his own composition ("ut quisque de Sacris Scripturis vel proprio ingenio potest"). Bishop Bull believed one of those primitive compositions to be the hymn appended by Clement of Alexandria to his *Pædagogus*; and Archbishop Ussher considered the ancient morning and evening hymns, of which the use was enjoined by the *Apostolical Constitutions*, and which are also mentioned in the "Tract on Virginity" printed with the works of St Athanasius, and in St Basil's treatise upon the Holy Spirit, to belong to the same family. Clement's hymn, in a short anapæstic metre, beginning στόμιον πώλων ἀδαῶν (or, according to some editions, βασιλεῦ ἁγίων, λόγε πανδαμάτωρ—translated by Mr Chatfield, "O Thou, the King of saints, all-conquering Word"), is rapid, spirited, and well-adapted for singing. The Greek "Morning Hymn" (which, as divided into verses by Archbishop Ussher in his treatise *De Symbolis*, has a majestic rhythm, resembling a choric or dithyrambic strophe) is the original form of "Gloria in Excelsis," still said or sung, with some variations, in all branches of the church which have not relinquished the use of liturgies. The Latin form of this hymn (of which that in the English communion office is an exact translation) is said, by Bede and other ancient writers, to have been brought into use at Rome by Pope Telesphorus, as early as the time of the emperor Hadrian. A third, the Vesper or "Lamp-lighting" hymn ("φῶς ἱλαρὸν ἁγίας δόξης,"—translated by Canon Bright "Light of Gladness, Beam Divine"), holds its place to this day in the services of the Greek rite. In the 3d century Origen seems to have had in his mind the words of some other hymns or hymn of like character, when he says (in his treatise *Against Celsus*); "We glorify in hymns God and His only begotten Son; as do also the Sun, the Moon, the Stars, and all the host of heaven. All these, in one Divine chorus, with the just among men, glorify in hymns God who is over all, and His only begotten Son." So highly were these compositions esteemed in the Syrian churches that the council which deposed Paul of Samosata from the see of Antioch in the time of Aurelian justified that act, in its synodical letter to the bishops of Rome and Alexandria, on this ground (among others) that he had prohibited the use of hymns of that kind, by uninspired writers, addressed to Christ.

After the conversion of Constantine, the progress of hymnody became closely connected with church controversies. There had been in Edessa, at the end of the 2d or early in the 3d century, a Gnostic writer of conspicuous ability, named Bardesanes, who was succeeded, as the head of his sect or school, by his son Harmonius. Both father and son wrote hymns, and set them to agreeable melodies, which acquired, and in the 4th century still retained, much local popularity. Ephraem Syrus, the first voluminous hymn writer whose works remain to us, thinking that the same melodies might be made useful to the faith, if adapted to more orthodox words, composed to them a large number of hymns in the Syriac language, principally in tetrasyllabic, pentasyllabic, and heptasyllabic metres, divided into strophes of from 4 to 12, 16, and even 20 lines each. When a strophe contained five lines, the fifth was generally an "ephymnium," detached in sense, and consisting of a prayer, invocation, doxology, or the like, to be sung antiphonally, either in full chorus or by a separate part of the choir. The *Syriac Chrestomathy* of Hahn (published at Leipsic in 1825), and the third volume of Daniel's *Thesaurus Hymnologicus*, contain specimens of these hymns. Some of them have been translated into (unmetrical) English by the Rev. Henry Burgess (*Select Metrical Hymns of Ephrem Syrus*, &c., 1853). A considerable number of those so translated are on subjects connected with death, resurrection, judgment, &c., and display not only Christian faith and hope, but much simplicity and tenderness of natural feeling. Theodoret speaks of the spiritual songs of Ephraem as very sweet and profitable, and as adding much, in his (Theodoret's) time, to the brightness of the commemorations of martyrs in the Syrian Church.

The Greek hymnody contemporary with Ephraem followed, with some licence, classical models. One of its favourite metres was the Anacreontic; but it also made use of the short anapæstic, Ionic, iambic, and other lyrical measures, as well as the hexameter and pentameter. Its principal authors were Methodius, bishop of Tyre (who died about 311 A.D.), Synesius, who became bishop of Ptolemais in Cyrenaica in 410, and Gregory Nazianzen, for a short time (380–381) patriarch of Constantinople. The merits of these writers have been perhaps too much depreciated by the admirers of the later Greek "Melodists." They have found an able English translator in the Rev. Allen Chatfield (*Songs and Hymns of Earliest Greek Christian Poets*, &c., London, 1876). Among the most striking of their works are μνώεο Χριστέ ("Lord Jesus, think of me"), by Synesius; σὲ τὸν ἄφθιτον μονάρχην ("O Thou, the One Supreme") and τί σοι θέλεις γενέσθαι ("O soul of mine, repining"), by Gregory; also ἄνωθεν παρθένοι ("The Bridegroom cometh"), by Methodius. There continued to be Greek metrical hymn writers, in a similar style, till a much later date. Sophronius, patriarch of Jerusalem in the 7th century, wrote seven Anacreontic hymns; and St John Damascene, one of the most copious of the second school of "Melodists," was also the author of some long compositions in trimeter iambics.

Period of Arian controversy.

An important development of hymnody at Constantinople arose out of the Arian controversy. Early in the 4th century Athanasius had rebuked, not only the doctrine of Arius, but the light character of certain hymns by which he endeavoured to make that doctrine popular. When, towards the close of that century (398), St John Chrysostom was raised to the metropolitan see, the Arians, who were still numerous at Constantinople, had no places of worship within the walls; but they were in the habit of coming into the city at sunset on Saturdays, Sundays, and the greater festivals, and congregating in the porticoes and other places of public resort, where they sung, all night through, antiphonal songs, with "acroteleutia" (closing strains, or refrains), expressive of Arian doctrine, often accompanied by taunts and insults to the orthodox. Chrysostom was apprehensive that this music might draw some of the simpler church people to the Arian side; he therefore organized, in opposition to it, under the patronage and at the cost of Eudoxia, the empress of Arcadius (then his friend), a system of nightly processional hymn-singing, with silver crosses, wax-lights, and other circumstances of ceremonial pomp. Riots followed, with bloodshed on both sides, and with some personal injury to the empress's chief eunuch, who seems to have officiated as conductor or director of the church musicians. This led to the suppression, by an imperial edict, of all public Arian singing; while in the church the practice of nocturnal hymn-singing on certain solemn occasions, thus first introduced, remained an established institution.

Greek system of hymnody.

It is not improbable that some rudiments of the peculiar system of hymnody which now prevails throughout the Greek communion, and whose affinities are rather to the Hebrew and Syriac than to the classical forms, may have existed in the church of Constantinople, even at that time. Anatolius, patriarch of Constantinople in the middle of the 5th century, was the precursor of that system; but the reputation of being its proper founder belongs to Romanus, of whom little more is known than that he wrote hymns still extant, and lived towards the end of that century. The importance of that system in the services of the Greek church may be understood from the fact that the late Dr Neale computed four-fifths of the whole space (about 5000 pages) contained in the different service-books of that church to be occupied by hymnody, all in a language or dialect which has ceased to be anywhere spoken.

The system has a peculiar technical terminology, in which the words "troparion," "ode," "canon," and "hirmus" (εἱρμός) chiefly require explanation.

The *troparion* is the unit of the system, being a strophe or stanza, seen, when analysed, to be divisible into verses or clauses, with regulated cæsuras, but printed in the books as a single prose sentence, without marking any divisions. The following (turned into English, from a "canon" by John Mauropus) may be taken as an example:—"The never-sleeping Guardian, | the patron of my soul, | the guide of my life, | allotted me by God, | I hymn thee, Divine Angel | of Almighty God." Dr Neale and most other writers regard all these "troparia" as rhythmical or modulated prose. Cardinal J. B. Pitra, on the other hand, who in 1867 and 1876 published two learned works on this subject, maintains that they are really metrical, and governed by definite rules of prosody, of which he lays down sixteen. According to him, each "troparion" contains from three to thirty-three verses; each verse varies from two to thirteen syllables, often in a continuous series, uniform, alternate, or reciprocal, the metre being always syllabic, and depending, not on the quantity of vowels or the position of consonants, but on an harmonic series of accents.

In various parts of the services solitary troparia are sung, under various names, "contacion," "œcos," "cathisma," &c., which mark distinctions either in their character or in their use.

An *ode* is a song or hymn compounded of several similar "troparia,"—usually three, four, or five. To these is always prefixed a typical or standard "troparion," called the *hirmus*, by which the syllabic measure, the periodic series of accents, and in fact the whole structure and rhythm of the stanzas which follow it are regulated. Each succeeding "troparion" in the same "ode" contains the same number of verses, and of syllables in each verse, and similar accents on the same or equivalent syllables. The "hirmus" may either form the first stanza of the "ode" itself, or (as is more frequently the case) may be taken from some other piece; and, when so taken, it is often indicated by initial words only, without being printed at length. It is generally printed within commas, after the proper rubric of the "ode." A hymn in irregular "stichera" or stanzas, without a "hirmus," is called "idiomelon." A system of three or four odes is "triodion" or "tetraodion."

A *canon* is a system of eight (theoretically nine) connected odes, the second being always suppressed. Various pauses, relieved by the interposition of other short chants or readings, occur during the singing of a whole "canon." The final "troparion" in each ode of the series is not unfrequently detached in sense (like the "ephymnia" of Ephraem Syrus), particularly when it is in the (very common) form of a "theotokion," or ascription of praise to the mother of our Lord, and when it is a recurring refrain or burden.

There were two principal periods of Greek hymnography constructed on these principles,—the first that of Romanus and his followers, extending over the 6th and 7th centuries, the second that of the schools which arose during the Iconoclastic controversy in the 8th century, and which continued for some centuries afterwards, until the art itself died out.

The works of the writers of the former period were collected in *Tropologia*, or church hymn-books, which were held in high esteem till the 10th century, when they ceased to be regarded as church-books, and so fell into neglect. They are now preserved only in a very small number of manuscripts. From three of these, belonging to public libraries at Moscow, Turin, and Rome, Cardinal Pitra has lately printed, in his *Analecta*, a number of interesting examples, the existence of which appears to have been unknown to the late learned Dr Neale, and which, in the cardinal's estimation, are in many respects superior to the "canons," &c., of the present Greek service-books, from which all Dr Neale's translations (except some from Anatolius) are taken. Cardinal Pitra's selections include twenty-nine works by Romanus, and some by Sergius, and nine other known, as well as some unknown, authors. He describes them as having generally a more dramatic character than the "melodies" of the later period, and a much more animated style; and he supposes that they may have been originally sung with dramatic accompaniments, by way of substitution for the theatrical performances of Pagan times. As an instance of their peculiar character, he mentions a Christmas or Epiphany hymn by Romanus, in twenty-five long strophes, in which there is, first, an account of the Nativity and its accompanying wonders, and then a dialogue between the wise men, the Virgin mother, and Joseph. The magi arrive, are admitted, describe the moral and religious condition of Persia and the East, and the cause and adventures of their journey, and then offer their gifts. The Virgin intercedes for them with her Son, instructs them in some parts of Jewish history, and ends with a prayer for the salvation of the world.

The controversies and persecutions of the 8th and succeeding centuries turned the thoughts of the "melodists" of the great monasteries of the Studium at Constantinople and St Saba in Palestine and their followers, and those of the adherents of the Greek rite in Sicily and South Italy (who suffered much from the Saracens and the Normans), into a less picturesque but more strictly theological course; and the influence of those controversies, in which the final success of the cause of "Icons" was largely due to the hymns, as well as to the courage and sufferings, of these confessors, was probably the cause of their supplanting, as they did, the works of the older school. Cardinal Pitra gives them the praise of having discovered a graver and more solemn style of chant, and of having done much to fix the dogmatic theology of their church upon its present lines of near approach to the Roman.

Among the "melodists" of this latter Greek school there were many saints of the Greek church, several patriarchs, and two emperors,—Leo the Philosopher, and Constantine Porphyrogenitus, his son. Their greatest poets were Theodore and Joseph of the Studium, and Cosmas and John (called Damascene) of St Saba. Dr Neale has translated into English verse several selected portions, or centoes, from the works of these and others, together with four selections from earlier works by Anatolius. Some of his translations,—particularly "The day is past and over," from Anatolius, and "Christian, dost thou see them," from Andrew of Crete, have been adopted into hymn-books used in many English churches; and the hymn "Art thou weary," &c., which is rather founded upon than translated from one by Stephen the Sabaite, has obtained still more general popularity.

The older learning on the subject of Greek hymnody and church music is collected in a dissertation prefixed to the second volume for June of the Bollandists' *Acta Sanctorum*; the more recent in Cardinal Pitra's *Hymnographie de l'Eglise Grecque* (Rome, 1867), and *Analecta Sacra*, &c. (Paris, 1876), in the *Anthologia Græca Carminum Christianorum* (Leipsic, 1871), and in Dr Daniel's *Thesaurus Hymnologicus*. There is also an able paper on Cardinal Pitra's works, by M. E. Miller, in the *Journal des Savants* for 1876.

4. *Western Church Hymnody.*

It was not till the 4th century that Greek hymnody was imitated in the West, where its introduction was due to two great lights of the Latin Church,—St Hilary of Poitiers and St Ambrose of Milan.

ry. Hilary was banished from his see of Poitiers in 356, and was absent from it for about four years, which he spent in Asia Minor, taking part during that time in one of the councils of the Eastern Church. He thus had full opportunity of becoming acquainted with the Greek church music of that day; and he wrote (as St Jerome, who was thirty years old when he died, and who was well acquainted with his acts and writings, and spent some time in or near his diocese, informs us) a "book of hymns," to one of which Jerome particularly refers, in the preface to the second book of his own commentary on the epistle to the Galatians. Isidore, archbishop of Seville, who presided over the fourth council of Toledo, in his book on the offices of the church, speaks of Hilary as the first Latin hymn-writer; that council itself, in its 13th canon, and the prologue to the Mozarabic hymnary (which is little more than a versification of the canon), associate his name, in this respect, with that of Ambrose. A tradition, ancient and widely spread, ascribed to him the authorship of the remarkable "Hymnum dicat turba fratrum, hymnum cantus personet" ("Band of brethren, raise the hymn, let your song the hymn resound"), which is a succinct narrative, in hymnal form, of the whole gospel history; and is perhaps the earliest example of a strictly didactic hymn. Both Bede and Hincmar much admired this composition, though the former does not mention, in connexion with it, the name of Hilary. The private use of hymns of such a character by Christians in the West may probably have preceded their ecclesiastical use; for Jerome says that in his day those who went into the fields might hear "the ploughman at his hallelujahs, the mower at his hymns, and the vine-dresser singing David's psalms." Besides this, seven shorter metrical hymns attributed to Hilary are still extant.

ose. Of the part taken by Ambrose, not long after Hilary's death, in bringing the use of hymns into the church of Milan, we have a contemporary account from his convert, St Augustine. Justina, mother of the emperor Valentinian, favoured the Arians, and desired to remove Ambrose from his see. The "devout people," of whom Augustine's mother Monica was one, combined to protect him, and kept guard in the church. "Then," says Augustine, "it was first appointed that, after the manner of the Eastern churches, hymns and psalms should be sung, lest the people should grow weary and faint through sorrow; which custom has ever since been retained, and has been followed by almost all congregations in other parts of the world." He describes himself as moved to tears by the sweetness of these "hymns and canticles":—"The voices flowed into my ears; the truth distilled into my heart; I overflowed with devout affections, and was happy." To this time, according to an uncertain but not improbable tradition which ascribed the composition of the "Te Deum" to Ambrose, and connected it with the conversion of Augustine, is to be referred the commencement of the use in the church of that sublime unmetrical hymn.

It is not, however, to be assumed that the hymnody thus introduced by Ambrose was from the first used according to the precise order and method of the later Western ritual. To bring it into (substantially) that order and method appears to have been the work of St Benedict. Walafridus Strabo, the earliest ecclesiastical writer on this subject (who lived at the beginning of the 9th century), says that Benedict, on the constitution of the religious order known by his name (about 530), appointed the Ambrosian hymns to be regularly sung in his offices for the canonical hours. Hence probably originated the practice of the Italian churches, and of others which followed their example, to sing certain hymns (Ambrosian, or by the early successors of the Ambrosian school) daily throughout the week, at "Vespers," "Lauds," and "Nocturns," and on some days at "Compline" also—varying them with the different ecclesiastical seasons and festivals, commemorations of saints and martyrs, and other special offices. Different dioceses and religious houses had their own peculiarities of ritual, including such hymns as were approved by their several bishops or ecclesiastical superiors, varying in detail, but all following the same general method. The national rituals, which were first reduced into a form substantially like that which has since prevailed, were probably those of Lombardy and of Spain, now known as the "Ambrosian" and the "Mozarabic." That of Spain was settled in the 7th century by Leander and Isidore, brothers, successively archbishops of Seville. It contained a copious hymnary, the original form of which may be regarded as canonically approved by the fourth council of Toledo (633). By the 13th canon of that council, an opinion (which even then found advocates) against the use in churches of any hymns not taken from the Scriptures,—apparently the same opinion which had been held by Paul of Samosata,—was censured; and it was ordered that such hymns should be used in the Spanish as well as in the Gallican churches, the penalty of excommunication being denounced against all who might presume to reject them.

The hymns of which the use was thus established and authorized were those which entered into the daily and other offices of the church, afterwards collected in the "Breviaries;" in which the hymns "proper" for "the week," and for "the season," continued for many centuries, with very few exceptions, to be derived from the earliest epoch of Latin Church poetry,—reckoning that epoch as extending from Hilary and Ambrose to the end of the pontificate of Gregory the Great. The "Ambrosian" music, to which those hymns were generally sung down to the time of Gregory, was more popular and congregational than the "Gregorian," which then came into use, and afterwards prevailed. In the service of the mass it was not the general practice, before the invention of sequences in the 9th century, to sing any hymns, except some from the Scriptures esteemed canonical, such as the "Song of the Three Children" ("Benedicite omnia opera"). But to this rule there were, according to Walafridus Strabo, some occasional exceptions; particularly in the case of Paulinus, patriarch of Aquileia under Charlemagne, himself a hymn-writer, who frequently used hymns, composed by himself or others, in the eucharistic office, especially in private masses.

Some of the hymns called "Ambrosian" (nearly 100 in number) are beyond all question by Ambrose himself, and the rest probably belong to his time or to the following century. Ambrosian hymns. Four, those beginning "Æterne rerum conditor" ("Dread Framer of the earth and sky"), "Deus Creator omnium" ("Maker of all things, glorious God"), "Veni Redemptor Gentium" ("Redeemer of the nations, come"), and "Jam surgit hora tertia" ("Christ at this hour was crucified"), are quoted as works of Ambrose by Augustine. These, and others by the hand of the same master, have the qualities most valuable in hymns intended for congregational use. They are short and complete in themselves; easy, and at the same time elevated in their expression and rhythm; terse and masculine in thought and language; and (though sometimes criticized as deficient in theological precision) simple, pure, and not technical in their rendering of the great facts and doctrines of Christianity, which they present in an objective and not a subjective manner. They have exercised a powerful influence, direct or indirect, upon many of the best works of the same kind in all succeeding generations. With the Ambrosian hymns are properly classed those of Hilary, and the contemporary works of Pope Damasus (who wrote two hymns in commemoration of saints), and of Prudentius, from whose *Cathemerina* ("Daily Devotions") and *Peristephana* ("Crown-songs for Martyrs"), all poems of considerable, some of great length, —about twenty-eight hymns, found in various Breviaries, were derived. Prudentius was a layman, a native of Saragossa, and it was in the Spanish ritual that his hymns were most largely used. In the Mozarabic Breviary almost the whole of one of his finest poems (from which most churches took one part only, beginning "Corde natus ex parentis") was appointed to be sung between Easter and Ascension-Day, being divided into eight or nine hymns; and on some of the commemorations of Spanish saints long poems from his *Peristephana* were recited or sung at large. He is entitled to a high rank among Christian poets, many of the hymns taken from his works being full of fervour and sweetness, and by no means deficient in dignity or strength.

5th and 6th centuries.

These writers were followed in the 5th and early in the 6th century by the priest Sedulius, whose reputation perhaps exceeded his merit; Elpis, a noble Roman lady, wife of the philosophic statesman Boetius; Pope Gelasius; and Ennodius, bishop of Pavia. Sedulius and Elpis wrote very little from which hymns could be extracted; but the small number taken from their compositions obtained wide popularity, and have since held their ground. Gelasius was of no great account as a hymn-writer; and the works of Ennodius appear to have been known only in Italy and Spain. The latter part of the 6th century produced Pope Gregory the Great, and Venantius Fortunatus, an Italian poet, the friend of Gregory, and the favourite of Radegunda, queen of the Franks, who died (609) bishop of Poitiers. Eleven hymns of Gregory, and twelve or thirteen (mostly taken from longer poems) by Fortunatus, came into general use in the Italian, Gallican, and British churches. Those of Gregory are in a style hardly distinguishable from the Ambrosian; those of Fortunatus are graceful, and sometimes vigorous. He does not, however, deserve the praise given to him by Dr Neale, of having struck out a new path in Latin hymnody. On the contrary, he may more justly be described as a disciple of the school of Prudentius, and as having affected the classical style, at least as much as any of his predecessors.

The poets of this primitive epoch, which closed with the 6th century, wrote in the old classical metres, and made use of a considerable variety of them—anapæstic, anacreontic, hendecasyllabic, asclepiad, hexameters and pentameters, and others. Gregory and some of the Ambrosian authors occasionally wrote in sapphics; but the most frequent measure was the iambic dimeter, and, next to that, the trochaic. The full alcaic stanza does not appear to have been used for church purposes before the 16th century, though some of its elements were. In the greater number of these works, a general intention to conform to the rules of Roman prosody is manifest; but even those writers (like Prudentius) in whom that conformity was most decided allowed themselves much liberty of deviation from it. Other works, including some of the very earliest, and some of conspicuous merit, were of the kind described by Bede as not metrical but "rhythmical,"—*i.e.* (as he explains the term "rhythm"), "modulated to the ear in imitation of different metres." It would be more correct to call them metrical—(*e.g.*, still trochaic or iambic, &c., but, according to new laws of syllabic quantity, depending entirely on accent, and not on the power of vowels or the position of consonants,—laws by which the future prosody of all modern European nations was to be governed. There are also, in the hymns of the primitive period (even in those of Ambrose), anticipations,—irregular indeed and inconstant, but certainly not accidental,—of another great innovation, destined to receive important developments, that of assonance or rhyme, in the final letters or syllables of verses. Archbishop Trench, in the introduction to his *Sacred Latin Poetry*, has traced the whole course of the transition from the ancient to the modern forms of versification, ascribing it to natural and necessary causes, which made such changes needful for the due development of the new forms of spiritual and intellectual life, consequent upon the conversion of the Latin speaking nations to Christianity.

6th century downward.

From the 6th century downwards we see this transformation making continual progress, each nation of Western Christendom adding, from time to time, to the earlier hymns in its service-books others of more recent and frequently of local origin. For these additions, the commemorations of saints, &c., as to which the devotion of one place often differed from that of another, offered especial opportunities. This process, while it promoted the development of a mediæval as distinct from the primitive style, led also to much deterioration in the quality of hymns, of which, perhaps, some of the strongest examples may be found in a volume published in 1865 by the Irish Archæological Society from a manuscript in the library of Trinity College, Dublin. It contains a number of hymns by Irish saints of the 6th, 7th, and 8th centuries,—in several instances fully rhymed, and in one mixing Erse and Latin barbarously together, as was not uncommon, at a much later date, in semi-vernacular hymns of other countries. The Mozarabic Breviary, and the collection of hymns used in the Anglo-Saxon churches, published in 1851 by the Surtees Society (chiefly from a Benedictine MS. in the college library of Durham, supplemented by other MSS. in the British Museum), supply many further illustrations of the same decline of taste:—such sapphics, *e.g.*, as the "Festum insigne prodiit coruscum" of Isidore, and the "O veneranda Trinitas laudanda" of the Anglo-Saxon books. The early mediæval period, however, from the time of Gregory the Great to that of Hildebrand, was far from deficient in the production of good hymns, wherever learning flourished. Bede in England, and Paul "the Deacon,"—the author of a fairly classical sapphic ode on St John the Baptist,—in Italy, were successful followers of the Ambrosian and Gregorian styles. Eleven metrical hymns are attributed to Bede by Cassander; and there are also in one of Bede's works (*Collectanea et Flores*) two rhythmical hymns of considerable length on the Day of Judgment, with the refrains "In tremendo die" and "Attende homo," both irregularly rhymed, and, in parts, not unworthy of comparison with the "Dies Iræ." Paulinus, patriarch of Aquileia, contemporary with Paul, wrote rhythmical trimeter iambics in a manner peculiar to himself. Theodulph, bishop of Orleans (793–835), author of the famous processional hymn for Palm Sunday in hexameters and pentameters, "Gloria, laus, et honor tibi sit, Rex Christe Redemptor" ("Glory and honour and laud be to Thee, King Christ the Redeemer"), and Hrabanus Maurus, archbishop of Mainz (847–856), the pupil of Alcuin, and the most learned theologian of his day, enriched the church with some excellent works. Among the anonymous hymns of the same period there are three of great beauty, of which the influence may be traced in most, if not all, of the "New Jerusalem" hymns of later generations, including those of Germany and Great Britain:—"Urbs beata Hierusalem" ("Blessed city, heavenly Salem"); "Alleluia piis edite laudibus" ("Alleluias sound ye in strains of holy praise,"—called, from its burden, "Alleluia perenne"); and "Alleluia dulce carmen" ("Alleluia, song of sweetness"), which, being found in Anglo-Saxon hymnaries certainly older than the Conquest, cannot be of the late date assigned to it, in his *Mediæval Hymns and Sequences*, by Dr Neale. These were followed by the "Chorus novæ Hierusalem" ("Ye Choirs of New Jerusalem") of Fulbert, bishop of Chartres (1007–1028). This group of hymns is remarkable for an attractive union of melody, imagination, poetical colouring, and faith. It represents, perhaps, the best and highest type of the middle school, between the severe Ambrosian simplicity and the florid luxuriance of later times.

Veni Creator. Another celebrated hymn, which belongs to the first mediæval period, is the "Veni Creator Spiritus" ("Come, Holy Ghost, our souls inspire"). The earliest recorded occasion of its use is that of a translation (898) of the relics of St Marcellus, mentioned in the *Annals* of the Benedictine order. It has since been constantly sung throughout Western Christendom (as versions of it still are in the Church of England), as part of the appointed offices for the coronation of kings, the consecration and ordination of bishops and priests, the assembling of synods, and other great ecclesiastical solemnities. It has been attributed—probably in consequence of certain corruptions in the text of Ekkehard's *Life of Notker* (a work of the 13th century)—to Charlemagne. Ekkehard wrote in the Benedictine monastery of St Gall, to which Notker belonged, with full access to its records; and an ignorant interpolator, regardless of chronology, added, at some later date, the word "Great" to the name of "the emperor Charles," wherever it was mentioned in that work. The biographer relates that Notker,—a man of a gentle contemplative nature, observant of all around him, and accustomed to find spiritual and poetical suggestions in common sights and sounds,—was moved by the sound of a mill-wheel to compose his "sequence" on the Holy Spirit, "Sancti Spiritus adsit nobis gratia" ("Present with us ever be the Holy Spirit's grace"); and that, when finished, he sent it as a present to "the emperor Charles," who in return sent him back, "by the same messenger," the hymn "Veni Creator," which (says Ekkehard), the same "Spirit had inspired him to write" ("Sibi idem Spiritus inspiraverat"). If this story is to be credited,—and, from its circumstantial and almost dramatic character, it has an air of truth,—the author of "Veni Creator" was not Charlemagne, but his grandson Charles the Bald, who succeeded to the royal crown in 840, about the time when Notker was born, and to the imperial in 875. Notker himself long survived that emperor, and died in 912.

Sequences. The invention of "sequences" by Notker may be regarded as the beginning of the later mediæval epoch of Latin hymnody. In the eucharistic service, in which (as has been stated) hymns were not generally used, it had been the practice, except at certain seasons, to sing "laud," or "Alleluia," between the epistle and the gospel, and to fill up what would otherwise have been a long pause, by extending the cadence upon the two final vowels of the "Alleluia" into a protracted strain of music. It occurred to Notker that, while preserving the spirit of that part of the service, the monotony of the interval might be relieved by introducing at that point a chant of praise specially composed for the purpose. With that view he produced the peculiar species of rhythmical composition which obtained the name of "sequentia" (probably from following after the close of the "Alleluia"), and also that of "prosa," because its structure was originally irregular and unmetrical, resembling in this respect the Greek "troparia," and the "Te Deum," "Benedicite," and canticles. That it was in some measure suggested by the forms of the later Greek hymnody seems probable, both from the intercourse (at that time frequent) between the Eastern and Western churches, and from the application by Ekkehard, in his biography and elsewhere (*e.g.*, in Lyndwood's *Provinciale*), of some technical terms, borrowed from the Greek terminology, to works of Notker and his school and to books containing them.

Dr Neale, in a learned dissertation prefixed to his collection of sequences from mediæval Missals, and enlarged in a Latin letter to Dr Daniel (printed in the fifth volume of Daniel's *Thesaurus*), has investigated the laws of cæsura and modulation which are discoverable in these works. Those first brought into use were sent by their author to Nicholas I., pope from 858 to 867, who authorized their use, and that of others composed after the same model by other brethren of St Gall, in all churches of the West.

Although the sequences of Notker and his school, which then rapidly passed into most German, French, and British Missals, were not metrical, the art of "assonance" was much practised in them. Many of those in the Sarum and French Missals have every verse, and even every clause or division of a verse, ending with the same vowel "a,"—perhaps with some reference to the terminal letter of "Alleluia." Artifices such as these naturally led the way to the adaptation of the same kind of composition to regular metre and fully developed rhyme. Dr Neale's full and large collection, and the second volume of Dr Daniel's *Thesaurus*, contain numerous examples, both of the "proses," properly so called, of the Notkerian type, and of those of the later school, which (from the religious house to which its chief writer belonged) has been called "Victorine." Most Missals appear to have contained some of both kinds. In the majority of those from which Dr Neale's specimens are taken, the metrical kind largely prevailed; but in some (*e.g.*, those of Sarum and Liége) the greater number were Notkerian.

Of the sequence on the Holy Ghost, sent by Notker (according to Ekkehard) to Charles the Bald, Dr Neale says that it "was in use all over Europe, even in those countries, like Italy and Spain, which usually rejected sequences"; and that, "in the Missal of Palencia, the priest was ordered to hold a white dove in his hands, while intoning the first syllables, and then to let it go." Another of the most remarkable of Notker's sequences, beginning "Media in vita" ("In the midst of life we are in death"), is said to have been suggested to him while observing some workmen engaged in the construction of a bridge over a torrent near his monastery. Miss Winkworth states that this was long used as a battle-song, until the custom was forbidden, on account of its being supposed to exercise a magical influence. A translation of it ("Mitten wir im Leben sind") is one of Luther's funeral hymns; and all but the opening sentence of that part of the burial service of the Church of England which is directed to be "said or sung" at the grave, "while the corpse is made ready to be laid into the earth," is taken from it.

The "Golden Sequence," "Veni, sancte Spiritus" ("Holy Spirit, Lord of Light"), is an early example of the transition of sequences from a simply rhythmical to a metrical form. Archbishop Trench, who esteems it "the loveliest of all the hymns in the whole circle of Latin sacred poetry," is inclined to give credit to a tradition which ascribes its authorship to Robert II., king of France, son of Hugh Capet (997–1031). Others have assigned to it a later date,—some attributing it to Pope Innocent III., and some to Stephen Langton, archbishop of Canterbury. Many translations, in German, English, and other languages, attest its merit. Berengarius of Tours, St Bernard of Clairvaux, and Abelard, in the 11th century and early in the 12th, followed in the same track; and the art of the Victorine school was carried to its greatest perfection by Adam of St Victor (who died between 1173 and 1194),—"the most fertile, and" (in the concurrent judgment of Archbishop Trench and Dr Neale) "the greatest of the Latin hymnographers of the Middle Ages." The archbishop's selection contains many excellent specimens of his works.

But the two most widely celebrated of all this class of compositions,—works which have exercised the talents of the greatest musical composers, and of innumerable translators in almost all languages,—are the "Dies Iræ" ("That day of wrath, that dreadful day"), by Thomas de Celano, the companion and biographer of St Francis of Assisi (who died in 1226), and the "Stabat Mater dolorosa" ("By the cross sad vigil keeping") of Jacopone or Jacobus de Benedictis, a Franciscan humorist and reformer, who was persecuted by Pope Boniface VIII. for his satires on the prelacy of the time, and died very old in 1306. Besides these, the 13th century produced the famous sequence "Lauda Sion Salvatorem" ("Sion, lift

Dies Iræ. Stabat Mater.

thy voice and sing"), and the four other well-known sacramental hymns of St Thomas Aquinas, viz., "Pange lingua gloriosi corporis mysterium" ("Sing, my tongue, the Saviour's glory"), "Verbum supernum prodiens" ("The Word, descending from above"—not to be confounded with the Ambrosian hymn from which it borrowed the first line), "Sacris solemniis juncta sint gaudia" ("Let us with hearts renewed our grateful homage pay"), and "Adoro Te devote, latens Deitas" ("O Godhead hid, devoutly I adore Thee"),—a group of remarkable compositions, written by him for the then new festival of Corpus Christi, of which he induced Pope Urban IV. (1261–1265) to decree the observance. In these (of which all but "Adoro Te devote," &c., passed rapidly into Breviaries and Missals) the doctrine of transubstantiation is set forth with a wonderful degree of scholastic precision; and they exercised, probably, a not unimportant influence upon the general reception of that dogma. They are undoubtedly works of genius, powerful in thought, feeling, and expression.

Aquinas.

Mediæval hymns.

These and other mediæval hymn-writers of the 12th and 13th centuries may be described, generally, as poet-schoolmen. Their tone is contemplative, didactic, theological; they are especially fertile and ingenious in the field of mystical interpretation. Two great monasteries in the East had, in the 8th and 9th centuries, been the principal centres of Greek hymnology; and, in the West, three monasteries,—St Gall, near Constance (which was long the especial seat of German religious literature), Cluny in Burgundy, and St Victor, near Paris,—obtained a similar distinction. St Gall produced, besides Notker, several distinguished sequence writers, probably his pupils,—Hartmann, Hermann, and Gottschalk,—to the last of whom Dr Neale ascribes the "Alleluiatic Sequence" ("Cantemus cuncti melodum nunc Alleluia"), well known in England through his translation, "The strain upraise of joy and praise." The chief poets of Cluny were two of its abbots, Odo (who died in 947) and Peter the Venerable (1122–1156), and one of Peter's monks, Bernard of Morlaix, who wrote the remarkable poem on "Contempt of the World" in about 3000 long rolling "leonine-dactylic" verses, from parts of which Dr Neale's popular hymns, "Jerusalem the golden," &c., are taken. The abbey of St Victor, besides Adam and his follower Pistor, was destined afterwards to produce the most popular church poet of the 17th century.

There were other distinguished Latin hymn-writers of the later mediæval period besides those already mentioned. The name of St Bernard of Clairvaux cannot be passed over with the mere mention of the fact that he was the author of some metrical sequences. He was, in truth, the father, in Latin hymnody, of that warm and passionate form of devotion which some may consider to apply too freely to Divine Objects the language of human affection, but which has, nevertheless, been popular with many devout persons, in Protestant as well as Roman Catholic churches. Spee, "Angelus," Madame Guyon, Bishop Ken, Count Zinzendorf, and Frederick William Faber may be regarded as disciples in this school. Many hymns, in various languages, have been founded upon St Bernard's "Jesu dulcis memoria" ("Jesu, the very thought of Thee"), "(Jesu dulcedo cordium" ("Jesu, Thou joy of loving hearts"), and "Jesu Rex admirabilis" ("O Jesu, King most wonderful"), —three portions of one poem, nearly 200 lines long. Cardinal Damiani, the friend of Pope Gregory VII., Marbode (bishop of Rennes) in the 11th, Hildebert (archbishop of Tours) in the 12th, and Cardinal Bonaventura in the 13th centuries, are other eminent men, who added poetical fame, as hymnographers, to high public distinction.

Bernard of Clairvaux.

Before the time of the Reformation, the multiplication of sequences (often as unedifying in matter as unpoetical in style) had done much to degrade the common conception of hymnody. In some parts of France, Portugal, Sardinia, and Bohemia, their use in the vernacular language had been allowed. In Germany also there were vernacular sequences as early as the 12th century, specimens of which may be seen in the third chapter of Miss Winkworth's *Christian Singers of Germany*. Scoffing parodies upon sequences are said to have been among the means used in Scotland to discredit the old church services. After the 15th century they were discouraged at Rome. They retained for a time some of their old popularity among German Protestants, and were only gradually relinquished in France. A new "prose," in honour of St Maxentia, is among the compositions of Jean Baptiste Santeul; and Dr Daniel's second volume closes with one written in 1855 upon the dogma of the Immaculate Conception.

Romai vision hymns

The taste of the Renaissance was offended by all deviations from classical prosody and Latinity. Pope Leo X. directed the whole body of the hymns in use at Rome to be reformed; and a volume of "new ecclesiastical hymns," prepared by Ferreri, a scholar of Vicenza, to whom Leo had committed that task, appeared in 1523, with the sanction of a later pope, Clement VII. The next step was to revise the whole Roman Breviary. That undertaking, after passing through several stages under different popes (particularly Pius V. and Clement VIII.), was at last brought to a conclusion by Urban VIII., in 1631. From this revised Breviary a large number of mediæval hymns, both of the earlier and the later periods, were excluded; and in their places many new hymns, including some by Pope Urban himself, and some by Cardinal Bellarmine and another cardinal (Silvius Antonianus) were introduced. The hymns of the primitive epoch, from Hilary to Gregory the Great, for the most part retained their places (especially in the offices for every day of the week); and there remained altogether from seventy to eighty of earlier date than the 11th century. Those, however, which were so retained were freely altered, and by no means generally improved. The revisers appointed by Pope Urban (three learned Jesuits,—Strada, Gallucci, and Petrucci), professed to have made "as few changes as possible" in the works of Ambrose, Gregory, Prudentius, Sedulius, Fortunatus, and other "poets of great name." But some changes, even in those works, were made with considerable boldness; and the pope, in the "constitution" by which his new book was promulgated, boasted that, "with the exception of a very small number ('perpaucis'), which were either prose or merely rhythmical, all the hymns had been made conformable to the laws of prosody and Latinity, those which could not be corrected by any milder method being entirely rewritten." The latter fate befel, among others, the beautiful "Urbs beata Hierusalem," which now assumed the form (to many, perhaps, better known), of "Cœlestis urbs Jerusalem." Of the "very few" which were spared, the chief were "Ave maris stella" ("Gentle star of ocean"), "Dies Iræ," "Stabat Mater dolorosa," the hymns of Thomas Aquinas, two of St Bernard, and one Ambrosian hymn, "Jesu nostra Redemptio" ("O Jesu, our Redemption"), which approaches nearer than others to the tone of St Bernard. A then recent hymn of St Francis Xavier, with scarcely enough merit of any kind to atone for its neglect of prosody, "O Deus, ego amo Te" ("O God, I love Thee, not because"), was at the same time introduced without change. This hymnary of Pope Urban VIII. is now in general use throughout the Roman Communion.

Paris revisi

The Parisian hymnary underwent three revisions—the first in 1527, when a new "Psaltery with hymns" was issued. In this such changes only were made as the revisers thought justifiable upon the principle of correcting supposed corruptions of the original text. Of these, the transposition, "Urbs Jerusalem beata," instead of "Urbs beata Hierusalem," may be taken as a typical example. The next revision was in 1670–1680, under Cardinal Péréfixe, preceptor of Louis XIV., and Francis Harlay, successively archbishops of Paris, who employed for this purpose Claude Santeul, of the monastery of St Magloire, and, through him, obtained the assistance of other French scholars, including his more celebrated brother, Jean Baptiste Santeul, of the abbey of St Victor,—better known as "Santolius Victorinus." The third and final revision was completed in 1735, under the primacy of Cardinal Archbishop de Vintimille, who engaged for it the services of Charles Coffin, then rector of the university of Paris. Many old hymns were omitted in Archbishop Harlay's Breviary, and a large number of new compositions, by the Santeuls and others, was introduced. It still, however, retained in their old places (without further changes than had been made in 1527) about seventy of earlier date than the 11th century,—including thirty-one Ambrosian, one by Hilary, eight by Prudentius, seven by Fortunatus, three by Paul the Deacon, two each by Sedulius, Elpis, Gregory, and Hrabanus Maurus, "Veni Creator," and "Urbs Jerusalem beata." Most of these disappeared in 1735, although Cardinal Vintimille, in his preface, professed to have still admitted the old hymns, except when the new were better —("veteribus hymnis locus datus est, nisi quibus, ob sententiarum vim, elegantiam verborum, et teneriores pietatis sensus, recentiores anteponi satius visum est"). The number of the new was, at the same time, very largely increased. Only twenty-one more ancient than the 16th century remained, of which those belonging to the primitive epoch were but eight, viz., four Ambrosian, two by Fortunatus, and one each by Prudentius and Gregory. The number of Jean Baptiste Santeul's hymns (who had died in 1697) rose to eighty-nine; those by Coffin,—including some old hymns, *e.g.*, "Jam lucis orto sidere" ("Once more the sun is beaming bright"), which he substantially re-wrote,—were eighty-three; those of other modern French writers, ninety-seven. Whatever opinion may be entertained of the principles on which these Roman and Parisian revisions proceeded, it would be unjust to deny very high praise as hymn-writers to several of their poets, especially to Coffin and Jean Baptiste Santeul. The noble hymn by Coffin, beginning—

"O luce qui mortalibus Lates inaccessa, Deus, Præsente quo sancti tremunt Nubuntque vultus angeli,"	"O Thou who in the light dost dwell, To mortals unapproachable, Where angels veil them from Thy rays, And tremble as they gaze,"

and several others of his works, breathe the true Ambrosian spirit; and though Santeul (generally esteemed the better poet of the two) delighted in alcaics, and did not greatly affect the primitive manner, there can be no question as to the excellence of such hymns as his "Fumant Sabæis templa vaporibus" ("Sweet incense breathes around"), "Stupete gentes, fit Deus hostia" ("Tremble, ye Gentile lands"), "Hymnis dum resonat curia cœlitum" ("Ye in the house of heavenly morn"), and "Templi sacratas pande, Sion, fores" ("O Sion, open wide thy gates"). It is a striking testimony to the merits of those writers that such accomplished translators as the Rev. Isaac Williams and the Rev. John Chandler appear (from the title page of the latter, and the prefaces of both) to have supposed their hymns to be "ancient" and "primitive." Among the other authors associated with them, perhaps the first place is due to the Abbé Besnault, of Sens, who contributed to the book of 1735 the "Urbs beata vera pacis Visio Jerusalem," in the opinion of Dr Neale "much superior" to the "Cœlestis urbs Jerusalem" of the Roman Breviary. This stood side by side with the "Urbs Jerusalem beata" of 1527 (in the office for the dedication of churches) till 1822, when the older form was at last finally excluded by Archbishop de Quelen.

The Parisian Breviary of 1735 remained in use till the national French service-books were superseded (as they have lately been, generally, if not universally) by the Roman. Almost all French dioceses followed, not indeed the Breviary, but the example, of Paris; and before the end of the 18th century the ancient Latin hymnody was all but banished from France.

odern tin mns. In some parts of Germany, after the Reformation, Latin hymns continued to be used even by Protestants. This was the case at Halberstadt until quite a recent date. In England, a few are still occasionally used in the older universities and colleges. Some, also, have been composed in both countries since the Reformation. The "Carmina Lyrica" of John Jacob Balde, a native of Alsace, and a Jesuit priest in Bavaria, have received high commendation from very eminent German critics, particularly Herder and Augustus Schlegel. Some of the Latin hymns of William Alard, a Protestant refugee from Belgium, and pastor in Holstein (1572–1645), have been thought worthy of a place in Archbishop Trench's selection. Two by W. Petersen (printed at the end of Haberkorn's supplement to Jacobi's *Psalmodia Germanica*) are good in different ways,—one, "Jesu dulcis amor meus" ("Jesus, Thee my soul doth love"), being a gentle melody of spiritual devotion, and the other, entitled *Spes Sionis*, violently controversial against Rome. An English hymn of the 17th century, in the Ambrosian style, "Te Deum Patrem colimus" ("Almighty, Father, just and good"), is sung on every May-Day morning by the choristers of Magdalen College, Oxford, from the top of the tower of their chapel; and another in the style of the Renaissance, of about the same date, "Te de profundis, summe Rex" ("Thee from the depths, Almighty King"), is, or until lately was, sung as part of a grace by the scholars of Winchester College.

ithori- s. The principal ancient authorities on Latin hymnody are the 25th chapter ("De hymnis et cantilenis et incrementis eorum") of the treatise of Walafridus Strabo, and a treatise of the 14th century ("De Psalterio observando"), by Radulphus, dean of Tongres in the Netherlands. Next to those are the first book of Clichtovens's *Elucidatorium Ecclesiasticum* (Paris, 1556); the chapter on Ambrosian and other hymns in the works of George Cassander (Paris, 1616); the *Psalterium*, &c., in the second volume of the works of Cardinal J. M. Thomasius (Rome, 1747); and the treatise "De Hymnis Ecclesiasticis," prefixed to the *Hymnodia Hispanica* of Faustinus Arevalus (Rome, 1786). The present century, more especially within the last fifty years, has added much to the stores of learning accessible on this subject. In Germany, Rambach's *Christian Anthology*; Mone's *Hymni Latini medii Ævi;* Daniel's *Thesaurus Hymnologicus*; and Mohnike's *Hymnologische Forschungen*;—and in England, Archbishop Trench's *Sacred Latin Poetry*; Dr Neale's two collections of *Latin Hymns and Sequences* (Oxford, 1851 and 1852), and his *Essays on Liturgiology and Church History*; the Oxford collection of Hymns from the Roman, Sarum, York, and other Breviaries (1838); the *Psalter*, &c., according to Sarum use, of Mr J. D. Chambers (1852); and the two volumes already referred to of Anglo-Saxon and Irish hymns, published in 1851 and 1865 by the Surtees Society and the Irish Archæological Society, have left little to be added by any future labourers in this field. The same period has also produced numerous English translations of Latin hymns, many of which are good and interesting, though perhaps few of the translators have overcome the inherent difficulties of their task sufficiently either to represent the characteristic merits of the originals, or to add to our vernacular hymns many adaptations really well-suited for popular use. The most important are—Mr Isaac Williams's *Hymns from the Parisian Breviary* (1839), and Mr Chandler's *Hymns of the Primitive Church* (1837); Bishop Mant's volume of 1837, and the Rev. Edward Caswall's *Lyra Catholica* (1849), both from the Roman Breviary; the versions of Mr Chambers, in his Sarum *Psalter*, &c.; Dr Neale's *Mediæval Hymns and Sequences* (1862), with his versions, separately published, of some other works; and *Hymns of the Latin Church*, translated by David T. Morgan, with the originals appended (privately printed in 1871). The first lines, in English, given in this article, are generally adopted from some of these.

5. *German Hymnody.*

Luther was a proficient in and a lover of music. He desired (as he says in the preface to his hymn-book of 1545) that this "beautiful ornament" might "in a right manner serve the great Creator and His Christian people." The persecuted Bohemian or Hussite Church, then settled on the borders of Moravia under the name of "United Brethren" (which their descendants still retain), had sent to him, on a mission in 1522, Michael Weiss, who not long afterwards published a number of German translations from old Bohemian hymns (known as those of the "Bohemian Brethren"), with some of his own. These Luther highly approved and recommended. He himself, in 1522, published a small volume of eight hymns, which was enlarged to 63 in 1527, and to 125 in 1545. He had formed what he called a "house choir" of musical friends, to select such old and popular tunes (whether secular or ecclesiastical) as might be found suitable, and to compose new melodies, for church use. His fellow labourers in this field (besides Weiss) were Justus Jonas, his own especial colleague; Paul Eber, the disciple and friend of Melanchthon; John Walther, choirmaster successively to several German princes, and professor of arts, &c., at Wittenberg; Nicholas Decius, who from a monk became a Protestant teacher in Brunswick, and translated the "Gloria in Excelsis," &c.; and Paul Speratus, chaplain to Duke Albert of Prussia in 1525. Some of their works are still popular in Germany. Weiss's "Funeral Hymn," "Nun lasst uns den Leib begraben" ("Now lay we calmly in the grave"); Eber's "Herr Jesu Christ, wahr Mensch und Gott" ("Lord Jesus Christ, true Man and God"), and "Wenn wir in höchsten Nöthen sein" ("When in the hour of utmost need"); Walther's "New Heavens and new Earth" ("Now fain my joyous heart would sing"); Decius's "To God on high be thanks and praise;" and Speratus's "Salvation now has come for all," are among those which at the time produced the greatest effect, and are still best remembered. Luther.

Luther's own hymns, thirty-seven in number (of which about twelve are translations or adaptations from Latin originals), are for the principal Christian seasons; on the sacraments, the church, grace, death, &c; and paraphrases of seven psalms, of a passage in Isaiah, and of the Lord's Prayer, Ten Commandments, Creed, Litany, and "Te Deum." There is also a very touching and stirring song on the martyrdom of two youths by fire at Brussels, in 1523–24. Homely and sometimes rugged in form, and for the most part objective in tone, they are full of fire, manly simplicity, and strong faith. Three rise above the rest. One for Christmas, "Vom Himmel hoch da komm ich her" ("From Heaven above to earth I come"), has a reverent tenderness, the influence of which may be traced in many later productions on the same subject. That on salvation through Christ, of a didactic character, "Nun freuet euch, lieben Christen g'mein" ("Dear Christian people, now rejoice"), is said to have made many conversions, and to have been once taken up by a large congregation to silence a Roman Catholic preacher in the cathedral of Frankfort. Pre-eminent above all is the celebrated paraphrase of the 46th Psalm: "Ein' feste Burg ist unser Gott" ("A sure stronghold our God is He"),—"the production" (as Ranke says) "of the moment in which Luther, engaged in a conflict with a world of foes, sought strength in the consciousness that he was defending a divine cause which could never perish." Carlyle compares it to "a sound of Alpine avalanches, or the first murmur of earthquakes." Heine called it "the Marseillaise of the Reformation."

Luther spent several years in teaching his people at Wittenberg to sing these hymns, which soon spread over Germany. Without adopting the hyperbolical saying of Coleridge, that "Luther did as much for the Reformation by his hymns as by his translation of the Bible," it may truly be affirmed that, among the secondary means by which the success of the Reformation was promoted, none was more powerful. They were sung everywhere,—in the streets and fields as well as the churches, in the workshop and the palace, "by children in the cottage and by martyrs on the scaffold." It was by them that a congregational character was given to the new Protestant worship. This success they owed partly to their metrical structure, which, though sometimes complex, was recommended to the people by its ease and variety; and partly to the tunes and melodies (many of them already well known and popular) to which they were set. They were used as direct instruments of teaching, and were therefore, in a large measure, didactic and theological; and it may be partly owing to this cause that German hymnody came to deviate, so soon and so generally as it did, from the simple idea expressed in the ancient Augustinian definition, and to comprehend large classes of compositions which, in most other countries, would be thought hardly suitable for church use.

Followers of Luther. The principal hymn-writers of the Lutheran school, in the latter part of the 16th century, were Selnecker, Nicholas Hermann, and Hans Sachs, the shoemaker of Nuremberg, also known in other branches of literature. All these wrote some good hymns. They were succeeded by men of another sort, to whom Cunz gives the name of "master-singers," as having raised both the poetical and the musical standard of German hymnody:—Ringwaldt, Helmbold, Pappus, Schalling, Rutilius, and Weingartner. The principal topics of their hymns (as if with some foretaste of the calamities which were soon to follow) were the vanity of earthly things, resignation to the Divine will, and preparation for death and judgment. The well-known English hymn, "Great God, what do I see and hear," is founded upon one by Ringwaldt. Of a quite different character were two of great beauty and universal popularity, composed by Philip Nicolai, a Westphalian pastor, during a pestilence in 1597, and published by him, with fine chorales, two years afterwards. One of these (the "Sleepers wake! a voice is calling," of Mendelssohn's oratorio, *St Paul*) belongs to the family of Advent or New Jerusalem hymns. The other, a "Song of the believing soul concerning the Heavenly Bridegroom" ("Wie schön leucht't uns der Morgenstern,"—"O morning Star, how fair and bright"), became the favourite marriage hymn of Germany.

The hymns produced during the Thirty Years' War are characteristic of that unhappy time, which (as Miss Winkworth says) "caused religious men to look away from this world," and made their songs more and more expressive of personal feelings. In point of refinement and graces of style, the hymn-writers of this period excelled their predecessors. Their taste was chiefly formed by the influence of Martin Opitz, the founder of what has been called the "first Silesian school" of German poetry, who died comparatively young in 1639, and who, though not of any great original genius, exercised much power as a critic. Some of the best of these works were by men who wrote little. In the famous battle-song of Gustavus Adolphus, published (1631) after the victory of Leipsic, for the use of his army, "Verzage nicht du Häuflein klein" ("Fear not, O little flock, the foe"), we have almost certainly a composition of the hero-king himself, the versification corrected by his chaplain Fabricius, and the music composed by Altenburg, whose name has been given to the hymn. This, with Luther's paraphrase of the 67th Psalm, was sung by Gustavus and his soldiers before the fatal battle of Lützen. Two very fine hymns, one of prayer for deliverance and peace, the other of trust in God under calamities, were written about the same time by Löwenstern, a saddler's son, poet, musician, and statesman, who was ennobled after the peace by the emperor Ferdinand III. Martin Rinckhart, in 1636, wrote the "Chorus of God's faithful children" ("Nun danket alle Gott,"—"Now thank we all our God"), introduced by Mendelssohn in his "Lobgesang," which has been called the "Te Deum" of Germany, being usually sung on occasions of public thanksgiving. Weissel, in 1635, composed a beautiful Advent hymn ("Lift up your heads, ye mighty gates"), and Meyfart, professor of theology at Erfurt, in 1642, a fine adaptation of the ancient "Urbs beata Hierusalem." The hymn of trust in Providence by Neumarck, librarian to that duke of Weimar who was a distinguished general in the war ("Wer nur den lieben Gott lässt walten"—"Leave God to order all thy ways"), is scarcely, if at all, inferior to that of Paul Gerhardt on the same theme. Paul Flemming, a great traveller and lover of nature, who died young in 1639, also wrote excellent compositions, coloured by the same tone of feeling; and some, of great merit, were composed, soon after the close of the war, by Louisa Henrietta, electress of Brandenburg, granddaughter of the famous Admiral Coligny, and mother of the first king of Prussia. With these may be classed (though of later date) a few striking hymns of faith and prayer under mental anxiety, by Anton Ulrich, duke of Brunswick, whose nominal conversion to Romanism cast a shade over the close of a life otherwise conscientious and honourable. Period of Thirty Years' War.

Heermann. The most copious, and in their day most esteemed, hymn-writers of this first half of the 17th century, were Heermann and Rist. Heermann, a pastor in Silesia, the theatre (in a peculiar degree) of war and persecution, experienced in his own person a very large share of the miseries of the time, and several times narrowly escaped a violent death. His *Devoti Musica Cordis*, published in 1630, reflects the feelings natural under such circumstances. With a correct style and good versification, his tone is subjective, and the burden of his hymns is not praise, but prayer. Among his works (which enter largely into most German hymn-books), two of the best are the "Song of Tears," and the "Song of Comfort," translated by Miss Winkworth in her *Christian Singers of Germany*. Rist published about 600 hymns, "pressed out of him," as he said, "by the cross." He was a pastor, and son of a pastor, in Holstein, and lived after the peace to enjoy many years of prosperity, being appointed poet-laureate to the emperor, and finally ennobled. The bulk of his hymns, like those of other copious writers, are of inferior quality; but some, particularly those for Advent, Epiphany, Easter Eve, and on Angels, are very Rist.

good. They are more objective than those of Heermann, and written, upon the whole, in a more manly spirit. Next to Heermann and Rist in fertility of production, and
.ch. above them in poetical genius, was Simon Dach, professor of poetry at Königsberg, who died in 1659. Miss Winkworth ranks him high among German poets, "for the sweetness of form and depth of tender contemplative emotion to be found in his verses."

The fame of all these writers was eclipsed in the latter part of the same century by three of the greatest hymnographers whom Germany has produced,—Paul Gerhardt (1604–1676), John Franck (1618–1677), and John Scheffler (1624–1677), the founder of the "second Silesian
hardt. school," who assumed the name of "Angelus." Gerhardt is by universal consent the prince of Lutheran poets. His compositions (which may be compared, in many respects, to those of the *Christian Year*) are lyric poems, of considerable length, rather than hymns, though many hymns have been taken from them. They are, with few exceptions, subjective, and speak the language of individual experience. They occupy a middle ground between the masculine simplicity of the old Lutheran style and the highly wrought religious emotion of the later Pietists, towards whom they (on the whole) incline. Being nearly all excellent, it is not easy to distinguish among the 123 those which are entitled to the highest praise. Two, which were written one during the war and the other after the conclusion of peace, "Zeuch ein zu deinen Thoren" ("Come to Thy temple here on earth"), and "Gottlob, nun ist erschollen," ("Thank God, it hath resounded"), are historically interesting. Of the rest, one is well known and highly appreciated in England through Wesley's translation, "Commit thou all thy ways," &c.; and the Evening and Spring-tide hymns ("Now all the woods are sleeping," and "Go forth, my heart, and seek delight") show an exquisite feeling for nature; while nothing can be more tender and pathetic than "Du bist zwar mein und bleibest mein" ("Thou'rt mine, yes, still thou art mine own"), on the
nck. death of his son. Franck, who was burgomaster of Guben in Lusatia, has been considered by some second only to Gerhardt. If so, it is with a great distance between them. His approach to the later Pietists is closer than that of Gerhardt. His hymns were published, under the title of *Spiritual Zion*, in 1674, some of them being founded on Ambrosian and other Latin originals. Miss Winkworth gives them the praise of a condensed and polished style and fervid and impassioned thought. It was after his
effler. conversion to Romanism that Scheffler adopted the name of "Angelus," and published (1657) his hymns, under a fantastic title, and with a still more fantastic preface. Their key-note is divine love; they are enthusiastic, intense, exuberant in their sweetness, like those of St Bernard among mediæval poets. An adaptation of one of them, by Wesley, "Thee will I love, my Strength, my Tower," is familiar to English readers. Those for the first Sunday after Epiphany, Sexagesima Sunday, and Trinity Sunday, in *Lyra Germanica*, are good examples of his excellences, with few of his defects. His hymns are generally so free from the expression, or even the indirect suggestion, of Roman Catholic doctrine, that it has been supposed they were written before his conversion, though published afterwards. The evangelical churches of Germany found no difficulty in admitting them to that prominent place in their services which they have ever since retained.

tists. Towards the end of the 17th century, a new religious school arose, to which the name of "Pietists" was given, and of which Philip Jacob Spener was esteemed the founder. He and his pupils and successors, August Hermann Francke and Anastasius Freylinghausen, all wrote hymns. Spener's hymns are not remarkable, and Francke's are not numerous. Freylinghausen was their chief singer: his rhythm is lively, his music florid; but, though his book attained extraordinary popularity, he was surpassed in solid merit by other less fertile writers of the same school. The "Auf hinauf zu deiner Freude" ("Up, yes, upward to thy gladness") of Schade may recall to an English reader a hymn by Seagrave, and more than one by Lyte; the "Malabarian hymn" (as it was called by Jacobi) of Schütz, "All glory to the Sovereign Good," has been popular in England as well as Germany; and one of the most exquisite strains of pious resignation ever written is "Whate'er my God ordains is right," by Rodigast.

Joachim Neander, a schoolmaster at Düsseldorf, and a Neander. friend of Spener and Schütz (who died before the full development of the "Pietistic" school), was the first man of eminence in the "Reformed" or Calvinistic Church who imitated Lutheran hymnody. This he did, while suffering persecution from the elders of his own church for some other religious practices, which he had also learnt from Spener's example. As a poet, he is sometimes deficient in art; but there is feeling, warmth, and sweetness in many of his "Bundeslieder" or "Songs of the Covenant," and they obtained general favour, both in the Reformed and in Lutheran congregations. The Summer Hymn ("O Thou true God alone") and that on the Glory of God in Creation ("Lo, heaven and earth and sea and air") are instances of his best style.

With the "Pietists" may be classed Schmolke and Dessler, representatives of the "Orthodox" division of Spener's school; Hiller, their leading poet in South Germany; Arnold and Tersteegen, who were practically independent of ecclesiastical organization, though connected, one with the "Orthodox" and the other with the "Reformed" churches; and Louis Count Zinzendorf. Schmolke, a Schmoll… pastor in Silesia, called the Silesian Rist (1672–1737), was perhaps the most voluminous of all German hymnwriters. He wrote 1188 religious poems and hymns, a large proportion of which do not rise above mediocrity. His style, if less refined, is also less subjective and more simple than that of most of his contemporaries. Among his best and most attractive works (which, indeed, it would be difficult to praise too highly) are the "Hosianna David's Sohn," for Palm Sunday,—much resembling a shorter hymn by Jeremy Taylor; and the Ascension, Whitsuntide, and Sabbath hymns,—"Heavenward doth our journey tend," "Come deck our feast to-day," and "Light of light, enlighten me." Dessler was a greater poet than Schmolke. Dessler. Few hymns, of the subjective kind, are better than his "I will not let Thee go, Thou Help in time of need;" "O Friend of souls, how well is me;" and "Now the pearly gates unfold," &c. Hiller was a pastor in Würtemberg Hiller. (1699–1769), who, falling into ill-health during the latter part of his ministry, published a *Casket of Spiritual Songs*, in a didactic vein, with more taste than power, but (as Miss Winkworth says) in a tone of "deep, thoughtful, practical piety." They were so well-adapted to the wants of his people that to this day Hiller's *Casket* is prized, next to their Bibles, by the peasantry of Würtemberg; and the numerous emigrants from that part of Germany to America and other foreign countries generally take it with them wherever they go. Arnold, a professor at Giessen, and Arnold. afterwards a pastor in Brandenburg, was a man of strong will, uncompromising character, and austere views of life, intolerant and controversial towards those whose doctrine or practice he disapproved, and more indifferent to separatism and sectarianism than the "Orthodox" generally thought right. His hymns, like those of our own Toplady (whom in these respects he resembled), unite with considerable strength more gentleness and breadth of sympathy than might be expected from a man of such a character.

Tersteegen. Tersteegen (1697–1769), who never formally separated himself from the "Reformed" communion, in which he was brought up, but whose sympathies were with the Moravians and Count Zinzendorf, was, of all the more copious German hymn-writers after Luther, perhaps the most remarkable man. Pietist, mystic, and missionary, he was also a great religious poet. His 111 hymns were published in 1731, in a volume called *The Spiritual Flower-garden.* They are intensely individual, meditative, and subjective. Wesley's adaptations of two—"Lo! God is here; let us adore," and "Thou hidden Love of God, whose source"—are well known. Among those translated by Miss Winkworth, "O God, O spirit, Light of all that live," and "Come, brethren, let us go," are specimens which exhibit favourably his manner and power. Miss Cox speaks of him as "a gentle heaven-inspired soul, whose hymns are the reflexion of a heavenly, happy life, his mind being full of a child-like simplicity;" and his own poem on the child-character, which Miss Winkworth has appropriately connected with Innocents' day ("Dear Soul, couldst thou become a child")—one of his best compositions, exquisitely conceived and expressed—shows that this was in truth the ideal which he sought to realize. **Zinzendorf.** The hymns of Zinzendorf are often disfigured by excess in the application of the language and imagery of human affections to Divine Objects; and this blemish is also found in many later Moravian hymns. But one hymn, at least, of Zinzendorf may be mentioned with unqualified praise, as uniting the merits of force, simplicity, and brevity,—"Jesu, geh voran" ("Jesus, lead the way"), which is taught to most children of religious parents in Germany. Wesley's "Jesus, Thy blood and righteousness" is a translation from Zinzendorf.

The transition from Tersteegen and Zinzendorf to Gellert and Klopstock marks strongly the reaction against Pietism which took place towards the middle of the 18th century. **Gellert.** The *Spiritual Odes and Songs* of C. F. Gellert were published in 1757, and are said to have been received with an enthusiasm almost like that which "greeted Luther's hymns on their first appearance." It is a proof of the moderation both of the author and of his times that they were largely used, not only by Protestant congregations, but in those German Roman Catholic churches in which vernacular services had been established through the influence of the emperor Joseph II. They became the model which was followed by most succeeding hymn-writers, and exceeded all others in popularity till the close of the century, when a new wave of thought was generated by the movement which produced the French Revolution. Since that time they have been, perhaps, too much depreciated. They are, indeed, cold and didactic, as compared with Scheffler or Tersteegen; but there is nevertheless in them a spirit of genuine practical piety; and, if not marked by genius, they are pure in taste, and often terse, vigorous, and graceful.

Klopstock. Klopstock, the author of the *Messiah*, cannot be considered great as a hymn-writer, though his "Sabbath Hymn" (of which there is a version in *Hymns from the Land of Luther*) is simple and good. Generally his hymns (ten are translated in Mr Sheppard's *Foreign Sacred Lyre*) are artificial and much too elaborate.

Of the "romantic" school, which came in with the French Revolution, the two leading writers are Frederick von Hardenberg, called "Novalis," and Frederick de la Motte Fouqué, the celebrated author of *Undine* and *Sintram*,—both romance-writers, as well as poets. **Novalis.** The genius of Novalis was early lost to the world; he died in 1802, just thirty years old. Some of his hymns are very beautiful; but even in such works as "Though all to Thee were faithless," and "If only He is mine," there is a feeling of insulation and of despondency as to good in the actual world, which was perhaps inseparable from his ecclesiastical idealism. **Fouqué.** Fouqué survived till 1843. In his hymns there is the same deep flow of feeling, richness of imagery, and charm of expression, which distinguishes his prose works. The two missionary hymns—"Thou, solemn Ocean, rollest to the strand," and "In our sails all soft and sweetly,"—and the exquisite composition which finds its motive in the gospel narrative of blind Bartimeus, "Was du vor tausend Jahren" (finely translated both by Miss Winkworth and by Miss Cox), are among the best examples.

The later German hymn-writers of the present century are numerous, and belong, generally, to the revived "Pietistic" school. Some of the best, *e.g.*, Arndt, Albertini, Krummacher, and especially Spitta, have produced works **Spitta.** not unworthy of the fame of their nation. Mr Massie, the able translator of Spitta's *Psaltery and Harp* (published at Leipsic in 1833), speaks of it as having "obtained for him in Germany a popularity only second to that of Paul Gerhardt." Such praise is hyperbolical; posterity alone can adjust the relative places of the writers of this and of former generations. In Spitta's poems (for such they generally are, rather than hymns) the subjective and meditative tone is tempered, not ungracefully, with a didactic element; and they are not, like some contemporary hymns, disfigured by exaggerated sentiment, or by a too florid and rhetorical style.

Authorities. The best and fullest modern collection of choice German hymns is that of Baron von Bunsen, in his *Versuch eines allgemeinen Gesang- und Gebetbuchs* of 1833, unfortunately not reprinted after the first edition. This contains about 900 hymns. In his later *Allgemeines evangelisches Gesang- und Gebetbuch* of 1846 the number was reduced to 440. Many other authors, besides those who have been here mentioned, are represented in these collections, and also in the excellent English translations contained in the *Lyra Germanica* of Miss Winkworth; Miss Cox's *Sacred Hymns from the German*; Miss Fry's *Hymns of the Reformation*; Miss Dunn's *Hymns from the German*; the Misses Borthwick's *Hymns from the Land of Luther*; and the Rev. Arthur T. Russell's *Hymns for the Church of England.* In Cunz's *Geschichte des deutschen Kirchenliedes* (Leipsic, 1855), the number of German hymn-writers named considerably exceeds 300. Besides the volumes of mixed translations from different authors just enumerated (of which the earliest is that of Miss Cox, 1841), translations of Luther's hymns were published by Mr John Hunt, of Preston, in 1853, and by Mr Massie, of Eccleston, in 1854. The *Lyra Domestica* of Mr Massie (which appeared in 1860) contains his translations from Spitta. A much earlier series of English versions of ninety-three mixed German hymns was published in 1722, 1725, and 1732, by John Christian Jacobi, under the patronage of Caroline, queen of George II. To this collection, entitled *Psalmodia Germanica*, a supplement, containing thirty-one more, and also two Latin hymns by Petersen, was added by John Haberkorn in 1765, with a dedication to the mother of George III. Some of these are now sung (though not without considerable alteration) in English churches.

Much of the historical and critical information contained in the foregoing account of German hymnody has been taken from Miss Winkworth's book, entitled *Christian Singers of Germany* (Macmillan, 1869); and to her also we are in most instances indebted for our English renderings of the first lines of hymns. The principal German authorities on the subject, Wackernagel's *Das Deutsche Kirchenlied*, Koch's *Geschichte des Kirchenliedes u Kirchengesanges*, &c., are mentioned in her preface; to which may be added the work already mentioned of F. A. Cunz.

6. *British Hymnody.*

After the Reformation, the development of hymnody was retarded, in both parts of Great Britain, by the example and influence of Geneva. Archbishop Cranmer appears at one time to have been disposed to follow Luther's course, and to present to the people, in an English dress, some at least of the hymns of the ancient church. In a letter to King Henry VIII. (7th October 1544), among some new "processions" which he had himself translated into English, he mentions the Easter hymn, "Salve, festa dies, toto memorabilis ævo" ("Hail, glad day, to be joyfully kept through all generations"), of Fortunatus. In the two "Primers" of 1535 (by Marshall) and of 1539 (by Bishop Hilsey of Rochester, published by order of the vicar-general Cromwell) there had been several rude English hymns, none of them taken from ancient sources. King Henry's "Primer" of 1545 (commanded by his injunction of the 6th May 1545 to be used throughout his dominions) was formed on the model of the daily offices of the Breviary; and it contains English metrical translations from some of the best-known Ambrosian and other early hymns. But in the succeeding reign different views prevailed. A new direction had been given to the taste of the "Reformed" congregations in France and Switzerland by the French metrical translation of the Old Testament Psalms, which appeared about 1540. This was the joint work of Clement Marot, valet or groom of the chamber to Francis I., and Theodore Beza, then a mere youth, fresh from his studies under Wolmar at Orleans.

Marot's Psalms.

Marot's Psalms were dedicated to the French king and the ladies of France, and, being set to popular airs, became fashionable. They were sung by Francis himself, the queen, the princesses, and the courtiers, upon all sorts of secular occasions, and also, more seriously and religiously, by the citizens and the common people. They were soon perceived to be a power on the side of the Reformation. Calvin, who had settled at Geneva in the year of Marot's return to Paris, was then organizing his ecclesiastical system. He rejected the hymnody of the Breviaries and Missals, and fell back upon the idea, anciently held by Paul of Samosata, and condemned by the fourth council of Toledo, that whatever was sung in churches ought to be taken out of the Scriptures. Marot's Psalter, appearing thus opportunely, was introduced into his new system of worship, and appended to his catechism. On the other hand, it was interdicted by the Roman Catholic priesthood. Thus it became a badge to the one party of the "Reformed" profession, and to the other of heresy.

Sternhold and Hopkins.

The example thus set produced in England the translation commonly known as the "Old Version" of the Psalms. It was begun by Thomas Sternhold, whose position in the household of Henry VIII., and afterwards of Edward VI., was similar to that of Marot with Francis I., and whose services to the former of those kings were rewarded by a substantial legacy under his will. Sternhold published versions of thirty-seven Psalms in 1549, with a dedication to King Edward, and died soon afterwards. A second edition appeared in 1551, with seven more Psalms added, by John Hopkins, a Suffolk clergyman. The work was continued during Queen Mary's reign by British refugees at Geneva, the chief of whom were William Whittingham (afterwards dean of Durham), who succeeded John Knox as minister of the English congregation there, and William Kethe (or Keith), said by Strype to have been a Scotchman. They published at Geneva in 1556 a service-book, containing fifty-one English metrical Psalms, which number was increased, in later editions, to eighty-seven. On the accession of Queen Elizabeth, this Genevan Psalmody was at once brought into use in England,—first (according to a letter of Bishop Jewell to Peter Martyr, dated 5th March 1560) in one London church, from which it quickly spread to others both in London and in other cities. Jewell describes the effect produced by large congregations, of as many as 6000 persons, young and old, women and children, singing it after the sermons at St Paul's Cross,—adding, "Id sacrificos et diabolum ægre habet; vident enim sacras conciones hoc pacto profundius descendere in hominum animos." The first edition of the completed "Old Version" (containing forty Psalms by Sternhold, sixty-seven by Hopkins, fifteen by Whittingham, six by Kethe, and the rest by Thomas Norton, a barrister, Robert Wisdom, John Mardley, and Thomas Churchyard) appeared in 1562.

In the meantime, the Books of Common Prayer, &c., of 1549, 1552, and 1559 had been successively established as law by the Acts of Uniformity of Edward VI. and Queen Elizabeth. In these no provision was made for the use of any metrical psalm or hymn on any occasion whatever, except at the consecration of bishops and the ordination of priests, in which offices (first added in 1552) an English version of "Veni Creator" (the longer of the two now in use) was appointed to be "said or sung." The canticles, "Te Deum," "Benedicite," &c., the Nicene and Athanasian Creeds, the "Gloria in Excelsis," and some other parts of the communion and other special offices were also directed to be "said or sung;" and, by general rubrics, the chanting of the whole service was allowed.

The silence, however, of the rubrics in these books as to any other singing was not meant to exclude the use of psalms not expressly appointed, when they could be used without interfering with the prescribed order of any service. It was expressly provided by King Edward's First Act of Uniformity (by later Acts made applicable to the later books) that it should be lawful "for all men, as well in churches, chapels, oratories, or other places, to use openly any psalms or prayers taken out of the Bible, at any due time, not letting or omitting thereby the service, or any part thereof, mentioned in the book." And Queen Elizabeth, by one of the injunctions issued in the first year of her reign, declared her desire that the provision made, "in divers collegiate and also some parish churches, for singing in the church, so as to promote the laudable service of music," should continue. After allowing the use of "a modest and distinct song in all parts of the common prayers of the church, so that the same may be as plainly understanded as if it were read without singing," the injunction proceeded thus—"And yet, nevertheless, for the comforting of such that delight in music, it may be permitted that in the beginning or in the end of the Common Prayer, either at morning or evening, there may be sung an hymn, or such like song to the praise of Almighty God, in the best sort of melody and music that may be conveniently devised, having respect that the sentence" (*i.e.*, sense) "of hymn may be understanded and perceived."

The "Old Version," when published (by John Daye, for the Stationers' Company, "cum gratia et privilegio Regiæ Majestatis"), bore upon the face of it that it was "newly set forth, and allowed to be sung of the people in churches, before and after morning and evening prayer, as also before and after the sermon." The question of its authority has been at different times much debated, chiefly by Heylin and Thomas Warton on one side (both of whom disliked and disparaged it), and by Bishop Beveridge and the Rev. H. J. Todd on the other. Heylin says, it was "permitted rather than allowed," which seems to be a distinction without much difference. "Allowance," which is all that the book claimed for itself, is authorization by way of permission, not of commandment. Its publication in that form could hardly have been licensed, nor could it have passed into use as it did without question, throughout the churches of England, unless it had been "allowed" by some authority then esteemed to be sufficient. Whether that authority was royal or ecclesiastical does not appear, nor (considering the proviso in King Edward's Act of Uniformity, and Queen Elizabeth's injunctions) is it very important. No inference can justly be drawn from the inability of inquirers, in Heylin's time or since, to discover any public record bearing upon this subject, many public documents of that period having been lost.

In this book, as published in 1562, and for many years afterwards, there were (besides the versified Psalms) eleven metrical versions of the "Te Deum," canticles, Lord's Prayer, &c., &c. (the best of which is that of the "Benedicite"); and also "Da pacem, Domine," a hymn suitable to the times, rendered into English from Luther; two original hymns of praise, to be sung before Morning and Evening Prayer; two penitential hymns (one of them the "Humble Lamentation of a Sinner"); and a hymn of faith, beginning, "Lord, in Thee is all my trust." In these respects, and also in the tunes which accompanied the words (stated by Dr Burney, in his *History of Music*, to be German, and not French), there was a departure from the Genevan platform. Some of these hymns, and some of the psalms also (*e.g.*, those by Robert Wisdom, being alternative versions), were omitted at a later period; and many alterations and supposed amendments were from time to time made by unknown hands in the Psalms which remained, so that the text, as now printed, is in many places different from that of 1562.

Scotch Psalms. In Scotland, the General Assembly of the kirk caused to be printed at Edinburgh in 1564, and enjoined the use of, a book entitled *The Form of Prayers and Ministry of the Sacraments used in the English Church at Geneva, approved and received by the Church of Scotland; whereto, besides that was in the former books, are also added sundry other prayers, with the whole Psalms of David in English metre.* This contained all the Psalms of the "Old Version" by Sternhold, Whittingham, and Kethe, but only thirty-seven of those by Hopkins, and none by any of the other English translators. Instead of those omitted, it had nineteen more by Kethe and Whittingham; one by John Pulleyn (one of the Genevan refugees, who became Archdeacon of Colchester); six by Robert Pont, Knox's son-in-law, who was a minister of the kirk, and also a lord of session; and fifteen signed with the initials I. C., supposed to be John Craig.

So matters continued in both churches until the Rebellion. During the interval, King James I. conceived the project of himself making a new version of the Psalms, and appears to have translated thirty-one of them,—the correction of which, together with the translation of the rest, he entrusted to Sir William Alexander, afterwards earl of Stirling. Sir William having completed his task, King Charles the First (after having it examined and approved by several archbishops and bishops of England, Scotland, and Ireland) caused it to be printed in 1631 at the Oxford University Press, as the work of King James; and, by an order under the royal sign manual, recommended its use in all churches of his dominions. In 1634 he enjoined the Privy Council of Scotland not to suffer any other Psalms, "of any edition whatever," to be printed in or imported into that kingdom. In 1636 it was republished, and was attached to the famous Scottish Service-book, with which the troubles began in 1637. It need hardly be added that the king did not succeed in bringing this Psalter into use in either kingdom.

When the Long Parliament undertook, in 1642, the task of altering the liturgy, its attention was at the same time directed to psalmody. It had to judge between two rival translations of the Psalms—one by Francis Rouse, a member of the House of Commons, afterwards one of Cromwell's councillors, and finally provost of Eton; the other by William Barton, a clergyman of Leicester. The House of Lords favoured Barton, the House of Commons Rouse, who had made much use of the labours of Sir William Alexander. Both versions were printed by order of parliament, and were referred for consideration to the Westminster Assembly. They decided in favour of Rouse. His version, as finally amended, was published in 1646, under an order of the House of Commons dated 14th November 1645. In the following year it was recommended by the parliament to the General Assembly at Edinburgh, who appointed a committee, with large powers, to prepare a revised Psalter, recommending to their consideration not only Rouse's book but that of 1564, and two other versions (by Zachary Boyd, and Sir William Mure of Rowallan), then lately executed in Scotland. The result of the labours of this committee was the "Paraphrase" of the Psalms, which, in 1649–1650, by the concurrent authority of the General Assembly and the committee of estates, was ordered to be exclusively used throughout the church of Scotland. Some use was made in the preparation of this book of the versions to which the attention of the revisers had been directed, and also of Barton's; but its basis was that of Rouse. It was received in Scotland with great favour, which it has ever since retained; and it is fairly entitled to the praise of striking a tolerable medium between the rude homeliness of the "Old," and the artificial modernism of the "New" English versions—perhaps as great a success as was possible for such an undertaking. Sir Walter Scott is said to have dissuaded any attempt to alter it, and to have pronounced it, "with all its acknowledged occasional harshness, so beautiful, that any alterations must eventually prove only so many blemishes." No further step towards any authorized hymnody was taken by the kirk of Scotland till the following century.

In England, two changes bearing on church hymnody were made upon the revision of the Prayer-book after the Restoration, in 1661–1662. One was the addition, in the offices for consecrating bishops and ordaining priests, of the shorter version of "Veni Creator" ("Come, Holy Ghost, our souls inspire"), as an alternative form. The other, and more important, was the insertion of the rubric after the third Collect, at Morning and Evening Prayer: "In quires and places where they sing, here followeth the Anthem." By this rubric synodical and parliamentary authority was given for the interruption, at that point, of the prescribed order of the service by singing an anthem, the choice of which was left to the discretion of the minister. Those actually used, under this authority, were for some time only unmetrical passages of Scripture, set to music by Blow, Purcell, and other composers, of the same kind with the anthems still generally sung in cathedral and collegiate churches. But the word "anthem" had no technical signification which could be an obstacle to the use under this rubric of metrical hymns.

Tate and Brady. The "New Version" of the Psalms, by Dr Nicholas Brady and the poet-laureate Nahum Tate (both Irishmen), appeared in 1696, under the sanction of an order in council of William III., "allowing and permitting" its use "in all such churches, chapels, and congregations as should think fit to receive it." Dr Compton, bishop of London, recommended it to his diocese. No hymns were then appended to it; but the authors added a "Supplement" in 1703, which received an exactly similar sanction from an order in council of Queen Anne. In that Supplement there were several new versions of the canticles, &c., and of the "Veni Creator;" a variation of the old "Humble Lamentation of a Sinner;" six hymns for Christmas, Easter, and Holy Communion (all versions or paraphrases of Scripture), which are still usually printed at the end of the Prayer-books containing the new version; and a hymn "On the Divine use of Music,"—all accompanied by tunes. The authors also reprinted, with very good taste, the excellent version of the "Benedicite" which appeared in the book of 1562. Of the hymns in this "Supplement," one ("While shepherds watched their flocks by night") greatly exceeded the rest in merit. It has been ascribed to Tate, but it has a character of simplicity unlike the rest of his works.

Old and new versions compared. The relative merits of the "Old" and "New" versions have been very variously estimated. Competent judges have given the old the praise, which certainly cannot be accorded to the new, of fidelity to the Hebrew. In both, it must be admitted, that those parts which have poetical merit are few and far between; but a reverent taste is likely to be more offended by the frequent sacrifice, in the new, of depth of tone and accuracy of sense to a fluent commonplace correctness of versification and diction, than by any excessive homeliness in the old. In both, however, some Psalms, or portions of Psalms, are well enough rendered to entitle them to a permanent place in our hymn-books,—especially the 8th, and parts of the 18th Psalm, by Sternhold; the 57th, 84th, and 100th, by Hopkins; the 23d, 34th, and 36th, and part of the 148th, by Tate and Brady.

The judgment which a fastidious critic might be disposed to pass upon both these books may perhaps be considerably mitigated by comparing them with the works of other labourers in the same field, of whom Mr Holland, in his interesting volumes entitled *Psalmists of Great Britain*, enumerates above 150. Some of them have been real poets—the celebrated earl of Surrey, Sir Philip Sidney and his sister the countess of Pembroke, George Sandys, George Wither, John Milton, and John Keble. In their versions, as might be expected, there are occasional gleams of power and beauty, exceeding anything to be found in Sternhold and Hopkins, or Tate and Brady; but even in the best these are rare, and chiefly occur where the strict idea of translation has been most widely departed from. In all of them, as a rule, the life and spirit, which in prose versions of the Psalms are so wonderfully preserved, have disappeared. The conclusion practically suggested by so many failures is that the difficulties of metrical translation, always great, are in this case insuperable; and that, while the Psalms (like other parts of Scripture) are abundantly suggestive of motive and material for hymnographers, it is by assimilation and adaptation, and not by any attempt to transform their exact sense into modern poetry, that they may be best used for this purpose.

The order in council of 1703 is the latest act of any public authority by which an express sanction has been given to the use of psalms or hymns in the Church of England. At the end, indeed, of many modern Prayer-books, there will be found, besides some of the hymns sanctioned by that order in council, or of those contained in the book of 1562, a Sacramental and a Christmas hymn by Doddridge; a Christmas hymn (varied by Martin Madan) from Charles Wesley; an Easter hymn of the 18th century, beginning "Jesus Christ has risen to day;" and abridgments of Bishop Ken's Morning and Evening Hymns. These additions first began to be made in or about 1791, in London editions of the Prayer-book and Psalter, at the mere will and pleasure (so far as appears) of the printers. They have no sort of authority.

[Eng]lish [con]gre[gati]onal [hy]m[nody]. In the state of authority, opinion, and practice disclosed by the preceding narrative may be found the true explanation of the fact that, in the country of Chaucer, Spenser, Shakespeare, and Milton, and notwithstanding the example of Germany, no native congregational hymnody worthy of the name arose till after the commencement of the 18th century. Yet there was no want of appreciation of the power and value of congregational church music. Milton could write, before 1645,—

"There let the pealing organ blow
To the full-voiced quire below
In service high, and anthems clear,
As may with sweetness through mine ear
Dissolve me into ecstasies,
And bring all Heaven before mine eyes."

Thomas Mace, in his *Music's Monument* (1676), thus described the effect of psalm-singing before sermons, by the congregation in York Minster on Sundays, during the siege of 1644: "When that vast concording unity of the whole congregational chorus came thundering in, even so as it made the very ground shake under us, oh, the unutterable ravishing soul's delight! in the which I was so transported and wrapt up in high contemplations that there was no room left in my whole man, body, soul, and spirit, for anything below divine and heavenly raptures; nor could there possibly be anything to which that very singing might be truly compared, except the right apprehension or conceiving of that glorious and miraculous quire, recorded in the Scriptures at the dedication of the Temple." Nor was there any want of men well-qualified, and by the turn of their minds predisposed, to shine in this branch of literature. Some (like Sandys, Boyd, and Barton) devoted themselves altogether to paraphrases of other Scriptures as well as the Psalms. Others (like George Herbert, and Francis and John Quarles) moralized, meditated, soliloquized, and allegorized in verse. Without reckoning these, there were a few, even before the Restoration, who came very near to the ideal of hymnody.

Wedderburn. First in time is the Scottish poet John Wedderburn, who translated several of Luther's hymns, and in his *Compendious Book of Godly and Spiritual Songs* added others of his own (or his brothers') composition. Some of these poems, published before 1560, are of uncommon excellence, uniting ease and melody of rhythm, and structural skill, with grace of expression, and simplicity, warmth, and reality of religious feeling. Those entitled "Give me thy heart," "Go, heart," and "Leave me not" (which will be found in a collection of 1860 called *Sacred Songs of Scotland*), require little, beyond the change of some archaisms of language, to adapt them for church or domestic use at the present day.

Next come the two hymns of "The New Jerusalem," by an English Roman Catholic priest signing himself F. B. P. (supposed by the late Mr Sedgwick to be "Francis Baker, Presbyter"), and by another Scottish poet, David Dickson, of which the history is given by Dr Bonar in his edition of Dickson's work. This (Dickson's), which begins "O mother dear, Jerusalem," and has long been popular in Scotland, is a variation and amplification (by the addition of a large number of new stanzas) of the English original, beginning "Jerusalem, my happy home," written in Queen Elizabeth's time, and printed (as appears by a copy in the British Museum) about 1616, when Dickson was still young. Both have an easy natural flow, and a simple happy rendering of the beautiful Scriptural imagery upon the subject, with a spirit of primitive devotion uncorrupted by mediæval peculiarities. The English hymn (of which some stanzas are now often sung in churches) is the true parent of the several shorter forms,—all of more than common merit,—which, in modern hymn-books, begin with the same first line, but afterwards deviate from the original. Kindred to these is the very fine and faithful translation, by Drummond of Hawthornden (who was Dickson's contemporary), of the ancient "Urbs beata Hierusalem" ("Jerusalem, that place divine"). Other ancient hymns (two of Thomas Aquinas, and the "Dies Iræ") were also well translated, in 1646, by Crashaw, after he had become a Roman Catholic, and had been deprived by the parliament of his fellowship at Cambridge. Dickson.

Conspicuous among the sacred poets of the first two Stuart reigns in England is the name of George Wither, an accomplished layman, of strong church principles, whose fate it was to be opposed and slighted while he was a staunch churchman and Royalist, and afterwards to be driven into the parliamentary and Puritan ranks; for which cause, probably, recognition was denied to his genius as a poet by Dryden, Swift, and Pope. He had almost fallen into oblivion, when attention was recalled to his merits by the more discerning criticisms of Charles Lamb and Southey; and, when his *Hallelujah* was republished in 1857 by Mr Farr, only two copies of it were known to exist, one in the British Museum, and another which had been in Mr Heber's library. His *Hymns and Songs of the Church* appeared in 1622–1623, under a patent of King James I., by which they were declared "worthy and profitable to be inserted, in convenient manner and due place, into every English Psalm-book to metre." This patent was opposed, as inconsistent with their privilege to print the "singing-psalms," by the Stationers' Company, to Wither's great mortification and loss. His *Hallelujah* (in which some of the former *Hymns and Songs* were repeated) followed, after several intermediate publications of a different kind, in 1641. The *Hymns and Songs* were set to music by Orlando Gibbons, and those in both books were written to be sung, though for the most part privately, there being no evidence that the author contemplated the use of any of them in churches. They included, however, hymns for every day in the week (founded, as those contributed nearly a century afterwards by Coffin to the Parisian Breviary also were, upon the successive works of the days of creation); hymns for all Wither.

the church seasons and festivals, including saints' days; hymns for various public occasions; and hymns of prayer, meditation, and instruction, for a great number of different sorts and conditions of men and women, in a variety of the circumstances incident to human life,—being at once a "Christian Year" and a manual of practical piety. Many of them rise to a very high point of excellence,—particularly the "general invitation to praise God" ("Come, O come, in pious lays"), with which *Hallelujah* opens; the Thanksgivings for Peace and for Victory, the Coronation Hymn, a Christmas, an Epiphany, and an Easter Hymn, and one for St Bartholomew's day (Hymns 1, 74, 75, and 84 in part i., and 26, 29, 36, and 54 in part ii., of *Hallelujah*). All these are properly entitled to the designation of hymns, which can hardly be conceded to some others, of singular beauty, viz., the Cradle-song ("Sleep, baby, sleep, what ails my dear"), the Anniversary Marriage Song ("Lord, living here are we"), the Perambulation Song ("Lord, it hath pleasèd Thee to say"), the Song for Lovers ("Come, sweet heart, come, let us prove"), the Song for the Happily Married ("Since they in singing take delight"), and that for a Shepherd ("Renownèd men their herds to keep")—(Nos. 50 in the first part, 17 and 24 in the second, and 20, 21, and 41 in the third). There is also in the second part a fine song (No 59), full of historical as well as poetical interest, upon the evil times in which the poet lived, beginning—

> "Now are the times, these are the days,
> Which will those men approve
> Who take delight in honest ways
> And pious courses love;
> Now to the world it will appear
> That innocence of heart
> Will keep us far more free from fear
> Than helmet, shield, or dart."

Wither wrote, generally, in a pure nervous English idiom, and preferred the reputation of "rusticity" (an epithet applied to him even by Baxter) to the tricks and artifices of poetical style which were then in favour. It may be partly on that account that he has been better appreciated by posterity than by his contemporaries.

Cosin. Cosin, afterwards bishop of Durham, published in 1627 a volume of "Private Devotions," for the canonical hours and other occasions. In this there are seven or eight hymns of considerable merit,—among them a very good version of the Ambrosian "Jam lucis orto sidere," and the shorter version of the "Veni Creator," which was introduced after the Restoration into the consecration and ordination services of the Church of England.

Milton. The hymns of Milton (on the Nativity, Passion, Circumcision, and "at a Solemn Music"), written about 1629, in his early manhood, were probably not intended for singing; but they are odes full of characteristic beauty and power.

Jeremy Taylor. During the Commonwealth, in 1654, Jeremy Taylor published, at the end of his *Golden Grove*, twenty-one hymns, described by himself as "celebrating the mysteries and chief festivals of the year, according to the manner of the ancient church, fitted to the fancy and devotion of the younger and pious persons, apt for memory, and to be joined to their other prayers." Of these, his accomplished editor, Bishop Heber, justly says:—

> "They are in themselves, and on their own account, very interesting compositions. Their metre, indeed, which is that species of spurious Pindaric which was fashionable with his contemporaries, is an obstacle, and must always have been one, to their introduction into public or private psalmody; and the mixture of that alloy of conceits and quibbles which was an equally frequent and still greater defilement of some of the finest poetry of the 17th century will materially diminish their effect as devotional or descriptive odes. Yet, with all these faults, they are powerful, affecting, and often harmonious; there are many passages of which Cowley need not have been ashamed, and some which remind us, not disadvantageously, of the corresponding productions of Milton."

He mentions particularly the Advent hymn ("Lord, come away"), part of the hymn "On Heaven," and (as "more regular in metre, and in words more applicable to public devotion") the "Prayer for Charity" ("Full of mercy, full of love").

Restoration period. The epoch of the Restoration produced in 1664 Samuel Crossman's *Young Man's Calling*, with a few "Divine Meditations" in verse attached to it; in 1668 John Austin's *Devotions in the Ancient Way of Offices, with psalms, hymns, and prayers for every day in the week and every holyday in the year*; and in 1681 Richard Baxter's *Poetical Fragments.* In these books there are altogether seven or eight hymns, the whole or parts of which are extremely good:—Crossman's "New Jerusalem" ("Sweet place, sweet place alone"), one of the best of that class, and "My life's a shade, my days;" Austin's "Hark, my soul, how everything," "Fain would my thoughts fly up to Thee," "Lord, now the time returns," "Wake all my hopes, lift up your eyes;" and Baxter's "My whole, though broken heart, O Lord," and "Ye holy angels bright." Austin's *Offices* (he was a Roman Catholic) seem to have attracted much attention. Theophilus Dorrington, in 1686, and afterwards Hickes, the non-juror, published variations of them under the title of *Reformed Devotions*; and the Wesleys, in their earliest hymn-book, adopted hymns from them, with little alteration. These writers were followed by John Mason in 1683, and Thomas Shepherd in 1692,—the former, a country clergyman, much esteemed by Baxter and other Nonconformists; the latter himself a Nonconformist, who finally emigrated to America. Between these two men there was a close alliance, Shepherd's *Penitential Cries* being published as an addition to the *Spiritual Songs* of Mason. Their hymns came into early use in several Nonconformist congregations; but, with the exception of one by Mason ("There is a stream which issues forth"), they are not suitable for public singing. In those of Mason there is often a very fine vein of poetry; and later authors have, by extracts or centoes from different parts of his works (where they were not disfigured by his general quaintness), constructed several hymns of more than average excellence.

Three other eminent names of the 17th century remain to be mentioned, John Dryden, Bishop Ken, and Bishop Simon Patrick; with which may be associated that of Addison, though he wrote in the 18th century.

Dryden. Dryden's translation of "Veni Creator" (a cold and laboured performance) is to be met with in many hymnbooks. Abridgments of Ken's Morning and Evening Hymns are in all. These, with the Midnight Hymn (not inferior to them), first appeared in 1697, appended to the third edition of the author's *Manual of Prayers for Winchester Scholars.* Between these and a large number of other hymns (on the Attributes of God, and for the Festivals of the Church) published by Bishop Ken after 1703 the contrast is remarkable. The universal acceptance of the Morning and Evening Hymns is due to their transparent simplicity, warm but not overstrained devotion, and extremely popular style. Those afterwards published have no such qualities. They are mystical, florid, stiff, didactic, and seldom poetical, and deserve the neglect into which they have fallen. Bishop Patrick's hymns were chiefly translations from the Latin, most of them from Prudentius. The best is a version of "Alleluia dulce carmen." Of the five attributed to Addison, not more than three are adapted to public singing; one ("The spacious firmament on high") is a very perfect and finished composition, taking rank among the best hymns in the English language.[1]

[1] The authorship of this and of one other, "When all Thy mercies, O my God," has been made a subject of controversy,—being claimed

From the preface to Simon Browne's hymns, published in 1720, we learn that down to the time of Dr Watts the only hymns known to be "in common use, either in private families or in Christian assemblies," were those of Barton, Mason, and Shepherd, together with "an attempt to turn some of Mr Herbert's poems into common metre," and a few sacramental hymns by authors now forgotten, named Vincent, Boyse, and (Joseph) Stennett. Of the 1410 authors of original British hymns enumerated in Mr Sedgwick's catalogue, published in 1863, 1213 are of later date than 1707; and, if any correct enumeration could be made of the total number of hymns of all kinds published in Great Britain before and after that date, the proportion subsequent to 1707 would be very much larger.

The English Independents, as represented by Dr Watts, have a just claim to be considered the real founders of modern English hymnody. Watts was the first to understand the nature of the want, and, by the publication of his *Hymns* in 1707–1709, and *Psalms* (not translations, but hymns founded on psalms) in 1719, he led the way in providing for it. His immediate followers were Simon Browne and Doddridge. Later in the 18th century, Hart, Gibbons, Grigg, and Mrs Barbauld (the two first Independents, the two last Presbyterians), and Miss Steele, Medley, Samuel Stennett, Ryland, Beddome, and Swaine (all Baptists), succeeded to them.

Among these writers (most of whom produced some hymns of merit, and several are extremely voluminous), Watts and Doddridge are pre-eminent. It has been the fashion with some to disparage Watts, as if he had never risen above the level of his *Hymns for Little Children.* No doubt his taste is often faulty, and his style very unequal, but, looking to the good, and disregarding the large quantity of inferior matter, it is probable that more hymns which approach to a very high standard of excellence, and are at the same time suitable for congregational use, may be found in his works than in those of any other English writer. Such are "When I survey the wondrous cross," "Jesus shall reign where'er the sun" (and also another adaptation of the same 72d Psalm), "Before Jehovah's awful throne" (which first line, however, is not his, but Wesley's), "Joy to the world, the Lord is come," "My soul, repeat His praise," "Why do we mourn departing friends," "There is a land of pure delight," "Our God, our help in ages past," "Up to the hills I lift mine eyes," and many more. It is true that in some of these cases dross is found in the original poems mixed with gold; but the process of separation, by selection without change, is not difficult. As long as pure nervous English, unaffected fervour, strong simplicity, and liquid yet manly sweetness are admitted to be characteristics of a good hymn, works such as these must command admiration.

Doddridge is, generally, much more laboured and artificial; but his place also as a hymn-writer ought to be determined, not by his failures, but by his successes, of which the number is not inconsiderable. In his better works he is distinguished by a graceful and pointed, sometimes even a noble style. His "Hark, the glad sound, the Saviour comes" (which is, indeed, his masterpiece), is as sweet, vigorous, and perfect a composition as can anywhere be found. Two other hymns, "How gentle God's commands," and that which, in a form slightly varied, became the "O God of Bethel, by whose hand," of the Scottish "Paraphrases," well represent his softer manner.

Of the other followers in the school of Watts, Miss Steele (1780) is the most popular and perhaps the best. Her hymn beginning "Far from these narrow scenes of night" deserves high praise, even by the side of other good performances on the same subject. Miss Steele.

The influence of Watts was felt in Scotland, and among the first whom it reached there was Ralph Erskine. This seems to have been after the publication of Erskine's *Gospel Sonnets*, which appeared in 1732, five years before he joined his brother Ebenezer in the Secession Church. The *Gospel Sonnets* became (as some have said) a "people's classic"; but there is in them very little which belongs to the category of hymnody. More than nineteen-twentieths of this very curious book are occupied with what are, in fact, theological treatises and catechisms, mystical meditations on Christ as a Bridegroom or Husband, and spiritual enigmas, paradoxes, and antithetical conceits, versified, it is true, but of a quality of which such lines as— Ralph Erskine.

> "Faith 's certain by fiducial acts,
> Sense by its evidential facts,"

may be taken as a sample. The grains of poetry scattered through this large mass of Calvinistic divinity are very few; yet in one short passage of seven stanzas ("O send me down a draught of love"), the fire burns with a brightness so remarkable as to justify a strong feeling of regret that the gift which this writer evidently had in him was not more often cultivated. Another passage, not so well sustained, but of considerable beauty (part of the last piece under the title "The Believer's Soliloquy"), became afterwards, in the hands of Berridge, the foundation of a very striking hymn ("O happy saints, who walk in light").

After his secession, Ralph Erskine published two paraphrases of the "Song of Solomon," and a number of other "Scripture songs," paraphrased, in like manner, from the Old and New Testaments. In these the influence of Watts became very apparent, not only by a change in the writer's general style, but by the direct appropriation of no small quantity of matter from Dr Watts's hymns, with variations which were not always improvements. His paraphrases of 1 Cor. i. 24, Gal. vi. 14, Heb. vi. 17–19, Rev. v. 11, 12, vii. 10–17, and xii. 7–12 are little else than Watts transformed. One of these (Rev. vii. 10–17) is interesting as a variation and improvement, intermediate between the original and the form which it ultimately assumed as the 66th "Paraphrase" of the Church of Scotland, of Watts's "What happy men or angels these," and "These glorious minds, how bright they shine." No one can compare it with its ultimate product, "How bright these glorious spirits shine," without perceiving that Cameron followed Erskine, and only added finish and grace to his work,—both excelling Watts, in this instance, in simplicity as well as in conciseness.

Of the contributions to the authorized "Paraphrases" (with the settlement of which committees of the General Assembly of the Church of Scotland were occupied from 1745 or earlier till 1781), the most noteworthy (besides the two already mentioned) were those of John Morrison and those claimed for Michael Bruce. The obligations of these "Paraphrases" to English hymnody, already traced in some instances (to which may be added the adoption from Addison of three out of the five "hymns" appended Scottish Paraphrases.

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for Andrew Marvell (who died in 1678), in the preface to Captain Thomson's edition (1776) of Marvell's *Works.* But this claim does not appear to be substantiated. The editor did not give his readers the means of judging as to the real age, character, or value of a manuscript to which he referred; he did not say that these portions of it were in Marvell's handwriting; he did not even himself include them among Marvell's poems, as published in the body of his edition; and he advanced a like claim on like grounds to two other poems, in very different styles, which had been published as their own by Tickell and Mallet. It is certain that all the five hymns were first made public in 1712, in papers contributed by Addison to the *Spectator* (Nos. 441, 453, 465, 489, 513), in which they were introduced in a way which might have been expected if they were by the hand which wrote those papers, but which would have been improbable, and unworthy of Addison, if they were unpublished works of a writer of so much genius, and such note in his day, as Marvell. They are all printed as Addison's in Dr Johnson's edition of the *British Poets.*

to them), are perceptible in the vividness and force with which these writers, while adhering with a severe simplicity to the sense of the passages of Scripture which they undertook to render, fulfilled the conception of a good original hymn. Morrison's "The race that long in darkness pined" and "Come, let us to the Lord our God," and Bruce's "Where high the heavenly temple stands" (if this was really his), are well entitled to that praise. The advocates of Bruce in the controversy, not yet closed, as to the poems said to have been entrusted by him to John Logan, and published by Logan in his own name, also claim for him the credit of having varied the paraphrase "Behold, the mountain of the Lord," from its original form, as printed by the committee of the General Assembly in 1745, by some excellent touches.

Methodist hymns.

Attention must now be directed to the hymns produced by the "Methodist" movement, which began about 1738, and which afterwards became divided, between those esteemed Arminian, under John Wesley, those who adhered to the Moravians, when the original alliance between that body and the founders of Methodism was dissolved, and the Calvinists, of whom Whitfield (himself no poet) was the leader, and Selina, countess of Huntingdon, the patroness. Each of these sections had its own hymn-writers, some of whom did, and others did not, secede from the Church of England. The Wesleyans had Charles Wesley, Seagrave, Olivers, and Bakewell; the Moravians, Cennick and Hammond (with whom, perhaps, may be classed John Byrom, who imbibed the mystical ideas of some of the German schools); the Calvinists, Toplady, Berridge, William Williams, Madan, Batty, Haweis, Rowland Hill, John Newton, and Cowper.

Charles Wesley.

Among all these writers, the palm undoubtedly belongs to Charles Wesley. In the first volume of hymns published by the two brothers are several good translations from the German, believed to be by John Wesley, who, although he translated and adapted, is not supposed to have written any original hymns; and the influence of German hymnody, particularly of the works of Paul Gerhardt, Scheffler, Tersteegen, and Zinzendorf, may be traced in a large proportion of Charles Wesley's works. He is more subjective and meditative than Watts and his school; there is a didactic turn, even in his most objective pieces (as, for example, in his Christmas and Easter hymns); most of his works are supplicatory, and his faults are connected with the same habit of mind. He is apt to repeat the same thoughts, and to lose force by redundancy—he runs sometimes even to a tedious length; his hymns are not always symmetrically constructed, or well balanced and finished off. But he has great truth, depth, and variety of feeling; his diction is manly, and always to the point; never florid, though sometimes passionate and not free from exaggeration; often vivid and picturesque. Of his spirited style there are few better examples than "O for a thousand tongues to sing," "Blow ye the trumpet, blow," "Rejoice, the Lord is King," and "Come, let us join our friends above;" of his more tender vein, "Happy soul, thy days are ended;" and of his fervid contemplative style (without going beyond hymns fit for general use), "O Thou who camest from above," "Forth in thy name, O Lord, I go," and "Eternal Beam of Light Divine." With those whose taste is for hymns in which warm religious feelings are warmly and demonstratively expressed, "Jesus, lover of my soul," is as popular as any of these.

Olivers.

Of the other Wesleyan hymn-writers, Olivers (originally a Welsh shoemaker, afterwards a preacher) is the most remarkable. He is the author of only two works, both odes, in a stately metre, and from their length unfit for congregational singing, but one of them, "The God of Abraham praise," an ode of singular power and beauty.

The Moravian Methodists produced few hymns now available for general use. The best are Cennick's "Children of the heavenly King," and Hammond's "Awake and sing the song of Moses and the Lamb," the former of which (abridged), and the latter as varied by Madan, are found in many hymn-books, and are deservedly esteemed. Byrom, whose name we have thought it convenient to connect with these, though he did not belong to the Moravian community, was the author of a Christmas hymn ("Christians awake, salute the happy morn") which enjoys great popularity in the county (Lancashire) of which he was a native; and also of a short subjective hymn, very fine both in feeling and in expression, "My spirit longeth for Thee within my troubled breast."

The contributions of the Calvinistic Methodists to English hymnody are of greater extent and value. Few writers of hymns had higher gifts than Augustus Montague Toplady, author of "Rock of Ages," by some esteemed the finest in the English language. He was a man of ardent temperament, enthusiastic zeal, strong convictions, and great energy of character. "He had," says one of his biographers, "the courage of a lion, but his frame was brittle as glass." Between him and John Wesley there was a violent opposition of opinion, and much acrimonious controversy; but the same fervour and zeal which made him an intemperate theologian gave warmth, richness, and spirituality to his hymns. In some of them (particularly those which, like "Deathless principle, arise," are meditations after the German manner, and not without direct obligation to German originals) the setting is somewhat too artificial; but his art is never inconsistent with a genuine flow of real feeling. Others (*e.g.*, "When languor and disease invade," and "Your harps, ye trembling saints") fail to sustain to the end the beauty with which they began, and would have been better for abridgment. But in all these, and in most of his other works, there is great force and sweetness, both of thought and language, and an easy and harmonious versification.

Berridge, Williams, and Rowland Hill (all men remarkable for eccentricity, activity, and the devotion of their lives to the special work of missionary preaching), though not the authors of many good hymns, composed, or adapted from earlier compositions, some of great merit. One of Berridge, adapted from Erskine, has been already mentioned; another, adapted from Watts, is "Jesus, cast a look on me." Williams, a Welshman (who wrote "Guide me, O Thou great Jehovah"), was especially an apostle of Calvinistic Methodism in his own country, and his hymns are still much used in the principality. Rowland Hill wrote the popular hymn beginning "Exalted high at God's right hand."

If, however, the number as well as the quality of good hymns available for general use is to be regarded, the authors of the "Olney Hymns" are entitled to be placed at the head of all the writers of this Calvinistic school. The greater number of the Olney Hymns are, no doubt, homely and didactic; but to the best of them (and they are no inconsiderable proportion) the tenderness of Cowper and the manliness of Newton give the interest of contrast, as well as that of sustained reality. If Newton carried to some excess the sound principle laid down by him, that "perspicuity, simplicity, and ease should be chiefly attended to, and the imagery and colouring of poetry, if admitted at all, should be indulged very sparingly and with great judgment," if he is often dry and colloquial, he rises at other times into "soul-animating strains," such as "Glorious things of thee are spoken, Zion, city of our God;" and sometimes (as in "Approach, my soul, the mercy seat") rivals Cowper himself in depth of feeling. Cowper's hymns in this book are, almost without exception, worthy of his name. Among them are "Hark, my soul, it is the Lord," "There is a fountain filled with blood," "Far from the world, O Lord, I flee," "God moves in a mysterious way," and "Sometimes a light surprises." Some, perhaps, even of these, and others of equal excellence (such as "O for a closer walk with God"), speak the language of a special experience, which, in Cowper's case, was only too real, but which could not (without a degree of unreality not desirable in exercises of public worship) be applied to themselves by all ordinary Christians.

...ury ...ns. During the first quarter of the present century there were not many indications of the tendency, which afterwards became manifest, to enlarge the boundaries of British hymnody. A few, indeed, of Bishop Heber's hymns, and

...rant. those of Sir Robert Grant (which, though offending rather too much against John Newton's canon, are well known and popular), appeared between 1811 and 1816, in the *Christian*

...dler. *Observer*. In John Bowdler's *Remains*, published soon after his death in 1815, there are a few more of the same, perhaps too scholarlike, character. But the chief hymn-writers of that period were two clergymen of the Established Church —one in Ireland, Thomas Kelly, and the other in England, William Hurn—who both became Nonconformists, and the Moravian poet, James Montgomery, a native of Scotland.

K...y. Kelly was the son of an Irish judge, and in 1804 published a small volume of ninety-six hymns, which grew in successive editions till, in the last before his death in 1854, they amounted to 765. There is (as might be expected) in this great number a large preponderance of the didactic and commonplace. But not a few very excellent hymns may be gathered from them. Simple and natural, without the vivacity and terseness of Watts or the severity of Newton, Kelly has some points in common with both those writers, and he is less subjective than most of the "Methodist" school. His hymns beginning "Lo! He comes, let all adore Him," and "Through the day Thy love hath spared us," have a rich melodious movement; and another, "We sing the praise of Him who died," is distinguished by a calm subdued power, rising gradually from a rather low to a very high key.

H...n. Hurn published in 1813 a volume of 370 hymns, which were increased after his secession to 420. There is little in them which deserves to be saved from oblivion; but one at least, "There is a river deep and broad," may bear comparison with the best of those which have been produced upon the same (and it is rather a favourite) theme.

M...go...ry. The *Psalms and Hymns* of James Montgomery were published in 1822 and 1825, though written earlier. More cultivated and artistic than Kelly, he is less simple and natural. The number of his valuable contributions to our hymnals is, upon the whole, considerable; and, though it may be doubted whether he ever attains to the first rank, all must acknowledge that he stands high in the second. His "Hail to the Lord's Anointed," "Songs of praise the angels sang," and "Mercy alone can meet my case" are among his most successful efforts.

...ions of ...ys. During this first quarter of the present century, the collections of miscellaneous hymns for congregational use, of which the example was set by the Wesleys, Whitfield, Toplady, and Lady Huntingdon, had greatly multiplied; and with them the practice (for which, indeed, too many precedents existed in the history of Latin and German hymnody) of every collector altering the compositions of other men without scruple, to suit his own doctrine or taste; with the effect, too generally, of patching and disfiguring, spoiling, and emasculating the works so altered, substituting neutral tints for natural colouring, and a dead for a living sense. In the Church of England, the use of these collections had become frequent in churches and chapels (principally in cities and towns) where the sentiments of the clergy approximated to those of the Nonconformists. In rural parishes, when the clergy were not of the "Evangelical" school, they were generally held in disfavour; for which (even if doctrinal prepossessions had not entered into the question) the great want of taste and judgment often manifested in their compilation, and perhaps also the prevailing mediocrity of the bulk of the original compositions from which most of them were derived, would be enough to account. In addition to this, the idea that no hymns ought to be used in any services of the Church of England (except prose anthems after the third Collect), without express royal or ecclesiastical authority, continued down to that time largely to prevail among churchmen of the higher school.

Heber, Milman, Keble. Two publications, which appeared almost simultaneously in 1827,—Bishop Heber's *Hymns*, with a few added by Dean Milman, and Keble's *Christian Year* (not a hymn-book, but one from which several admirable hymns have been taken, and the well-spring of many streams of thought and feeling by which good hymns have since been produced), —introduced a new epoch, breaking down the barrier as to hymnody which had till then existed between the different theological schools of the Church of England. In

Mant. this movement Bishop Mant was also one of the first to cooperate. It soon received a great additional impulse from the increased attention which, about the same time, began to be paid to ancient hymnody, and from the publication in 1833 of Bunsen's *Gesangbuch*. Among its earliest fruits was the *Lyra Apostolica*, containing hymns, sonnets, and other devotional poems, most of them originally contributed by some of the leading authors of the *Tracts for the Times* to the "British Magazine"; the finest of which is the pathetic "Lead, kindly Light, amid th' encircling gloom," by John Henry (now Cardinal) Newman,—well known, and universally admired. Newman. From that time hymns and hymn-writers rapidly multiplied in the Church of England, and in Scotland also, and their number is still on the increase. Nearly 600 authors, whose publications were later than 1827, are enumerated in Mr Sedgwick's catalogue of 1863, and many more have since appeared. Works, critical and historical, upon the subject of hymns, have also multiplied; and collections for church use have become innumerable,— several of the various religious denominations, and many of the leading ecclesiastical and religious societies, having issued hymn-books of their own, in addition to those compiled for particular dioceses, churches, and chapels, and to books (like *Hymns Ancient and Modern*) which have become popular without any sanction from authority. In these more recent collections, an improved standard of taste has become generally apparent. There is a larger and more liberal admission of good hymns from all sources than might have been expected from the jealousy, so often felt by churches, parties, and denominations, of everything which does not bear their own mint-mark; a considerable (perhaps too large) use of translations, especially from the Latin; and an increased (though not as yet sufficient) scrupulousness about tampering with the text of other men's works. To mention all the authors of good hymns since the commencement of this new epoch would be impossible; but probably no names could be chosen more fairly representative of its characteristic merits, and perhaps also of some of its defects, than those of Josiah Conder and James Edmeston among English Nonconformists; Henry Francis Lyte and Charlotte Elliott among evangelicals in the Church of England; John Mason Neale and Bishop Christopher Wordsworth among English churchmen of the higher school; and, in Scotland, Dr Horatius Bonar. Criticism, in this place, of the works of these and other living or recent authors, or of those of Heber and Keble, which are on everybody's lips, and in everybody's hands, would be at once premature and superfluous.

Ameri-can hymns.

What has been said of British hymnody during the last fifty years is equally true of American. The American hymn-writers belong to the same schools, and have been affected by the same influences. Some of them enjoy a just reputation on both sides of the Atlantic. Among those best known are Bishop Doane, Dr Muhlenberg, and Mr Thomas Hastings; and it is difficult to praise too highly such works as the Christmas hymn, "It came upon the midnight clear," by Mr Edmund H. Sears; the Ascension hymn, "Thou, who didst stoop below," by Mrs S. E. Miles; and two by Dr Ray Palmer, "My faith looks up to Thee, Thou Lamb of Calvary," and "Jesus, Thou joy of loving hearts," the latter of which is the best among several good English versions of "Jesu, dulcedo cordium."

Among the authorities of which use has been made in the foregoing account of British Hymnody are the Appendix on Scottish Psalmody in Mr Laing's edition of Baillie's *Letters and Journals*; Mr Holland's *Psalmists of Britain* (1843); Mr Josiah Miller's *Our Hymns, their Authors and Origin* (1866); Mr John Gadsby's *Memoirs of the Principal Hymn-writers*, &c. (3d ed., 1861); the "Annotations" of the Rev. Louis Coutier Biggs to *Hymns Ancient and Modern* (1867); and the late Mr Daniel Sedgwick's *Comprehensive Index of Names of original Authors of Hymns*, &c. (2d ed., 1863). Mr Sedgwick's name cannot be mentioned without special honour, as one of the most painstaking, sympathetic, and accurate of all modern students of British hymns.

7. *Conclusion.*

The object aimed at in this article has been to trace the general history of the principal schools of ancient and modern hymnody, and especially the history of its use in the Christian church. For this purpose it has not been thought necessary to give any account of the hymns of Racine, Madame Guyon, and others, who can hardly be classed with any school, nor of the works of Cæsar Malan and other quite modern hymn-writers of the Reformed churches in Switzerland and France.

On a general view of the whole subject, hymnody is seen to have been a not inconsiderable factor in religious worship. It has been sometimes employed to disseminate and popularize particular views, but its spirit and influence has been Catholic, on the whole. It has embodied the faith, trust, and hope, and no small part of the inward experience, of generation after generation of men, in many different countries and climates, of many different nations, and in many varieties of circumstances and condition. Coloured, indeed, by these differences, and also by the various modes in which the same truths have been apprehended by different minds (and sometimes reflecting partial and imperfect conceptions of them, and errors with which they have been associated in particular churches, times, and places), its testimony is, nevertheless, generally the same. It has upon it a stamp of genuineness which cannot be mistaken. It bears witness to the force of a central attraction more powerful than all causes of difference, which binds together times ancient and modern, nations of various race and language, churchmen and nonconformists, churches reformed and unreformed; to a true fundamental unity among good Christians; and to a substantial identity in their moral and spiritual experience. (s.)

HYPATIA (Ὑπατία or Ὑπάτεια), mathematician, philosopher, and finally one of the martyrs of paganism, was the daughter and disciple of the mathematician and philosopher Theon,[1] and was born in Alexandria not earlier than 350 A.D.[2] After a long period of study (partly, perhaps, in Athens) she became a distinguished lecturer on philosophy in her native town, and ultimately became the recognized head of the Neo-Platonic school there (*c.* 400). The fascination of her great eloquence (she is said on more than one occasion to have proved an effective advocate in the courts of law), and the charm of a rare modesty and beauty, combined with her remarkable intellectual gifts to attract to her class-room a large number of disciples, over some of whom her influence was very great. Among these was Synesius, who afterwards (*c.* 410) became bishop of Ptolemais, several of whose letters addressed to her (τῇ φιλοσόφῳ), full of chivalrous admiration and reverence, are still extant (*Epp.* 10, 15, 16, 33, 80, 124, 153). In the conflicts between the various elements of Alexandrian society which took place shortly after the accession of Cyril to the patriarchate in 412, she became closely identified as counsellor and friend with the prefect Orestes, and in the same degree made herself an object of fear and hatred to the Nitrian monks and the fanatical Christian mob, by whom she was ultimately murdered under circumstances of revolting barbarity (Lent, 415). Socrates has related how she was torn from her chariot, dragged to the Cæsareum (then a Christian church), stripped naked, cut to pieces with oyster shells (ὀστράκοις ἀνεῖλον), and finally burnt piecemeal. Most prominent among the actual perpetrators of the crime was one Peter, a reader; but there seems little reason to doubt Theodoret's assertion of Cyril's real complicity.

Hypatia, according to Suidas, was the author of commentaries on the mathematician Diophantus and on the *Conics* of Apollonius of Perga, and also of an astronomical canon. None of these works have come down to our time; but their titles, combined with expressions in the letters of Synesius, who consulted her about the construction of an astrolabe, would seem to indicate that she devoted herself specially to astronomy and mechanics. Of her philosophical opinions nothing is known, except that they shared the general eclectic features of the Alexandrian Neo-Platonism. A Latin letter to Cyril on behalf of Nestorius, which has sometimes been attributed to her, is undoubtedly spurious. It can be read in Baluze. The story of Hypatia appears in a considerably disguised yet still recognizable form in the legend of St Catherine as recorded in the Roman *Breviary* (Nov. 25), and still more fully in the *Martyrologies* (see Jameson, *Sacred and Legendary Art*, p. 467 *sqq.*).

The chief source for the little we know about Hypatia is the account given by Socrates (*H. E.*, vii. 15). The article in Suidas, which Gibbon has characterized as "curious and original," must be received with some caution. It is on his authority that the somewhat doubtful statement is made that she was the wife of Isidorus the philosopher. She is the subject of an epigram by Palladas in the *Anthology* (ix. 400; ed. Jacobs). See Menage, *Hist. Mul. Phil.*, p. 52; Fabricius, *Bibl. Gr.*, ix. 187 *sqq.*; Wernsdorf, *op. cit.*; and the exhaustive monograph of Hoche in *Philologus*, xv. 435 *sqq.* (1860). An anonymous work entitled *Hypatia, or the history of a most beautiful, most virtuous, most learned, and every way accomplished lady, who was torn to pieces by the clergy of Alexandria to gratify the pride, emulation, and cruelty of their archbishop Cyril, commonly but undeservedly styled Saint Cyril*, was published in London in 1720. The history of Hypatia has also been made the basis of an attractive historical romance by Charles Kingsley (1853).

HYPERIDES (Ὑπερείδης), one of the ten Attic orators, was son of Glaucippus, of a noble family of the tribe Ægeis and the deme Collytus. He was probably younger than Lycurgus (born about 396 B.C.) and older than Demosthenes (born about 385 B.C.). Having studied under Isocrates, he began life as a writer of speeches for the courts, and in 360 B.C. he prosecuted Autocles, a general charged with treason in Thrace. From the end of the Sacred War, 346–

[1] For some account of whom see Suidas; compare Fabricius, *Bibl. Gr.*, ix. 178 *sqq.* (1804). He observed an eclipse in 365.

[2] The date assigned by Wernsdorf (*Diss. Acad. IV. de Hypatia*, Wittenberg, 1747). Hoche (*Philologus*, xv.) gives 370.

324 B.C., Hyperides supported Demosthenes in the struggle against Macedon; but in the affair of Harpalus he was one of the ten public prosecutors of Demosthenes, and on the exile of his former leader he became the head of the patriotic party (see DEMOSTHENES). He was the chief promoter of the Lamian War against Antipater and Craterus. After the decisive defeat of Crannon, 322 B.C., Hyperides with the other orators demanded by Antipater was condemned to death by the subdued Athenians, but fled to Ægina and thence into sanctuary in the temple of Demeter at Hermione. Antipater's emissaries dragged him forth to be put to death at Athens. Hyperides was an ardent pursuer of "the beautiful," which in his time generally meant pleasure and luxury. His temper was easy-going and humorous; and hence, though in his development of the periodic sentence he followed Isocrates, the essential tendencies of his style are those of Lysias, whom he surpassed, however, in the richness of his vocabulary and in the variety of his powers. His diction was plain and forcible, though he occasionally indulged in long compound words probably borrowed from the Middle Comedy, with which, and with the everyday life of his time, he was in full sympathy. His composition was simple. He was specially distinguished for subtlety of expression, grace, and wit, as well as for tact in approaching his case and handling his subject matter. Professor Jebb sums up the criticism of Longinus in the phrase—"Hyperides was the Sheridan of Athens." Of his lost speeches we should perhaps regret most the Δηλιακός, on the presidency of the Delian temple claimed by Athens and Delos, which was adjudged by the Amphictyons to Athens.

The extant works of Hyperides are—1, Fragment of the ἀπολογία ὑπὲρ Λυκόφρονος, *Pro Lycophrone*, delivered before 349 B.C., incidentally interesting as throwing light on the order of marriage processions and other details of Athenian life, and on the Athenian government of Lemnos; 2, Ὑπὲρ Εὐξενίππου εἰσαγγελίας ἀπολογία πρὸς Πολύευκτον, *Pro Euxenippo*, about 330 B.C., nearly perfect (a *locus classicus* on εἰσαγγελίαι); 3, fragments of the Κατὰ Δημοσθένους, *In Demosthenem*, see above; 4, a considerable portion of the λόγος ἐπιτάφιος, *Oratio Funebris*, over Leosthenes and his comrades who fell in the Lamian war, 322 B.C., after Antiphilus's victory over Leonnatus at Melitea. This is an elevated panegyric in the style of Isocrates, but in invention and sentiment the best specimen we have of epideictic oratory. Of the epilogue a portion is preserved by Stobæus only. The MSS. are papyri—those of the first two speeches found by Joseph Arden, January 1847, that of the third speech by A. C. Harris, 1847, of the last by the Rev. H. Stobart, 1856, all at Thebes in Egypt. They are among the oldest extant MSS., dating within the limits 300 B.C. and 300 A.D.

Principal Editions.—All the remains, F. Blass, Leipsic, 1869: Λογ. ἐπιταφ. and ὑπὲρ Εὐξεν., J. C. Cobet, Leyden, 1877; Κατὰ Δημ. (with *facsimile* of MS.), A. C. Harris, London, 1877; Κατὰ Δημ., Professor Churchill Babington, London, 1850; *Orations for Lyc. and for Euxen.* (with *facsimile* of MS.), Id., Cambridge, 1853; *The Funeral Oration*, Id., *ib.*, 1859. See also *Oratores Attici*, J. G. Baiter and H. Sauppe, 1850. *Translations.*—German, W. S. Teuffel, Stuttgart, 1865-69; French, *Euxen.*, 1860, *Or. Fun.*, 1858, H. Cafflaux, Valenciennes.

See Egger in *Mém. de l'Acad. des Inscript. et Belles Lettres*, 1870; W. Tröbst in *Neue Jahrb. f. class. Philol.*, 1876; Herm. Hager in Curtius's *Gram. Stud.*, 1870; *Journ. of Philology*, Cambridge, 1872-73; Mähly in *Neue Jahrb. f. class. Philol. u. Pädagog.*, 1872; Professor R. C. Jebb, *The Attic Orators* (vol. ii., ch. xxii., pp. 381-92), London, 1876; G. Boehnecke, *Demosthenes, Lykurgos, Hyperides, und ihr Zeitalter*, Berlin, 1874. There is a Russian study by A. N. Schwarz, on the speech for Euxenippus, published at Moscow, 1875.

HYPERTROPHY (from ὑπέρ, over, and τροφή, nourishment), a term in medicine employed to designate an abnormal increase in bulk of one or more of the organs or component tissues of the body. In its strict sense this term can only be applied where the increase affects the natural textures of a part, and is not applicable where the enlargement is due to the presence of some extraneous morbid formation. Hypertrophy of a part may manifest itself either by simply an increase in the size of its constituents, or by this combined with an increase in their number (hyperplasia). In many instances both are associated.

The conditions giving rise to hypertrophy are the reverse of those already described as producing ATROPHY (*q.v.*). They are concisely stated by Sir James Paget as being chiefly or only three, namely:—(1) the increased exercise of a part in its healthy functions; (2) an increased accumulation in the blood of the particular materials which a part appropriates to its nutrition or in secretion; and (3) an increased afflux of healthy blood.

Illustrations are furnished of the first of these conditions by the high development of muscular tissue under habitual active exercise; of the second in the case of obesity, which is an hypertrophy of the fatty tissues, the elements of which are furnished by the blood; and of the third in the occasional overgrowth of hair in the neighbourhood of parts which are the seat of inflammation. Obviously therefore, in many instances, hypertrophy cannot be regarded as a deviation from health, but rather on the contrary as indicative of a high degree of nutrition and physical power. Even in those cases where it is found associated with disease, it is often produced as a salutary effort of nature to compensate for obstructions or other difficulties which have arisen in the system, and thus to ward off evil consequences. No better example of this can be seen than in the case of certain forms of heart disease, where from defect at some of the natural orifices of that organ the onward flow of the blood is interfered with, and would soon give rise to serious embarrassment to the circulation, were it not that behind the seat of obstruction the heart gradually becomes hypertrophied, and thus acquires greater propelling power to overcome the resistance in front. Again, it has been noticed, in the case of certain double organs such as the kidneys, that when one has been destroyed by disease the other has become hypertrophied to such a degree as enables it to discharge the functions of both.

Hypertrophy may, however, in certain circumstances constitute a disease, as in GOITRE and ELEPHANTIASIS (*q.v.*), and also in the case of certain tumours and growths (such as cutaneous excrescences, fatty tumours, mucous polypi, &c.), which are simply enlargements of normal textures. Hypertrophy does not in all cases involve an increase in bulk; for, just as in atrophy there may be no diminution in the size of the affected organ, so in hypertrophy there may be no increase. This is apt to be the case where certain only of the elements of an organ undergo increase, while the others remain unaffected or are actually atrophied by the pressure of the hypertrophied tissue, as is seen in the disease known as cirrhosis of the liver.

A spurious sort of hypertrophy is observed in the rare disease to which M. Duchenne has applied the name of *pseudo-hypertrophic paralysis*. This ailment, which appears to be confined to children, consists essentially of a progressive loss of power accompanied with a remarkable enlargement of certain muscles or groups of muscles, more rarely of the whole muscular system. This increase of bulk is, however, not a true hypertrophy, but rather an excessive development of connective tissue in the substance of the muscles, the proper texture of which tends in consequence to undergo atrophy or degeneration. The appearance presented by a child suffering from this disease is striking. The attitude and gait are remarkably altered, the child standing with shoulders thrown back, small of the back deeply curved inwards, and legs wide apart, while walking is accompanied with a peculiar swinging or rocking movement. The calves of the legs, the buttocks, the muscles of the back, and occasionally other muscles, are seen to be unduly enlarged, and contrast strangely with the general feebleness. The progress of the disease is marked by increasing failure of locomotory power, and ultimately by complete paralysis of the limbs. The malady is little amenable to treatment, and, although often prolonged for years, generally proves fatal before the period of maturity.

HYPOCHONDRIASIS (synonyms—the spleen, the vapours). As the name implies (from τὸ ὑποχόνδριον, τὰ ὑποχόνδρια, the soft part of the body immediately under the χόνδρος or cartilage of the breast-bone), hypochondriasis and its symptoms were referred by the ancients, and indeed by physicians down to the time of Cullen, to diseases or derangements of one or more of the abdominal viscera. Cullen classified it amongst nervous diseases, and Falret more fully described it as a morbid condition of the nervous system characterized by depression of feeling and false beliefs as to an impaired state of the health. The subjects of hypochondriasis are for the most part members of families in which hereditary predisposition to degradation of the nervous system is strong, or those who have suffered from morbid influences affecting this system during the earlier years of life. It may be dependent on depressing disease affecting the general system, but under such circumstances it is generally so complicated with the symptoms of hysteria as to render differentiation difficult (see HYSTERIA). Hypochondriasis is often handed down from one generation to another in its individual form, but it is also not unfrequently to be met with in an individual as the sole manifestation in him of a family tendency to insanity. In its most common form it is manifested by simple false belief as to the state of the health, the intellect being otherwise unaffected. We may instance the "vapourish" woman or the "splenetic" as terms society has applied to its milder manifestations. Such persons are constantly asserting a weak state of health although no palpable cause can be discovered. In its more definite phases pain or uneasy sensations are referred by the patient to some particular region, generally the abdomen, the heart, or the head. That these are subjective is apparent from the fact that the general health is good: all the functions of the various systems are duly performed; the patient eats and sleeps well; and, when any circumstance temporarily overrides the false belief, he is happy and comfortable. No appeal to the reason is of any avail, and the hypochondriac idea so dominates his existence as to render him unable to perform the ordinary duties of life. In its most aggravated form hypochondriasis amounts to actual insanity, delusions arising as to the existence of living creatures in the intestines or brain, or to the effect that the body is materially changed, *e.g.*, into glass, wood, &c. (see INSANITY). The symptoms of this condition may be remittent; they may even disappear for years, and only return on the advent of some exciting cause. Suicide is occasionally committed in order to escape from the constant misery. As there is nothing to treat, medication is of no avail, and recovery can only be looked for by placing the patient under such morally hygienic conditions as may help to take his mind off himself. More generally he lives through the attack rather than is cured of it.

See Cullen, *Clinical Lectures*, pp. 39–57 (London, 1777); Georget, *De la Phys. du Syst. Nerv.* (Paris, 1819); Reynolds, *System of Medicine*, vol. ii. p. 293 (London, 1868); Griesinger, *Mental Pathology and Therapeutics* (1867); Niemeyer, *Practical Medicine* (1871).

HYPOTHEC (*Hypotheca*), in Roman law, is the most advanced form of the contract of pledge. A specific thing may be given absolutely to a creditor on the understanding that it is to be given back when the creditor's debt is paid; or the property in the thing may be assigned to the creditor while the debtor is allowed to remain in possession, the creditor as owner being able to take possession if his debt is not discharged. Here we have the kind of security known as pledge and mortgage respectively. In the *hypotheca*, the property does not pass to the creditor, nor does he get possession, but he acquires a preferential right to have his debt paid out of the hypothecated property; that is, he can sell it and pay himself out of the proceeds, or in default of a purchaser he can become the owner himself. The name and the principle have passed into the law of Scotland, which distinguishes between conventional hypothecs, as *bottomry* and *respondentia*, and tacit hypothecs established by law. Of the latter the most important is the landlord's hypothec for rent (corresponding to distress in the law of England), which extends over the produce of the land and the cattle and sheep fed on it, and over stock and horses used in husbandry. The law of agricultural hypothec has long caused much discontent in Scotland; its operation was restricted by 30 & 31 Vict. c. 42, and finally by 43 Vict. c. 12 it has been enacted that the "landlord's right of hypothec for the rent of land, including the rent of any buildings thereon, exceeding two acres in extent, let for agriculture or pasture, shall cease and determine." As a set off the landlord is to have the same rights and remedies against a tenant when six months' rent or twelve months' rent is due and unpaid as he had formerly against a tenant when twelve months' rent or two years' rent respectively was due and unpaid.

HYRAX, a genus of diminutive plantigrade mammals, the position of which in the mammalian series has, owing to their apparent affinity with several widely different groups, given rise to considerable controversy. Approaching the hare in their external appearance and habits, the rhinoceros in their molar teeth and much of their skeleton, the hippopotamus in the form of their lower incisors, and the sloth in the great number of their dorsal vertebræ, they were at first classed with the rodents, and afterwards, by Cuvier, with the pachyderms, where they remained until, on the breaking up of that most heterogeneous of groups,

Cape Hyrax.

Professor Huxley established the order *Hyracoidea* for their reception. They are small, rabbit-like creatures, the largest not exceeding 18 inches in length, covered with a thick soft fur with numerous bristles interspersed. Their ears and legs are short; the tail is represented only by a small tubercle; and their toes, of which they have four on each foot in front and three behind, are, with the exception of the inner one on each hind foot, provided with flat hoof-like nails. They have twenty-one pairs of ribs—a larger number than is possessed by any other mammals except the sloths, which have twenty-three pairs. They are gregarious animals, dwelling in colonies in the crevices of rocks and in the caverns which abound in the hilly regions they frequent, and feeding on grass and other herbage, on roots, fruits, and the tender shoots of plants. There are, according to Dr Gray, thirteen species of *Hyrax*, many of which are, however, regarded by other authorities as merely varieties. They are all confined to the African continent with the exception of the Syrian hyrax or daman (*Hyrax syriacus*), whose range extends from Abyssinia into Arabia, Syria, and Palestine. This species is generally regarded as the "shaphan," rendered "conies" in the English Bible, which "are but a feeble folk, yet make their houses in the rocks" (Prov. xxx. 26). They measure about a foot in length and 11 inches in height, and are of a greyish-brown colour above, fulvous on the flanks, and white beneath. They are active little creatures, darting in and out of their rocky shelters with remarkable agility. Bruce, who observed their habits in Abyssinia, states that large numbers of them were frequently to be seen sitting on great stones at the mouths of caves, basking in the sunshine, or enjoying the coolness of the summer evening. Of timid and gentle disposition, they can be readily tamed, although when roughly handled at first they are said to bite severely. The Cape hyrax (*Hyrax capensis*) or "badger" (dasse; Dutch, Das; German, Dachs) is the largest known species, measuring about 18 inches in length. It frequents situations similar to those occupied by the Syrian form, and is exceedingly shy, peeping out of its rocky hiding places with a circumspection which is by no means uncalled for, as it forms a favourite food of lions, hyænas, and the larger birds of prey. The latter, it is said, may often be seen perched, for hours, like statues on the rocks, watching their opportunity to dart upon the luckless "badger." To guard against such surprises, they are said, when feeding, to place one of their number, usually an old male, as a sentinel, whose shrill prolonged cry gives timely notice of approaching danger. Like the "conies," they are readily tamed, and seem capable of considerable attachment, although their natural timidity and suspicion cause them to hide themselves on the appearance of a stranger. There are two species of hyrax, one in the south and the other in the west of Africa, which are said to be arboreal in their habits, making their abode in the holes of trees. Dr Gray has placed these in a separate genus—*Dendrohyrax*. The island of Fernando Po possesses a species peculiar to itself, while the genus is entirely wanting in Madagascar. No fossil remains of the hyrax have yet been found.

HYRCANIA, a province of Asia, south of the Caspian Sea, and bounded on the E. by the river Oxus. It was, however, a wide and indefinite tract, the extent of which is variously conceived. Its chief city is called Tape by Strabo, Zadracarta by Arrian. The latter is evidently the same as Carta, mentioned by Strabo as an important city. Some parts of the country were fertile, but the general idea prevalent among the classical writers is that it was a rude region of forests full of dangerous wild animals. Little is known of the history of the country, as it seldom came into connexion with the better known races. Xenophon says it was subdued by the Assyrians; Curtius says that 6000 Hyrcanians were in the army of the last Persian king Darius. Two towns named Hyrcania are mentioned, one in the country of Hyrcania, the other in Lydia. The latter is said to have derived its name from a colony of Hyrcanians, transported thither by the Persians.

HYRCANUS (Ὑρκανός), a Greek surname, of unknown origin, borne by several Jews of the Maccabæan period.

John Hyrcanus I., high priest of the Jews from 135 to 105 B.C., was the youngest son of Simon Maccabæus. In 137 B.C. he, along with his brother Judas, commanded the force which repelled the invasion of Judæa led by Cendebeus the general of Antiochus VII. (Sidetes). On the assassination of his father and two elder brothers by Ptolemy, governor of Jericho, his brother-in-law, in February 135, he succeeded to the high priesthood and the supreme authority in Judæa. While still engaged in the struggle with Ptolemy, he was attacked by Antiochus with a large army (134), and compelled to shut himself up in Jerusalem; after a severe siege peace was at last secured only on condition of a Jewish disarmament, and the payment of an indemnity and an annual tribute, for which hostages were taken. In 129 he accompanied Antiochus as a vassal prince on his ill-fated Parthian expedition; returning, however, to Judæa before winter, he escaped the final disaster. By the judicious mission of an embassy to Rome he now obtained confirmation of the alliance which his father had previously made with the growing western power; at the same time he availed himself of the weakened state of the Syrian monarchy under Demetrius II. to overrun Samaria, and also to invade Idumæa, which he completely subdued, compelling its inhabitants to receive circumcision and accept the Jewish faith. After a long period of rest he directed his arms against the town of Samaria, which, in spite of the intervention of Antiochus, his sons Antigonus and Aristobulus ultimately took, and by his orders razed to the ground (*c.* 109 B.C.). He died in 105, and was succeeded by Aristobulus, the eldest of his five sons. The external policy of Hyrcanus was marked by considerable energy and tact, and, aided as it was by favouring circumstances, was so successful as to leave the Jewish nation in a position of independence and of influence such as it had not known since the days of Solomon. During its later years his reign was much disturbed, however, by the contentions for ascendency which arose between the Pharisees and Sadducees, the two rival sects or parties which then for the first time (under those names at least) came into prominence. Josephus has related the curious circumstances under which he ultimately transferred his personal support from the former to the latter.

John Hyrcanus II., high priest from 78 to 40 B.C., was the eldest son of Alexander Jannæus by his wife Alexandra, and was thus a grandson of the preceding. When his father died in 78, he was by his mother forthwith appointed high priest, and on her death in 69 he claimed the succession to the supreme civil authority also; but, after a brief and troubled reign of three months, he was compelled to abdicate both kingly and priestly dignities in favour of his more energetic and ambitious younger brother Aristobulus II. In 63 it suited the policy of Pompey that he should be restored to the high priesthood, with some semblance of supreme command, but of much of this semblance even he was soon again deprived by the arrangement of the proconsul Gabinius, according to which Palestine was in 57 B.C. divided into five separate circles (σύνοδοι, συνέδρια). For services rendered to Cæsar after the battle of Pharsalia, he was again rewarded with the sovereignty (προστασία τοῦ ἔθνους, Jos., *Ant.*, xx. 10) in 47 B.C., Antipater of Idumæa, however, being at the same time made procurator of Judæa. In 41 B.C. he was practically superseded by Antony's appointment of Herod and Phasael to be tetrarchs of Judæa; and in the following year he was taken prisoner by the Parthians, deprived of his ears that he might be permanently disqualified for priestly office, and carried to Babylon. He was permitted in 33 B.C. to return to Jerusalem, where on a charge of treasonable correspondence with Malchus, king of Arabia, he was put to death in 30 B.C.

See Josephus (*Ant.*, xiii. 8–10; xiv. 5–13; *Bell. Jud.*, i. 2; i. 8–13), upon whose narrative all the modern accounts, as, *e.g.*, those by Ewald, Grätz, and Hitzig in their *Histories*, are based.

HYSSOP (*Hyssopus officinalis*), a garden herb belonging to the natural order *Labiatæ*, cultivated for use in domestic medicine. It is a small perennial plant about 2 feet high, with slender, quadrangular, woody stems; narrowly elliptical, pointed, entire, dotted leaves, about 1 inch long and ⅓ inch wide, growing in pairs on the stem; and long terminal, erect, half-verticillate, leafy spikes of small violet-blue flowers, which are in blossom from June to September. Two varieties of the plant occur in gardens, one having variegated leaves and the other reddish flowers. The leaves have a warm, aromatic, bitter taste, and are believed to owe their properties to a volatile oil which is present in the proportion of $\frac{1}{4}$ to $\frac{1}{2}$ per cent. Hyssop is a native of the south of Europe, its range extending eastward to Siberia; it was introduced into England by Gerard in the year 1596. A strong tea made of the leaves, and sweetened with honey, was formerly used in pulmonary and catarrhal affections, and externally as an application to bruises and indolent swellings.

The Hedge Hyssop (*Gratiola officinalis*) belongs to the natural order *Scrophulariaceæ*, and is a native of marshy lands in the south of Europe, whence it was introduced into Britain nearly 300 years ago. Like *Hyssopus officinalis*, it has smooth opposite entire leaves, but the stems are cylindrical, the leaves twice the size, and the flowers solitary in the axils of the leaves and having a yellowish-red veined tube and bluish-white limb, while the capsules are oval and many-seeded. The herb has a bitter, nauseous taste, but is almost odourless. In small quantities it acts as a purgative, diuretic, and emetic when taken internally. It was formerly official in the Edinburgh Pharmacopœia, being esteemed as a remedy for dropsical and scrofulous affections. It has also been given in the form of wine for hypochondriasis. It is said to have formed the basis of a celebrated nostrum for gout, called *Eau médicinale*, and in former times was called *Gratia Dei*, on account of its medicinal properties. When growing in abundance, as it does in some damp pastures in Switzerland, it becomes dangerous to cattle. *G. peruviana* is known to possess similar properties.

The hyssop (*'ezob*) of Scripture (Ex. xii. 22; Lev. xiv. 4, 6; Numb. xix. 6, 18; 1 Kings v. 13 (iv. 33); Ps. li. 9 (7); John xix. 29), a wall-growing plant adapted for sprinkling purposes, has long been the subject of learned disputation, the only point on which all have agreed being that it is not to be identified with the *Hyssopus officinalis*, which is not a native of Palestine. No less than eighteen plants have been supposed by various authors to answer the conditions, and Celsius has devoted more than forty pages to the discussion of their several claims. By Tristram (*Oxford Bible for Teachers*, 1880) and others the caper plant (*Capparis spinosa*) is supposed to be meant; but, apart from other difficulties, this identification is open to the objection that the caper seems to be, at least in one passage (Eccl. xii. 5), otherwise designated (*'abiyyônah*). Thenius (on 1 Kings v. 13) suggests *Orthotrichum saxatile*. The most probable opinion would seem to be that found in Maimonides and many later writers, according to which the Hebrew *'ezob* is to be identified with the Arabic *sa'atar*, now understood to be *Satureja Thymus*, a plant of very frequent occurrence in Syria and Palestine, with which *Thymus Serpyllum*, or Wild Thyme, and *Satureja Thymbra* are closely allied. Its smell, taste, and medicinal properties are similar to those of *H. officinalis*. In Morocco the *sa'atar* of the Arabs is *Origanum compactum*, Benth.; and it appears probable, as suggested by Mr W. Carruthers, that several plants of the genera *Thymus*, *Origanum*, and others nearly allied in form and habit, and found in similar localities, were used under the name of hyssop.

See Gerard, *Herball*, p. 578–582; Stillé and Maisch, *National Dispensatory*, p. 7512; Carruthers, in *Bible Educator*, vol. iv. p. 226–27; Thomson, *The Land and the Book*, p. 112; J. Smith, *Bible Plants*, p. 214; Furrer, art. "Ysop," in Schenkel's *Bibel-Lexicon*, vol. v.

HYSTERIA, a term applied to a disordered condition of the nervous system, the anatomical seat and nature of which are unknown to medical science, but of which the symptoms consist in well-marked and very varied disturbances of nerve function. By the ancients and by modern physicians down to the time of Sydenham its symptoms were supposed to be due to disturbances of the uterus (ὑστέρα, whence the name), but it is now universally recognized that they are dependent on a variety of causes with which that organ has no necessary connexion. The causes of hysteria may be divided into the predisposing, such as hereditary predisposition to nervous degeneration, sex, age, occupation, and national idiosyncracy; and the immediate, such as mental and physical exhaustion, fright, and other emotional influences, pregnancy, the puerperal condition, diseases of the uterus and its appendages, and the depressing influence of injury or general disease. Each and all of these causes may act and react in any given case; in fact, it is nearly always impossible to assign a particular cause in a particular instance. Perhaps, taken over all, hereditary predisposition to nerve-instability may be asserted as the most prolific cause. It is often noticed in families in which this instability exists that hysteria presents itself to a greater or less extent in a considerable number of its members as the sole indication of the diathesis. As regards age the condition is apt to appear at the evolutional periods of life—puberty, pregnancy, and the climacteric—without any further assignable cause except that first spoken of. It is very frequent in girls between the ages of twelve and fifteen, and in women on the cessation of the menstrual flow. It is much more common in the female than the male,—in the proportion of 20 to 1,—which circumstance points to the important influence of the uterus in causation, but definitely places hysteria in the category of nervous diseases. It has been asserted that certain races are more liable to the disease than others—that for instance the Latins and the Slavs are more prone to it than other inhabitants of Europe. This, however, is doubtful; in the more excitable races we find on the whole a greater tendency to hysterical excitement, in those whose national characteristic is calm and impassionateness a tendency to hysterical depression; and it is probable that the greater prominence of the symptoms in the former may have masked the more subtle yet not less important manifestations of the disease presented in the latter. Occupation, or be it rather said want of occupation, is a prolific cause. This is noticeable in all classes of society: in the higher the idle luxurious woman concentrates herself upon herself, and the frivolity of her existence helps to aggravate the evil which may be innate in her constitution; in the lower classes the disease is not so prevalent except among women who live a vicious and excited life. The experience of prison authorities shows not only that women of the criminal classes are individually liable to the hysterical paroxysm, but that it is very apt to assume an epidemic form amongst them. There is no proof that any particular legitimate occupation tends to its development. The depressing effects of almost any disease may be directly productive of hysteria, more especially those accompanied by pain and loss of sleep. There can be little doubt, however, that disease of the uterus and its appendages has a greater tendency towards its production than disease of any other system. At the same time, hysteria seems to follow more frequently on the less severe than on the graver forms of uterine complaints.

In point of duration hysteria may be transient or chronic. In the first phase it consists of an explosion of emotionalism, generally the result of mental excitement, to which the popular term "hysterics" is applied. Such attacks are generally preceded and accompanied by a sensation of a lump in the throat (the "globus hystericus"), a flow of limpid urine, violent outbursts of alternate laughter and weeping, and sometimes even convulsion. In the chronic condition we find an extraordinary complexity of symptoms, both physical and mental. These are continuous, constituting the "status hystericus," and paroxysmal. The physical symptoms are extremely diverse: there may be a pseudo-paralysis, the patient lying palsied wholly or partially, or there may be rigidity of one or more limbs, in either case the symptom persisting for weeks or months or even years; there may be flushing or pallor of the face, an increase or decrease of temperature. Perversions of sensation are frequent symptoms; these consist in complaint of pain, generally of a local character: a common instance is the sensation of a nail being driven through the vertex of the head ("clavus hystericus"), or of increased sensibility of particular parts. On the other hand loss of sensation may be complained of, or, as occasionally happens, hyperæsthesia and anæsthesia may be stated by an individual to exist in different parts of the body. The region of the spine is a very frequent seat of hysterical pain. Pain, more especially when referred to a joint, is apt to be accompanied by swelling. Both the motor and the sensory symptoms are in every instance out of all proportion to any assignable cause, and for the most part disappear suddenly, leaving the patient in perfect health. It is to such cases that the wonderful cures effected by quacks and charlatans may be referred. The mental symptoms have not the same tendency to pass away suddenly. They may be spoken of as interparoxysmal and paroxysmal. The chief characteristics of the former are extreme emotionalism combined with a curious obstructiveness, a desire to be an object of importance, and a constant craving for sympathy. This is sought to be procured at an immense sacrifice of personal comfort, and to this may be referred a very large proportion of the motor and sensory symptoms above spoken of. The paroxysmal condition does not materially differ from the transient hysteric attack, except that convulsion is more common and more violent. The special senses of taste, sight, and hearing may be affected, sometimes temporarily obliterated. Hysteria may pass into absolute insanity.

Treatment consists in attention to the general health, and to such special symptoms as may arise, notably those connected with the function of menstruation. The submission of the patient to the best moral influences is of no mean importance. But it may be admitted that the results are generally unsatisfactory so far as medication is concerned, as the cure is usually spontaneous or dependent on some sudden mental influence.

See Ziemssen's *Cyclopedia of the Practice of Medicine*, vol. xiv.; Reynolds's *System of Medicine*, vol. ii. (J. B. T.)

HYSTERO-EPILEPSY, a nervous disease of women, occurring during the fertile period of life, first observed and described by Professor Charcot of Paris. As yet it has been rarely observed in Great Britain. Its phenomena are very extraordinary, and serious doubts have been entertained by eminent authorities as to their substantiality, it being asserted that they are merely manifestations of ordinary hysteria, intensified by a process of education. But these doubts are being rapidly dissipated by the observations of competent observers. The disease is of a paroxysmal nature, and its symptoms may be divided into inter-paroxysmal and paroxysmal. The former consist of extreme sensitiveness over the region of one or (less frequently) both ovaries, and loss of tactile sensibility and complete insensibility to pain in one lateral half of the body, the side on which ovarian tenderness exists. Sight is sometimes implicated, manifested by a peculiar form of colour-blindness. Perhaps the most remarkable phenomenon presented in this disease is that all these impairments of sensation may be shifted to the other side of the body on the application of magnets and plates of metals, the originally affected side regaining sensibility so long as the opposite one is insensible. In some cases the symptoms are permanently bilateral. The paroxysm consists in violent general convulsion, epileptiform in character, which is at once checked by pressure over the tender ovary. The mental faculties are generally weakened, and the disease is for the most part incurable. (See Charcot, *Lectures on Diseases of the Nervous System*, New Sydenham Soc., 1877.)

HYTHE, a municipal and parliamentary borough of Kent, England, and one of the original Cinque Ports, is beautifully situated at the foot of a steep cliff near the eastern extremity of Romney Marsh, about half a mile from the sea, on a branch line of the South-Eastern Railway, 66 miles E.S.E. of London, 16 S.W. of Dover, and 5 W. of Folkestone. It consists principally of one long handsome street running parallel with the shore. On the slope of the hill above the town stands the fine old church of St Leonard, partly Late Norman and partly Early English, with a tower rebuilt about 1750. In a vault under the chancel there is a collection of human skulls and bones supposed to be the remains of ancient Britons and Saxons slain in a battle which took place near Hythe in 456. Of late the church has been undergoing restoration at a considerable cost, and it is proposed to complete the chancel, which was originally left unfinished. At Lympne there are the remains of a Roman *castrum*, and excavations made some years ago brought to light many interesting remains of the old Roman town, the *Portus Lemanus*. The site of the *castrum* is now occupied by the fine old castellated mansion of Studfall Castle, at one time the residence of the archdeacons of Canterbury, but at present used as a farm-house. Norman portions of the Lympne church originally built by Archbishop Lanfranc are still standing; and a small distance east from it is Shipway or Shepway Cross, where the great assemblies relating to the Cinque Ports used to be held until they were removed to Romney. Several bronze implements and weapons were discovered near Hythe in 1873, during the excavation of the railway line from Hythe to Sandgate. A mile north from Hythe is Saltwood Castle, of very ancient origin, but rebuilt in the time of Richard II. Hythe possesses a guild hall founded in 1794, and two hospitals, that of St Bartholomew founded by Haimo, bishop of Rochester, in 1336, and that of St John, of still greater antiquity but unknown date, and founded originally for the reception of lepers. A Government school of musketry, in which instructors of musketry for the army are trained, was established in 1854; and the Shorncliffe military camp is within 2½ miles of the town. On account of its pleasant situation and its picturesque and interesting neighbourhood, Hythe has become a favourite watering-place. Baths were erected in 1854 at a cost of £2000, and the sea wall and parade has lately been extended eastwards to Sandgate, the total length being 3 miles. From the town to the sea-shore there is a stately avenue of wych elms. The area of the municipal borough is 1744 acres, and of the parliamentary borough 3571 acres. The population of the municipal borough in 1871 was 3383, and of the parliamentary borough 24,078. The latter includes the municipal borough of Folkestone.

Hythe occurs in old documents as Hethe, and in Domesday Book as Hede. The word is derived from the Saxon *Hyth*, meaning a harbour. The present town of Hythe rose to importance after the decay of West Hythe by the withdrawal of the sea, West Hythe having previously succeeded to the *Portus Lemanus*, whose decay had been due to a like cause. Since the reign of Elizabeth the harbour has been choked up with sand. It is a theory of some writers that the landing place of Julius Cæsar on his first invasion of Britain was in the vicinity of Lympne. Anciently Hythe, with the parish of West Hythe, was within a "hundred" of its own. Along with Saltwood it was given in 1026 by Halfdan, a Saxon thane, to Christ Church in Canterbury; and it was afterwards held for knight's service by Earl Godwine. According to Leland, it at one time had a fine abbey and four parish churches. It succeeded to the ancient privileges which West Hythe enjoyed as a Cinque Port, its quota being 5 ships, 105 men, and 5 boys. When Earl Godwine ravaged the coast of Kent in 1052 he took several ships from the harbour of Hythe. In 1293 the inhabitants with great valour repulsed the attacks of the seamen of a French man-of-war who had disembarked in the harbour and were beginning to plunder the town. In the reign of Richard II. a great conflagration destroyed 200 of the houses and 5 of the ships in the harbour. Hythe and Saltwood were given by Archbishop Cranmer to Henry VIII. in lieu of other estates, and they continued vested in the crown until the 17th year of Elizabeth, when the town received a charter of incorporation. It is now governed by 4 aldermen and 12 councillors, one of whom is mayor. From the 42d year of Edward III. it possessed the privilege of returning two members to parliament, but since 1832 it has returned only one.

I

I is one of those symbols which the Greeks employed differently from the Phœnicians. In Phœnician it denoted the palatal semi-vowel *y*, called in Hebrew *yodh*. The Greeks disliked this sound, and it vanished at an early time out of their language. Consequently they needed no symbol to represent it, and could use the Phœnician symbol to denote that for which the Phœnician alphabet gave them no help, namely, the vowel *i*. The symbol, however, had not at that time its present simple form, as may be seen by reference to the table at the end of the article ALPHABET. It was made up of several lines, and so it appears in the oldest Greek inscriptions, *e.g.*, in those of Thera, about the 40th Olympiad, in which it is not unlike the later form of sigma (Σ). In the old Corinthian alphabet it sometimes has this form; sometimes the angles to the left are rounded, so that it resembles an *e*. Generally, however, we find it in Greek simplified into the single straight line with which we are familiar. It has no other form in the Latin alphabet. In the last century before Christ, the Romans sometimes lengthened the symbol to denote the long vowel, so that it reached above the top of the line, while the short vowel was expressed by a line of the usual length. This took the place of the older method by which the symbol was doubled to denote the long vowel; as *aa, ee, ii*. But it never became universal, nor was the lengthened symbol always put to the same use; for about the same time we find it used to denote the *y* sound in words like *Maia, cuius*, where the Romans rightly thought it expedient to have a distinct mark for the semi-vowel. But this also was not permanent.

The value of the symbol is generally constant in all European languages, ancient or modern, with the exception of English. It is the vowel sound produced by raising the front of the tongue towards the palate, as high as it can be raised without touching. The lips are not rounded; by rounding them, when the tongue is in this position, we should produce the sound of the French *u* or the German *ü*. The vowel may, however, be either open or close, and in either of these cases it may be short or long. Therefore we have four variations, of which, however, probably not more than two are found in any spoken language:—(1) the short open *i*, heard in English "sin"; (2) the long open *ī*, which is not one of our spoken sounds, but can be produced in singing; (3) the short close *i*, which again is not English, but is the Italian short *i*; (4) the long close *i*, which is the Italian long *i*, and is also common in English; but we denote the sound, not by *ī*, but by *ee*, as in "seen." It is generally supposed that the sound of *ee* stands to that of *i* in English as a long vowel to the corresponding short; but this is not so; there is a difference in quality as well; *ee* denotes (as has been just explained) a close vowel, whereas *i* is open. It is true that in ordinary English the open vowel *i* only occurs short, and the close vowel long, therefore the confusion is natural. A Scotchman, however, finds no difficulty in pronouncing "seen" short.

It is practically necessary in English to denote the simple long *i* sound by *ee*, because the English language has habitually altered the simple sound into a diphthong, and has retained for that diphthong the original spelling *i*. Thus in words like "pride," "mine," "fire," &c., the vowel had once in England the same sound as it has on the Continent; but now it is sounded as the diphthong *ai*, though the spelling has not been changed. It appears from Mr Alexander J. Ellis's investigations into the history of English pronunciation that *i* had become a diphthong in the 16th century; but the exact date of the change must remain uncertain. There can be little doubt that its nature has been correctly explained by the same philologist. It consists in pronouncing the long vowel without sufficiently raising the tongue at the beginning of the sound; hence the sound is at first too open, and is modified into the proper *i* sound before it is terminated. Changes of this sort are natural in long vowels, because there is time to vary the original sound, either as a refinement, or, more probably, through mere inattention and laziness.

IAMBLICHUS, the chief representative of Syrian Neo-Platonism, is only imperfectly known to us in the events of his life and the details of his creed. We learn, however, from Suidas, and from his biographer Eunapius, that he was born at Chalcis in Cœle-Syria, the scion of a rich and illustrious family, that he studied under Anatolius and afterwards under Porphyry, the pupil of Plotinus, that he himself gathered together a large number of disciples of different nations with whom he lived on terms of genial friendship, that he wrote "various philosophical books," and that he died during the reign of Constantine,—according to Fabricius, before 333 A.D. His residence (probably) at his native town of Chalcis was varied by a yearly visit with his pupils to the baths of Gadara. Of the books referred to by Suidas only a fraction has been preserved. His commentaries on Plato and Aristotle, and works on the Chaldæan theology and on the soul, are lost. For our knowledge of his system we are indebted partly to the fragments of these writings preserved by Stobæus and others, and to the notices of his successors, especially Proclus, partly to his five extant books, the sections of a great work on the Pythagorean philosophy. Besides these, Proclus (412–485) seems to have ascribed to him[1] the authorship of the celebrated book *On the Egyptian Mysteries* (so-called), and although its differences in style and in some points of doctrine from the writings just mentioned make it improbable that the work was by Iamblichus himself, it certainly emanated from his school, and in its systematic attempt to give a speculative justification of the polytheistic cultus of the day, marks the turning-point in the history of thought at which Iamblichus stood.

As a speculative theory Neo-Platonism had received its highest development from Plotinus. The modifications introduced by Iamblichus were the elaboration in greater detail of its formal divisions, the more systematic application of the Pythagorean number-symbolism, and chiefly, under the influence of Oriental systems, the thorough-going mythic interpretation of what the previous philosophy had still regarded as notional. It is on the last account, probably, that Iamblichus was looked upon with such extravagant veneration. As a philosopher he had learning indeed, but little originality. But by using what he had to throw a haze of philosophy over the popular superstition, he acquired his fame. By his contemporaries he was accredited with miraculous powers (which he, however, disclaimed), and by his followers in the decline of Greek philosophy, and his admirers on its revival in the 15th and 16th centuries, his name was scarcely mentioned without the epithet "divine" or "most divine," while, not content with the more modest eulogy of Eunapius that he was inferior to Porphyry only in style, the emperor Julian regarded him as not even

[1] Besides the anonymous testimony prefixed to an ancient MS. of Proclus, *De Myst.* viii. 3 seems to be quoted by the latter as Iamblichus's. *Cf.* Meiners, "Judicium de Libro qui de Myst. Æg. inscribitur," in *Comment. Soc. Reg. Sci. Gott.*, vol. iv., 1781, p. 77.

second to Plato, and said that he would give all the gold of Lydia for one epistle of Iamblichus.

Theoretically, the philosophy of Plotinus was an attempt to harmonize the principles of the various Greek schools. At the head of his system he placed the transcendent incommunicable one (ἓν ἀμέθεκτον), whose first-begotten is intellect (νοῦς), from which proceeds soul (ψυχή), which in turn gives birth to φύσις, the realm of nature. Immediately after the absolute one, Iamblichus introduced a second superexistent unity to stand between it and the many as the producer of intellect, and made the three succeeding moments of the development (intellect, soul, and nature) undergo various modifications. He speaks of them as intellectual (θεοὶ νοεροί), supramundane (ὑπερκοσμίοι), and mundane gods (ἐγκοσμίοι). The first of these—which Plotinus represented under the three stages of (objective) being (ὄν), (subjective) life (ζωή), and (realized) intellect (νοῦς)—is distinguished by him into spheres of intelligible gods (θεοὶ νοητοί) and of intellectual gods (θεοὶ νοεροί), each subdivided into triads, the latter sphere being the place of ideas, the former of the archetypes of these ideas. Between these two worlds, at once separating and uniting them, some scholars think there was inserted by Iamblichus, as afterwards by Proclus, a third sphere partaking of the nature of both (θεοὶ νοητοὶ καὶ νοεροί). But this supposition depends on a merely conjectural emendation of the text. We read, however, that "in the intellectual hebdomad he assigned the third rank among the fathers to the Demiurge." The Demiurge, Zeus, or world-creating potency, is thus identified with the perfected νοῦς, the intellectual triad being increased to a hebdomad, probably (as Zeller supposes) through the subdivision of its first two members. As in Plotinus νοῦς produced nature by mediation of ψυχή, so here the intelligible gods are followed by a triad of psychic gods. The first of these is incommunicable and supramundane, while the other two seem to be mundane though rational. In the third class, or mundane gods (θεοὶ ἐγκοσμίοι), there is a still greater wealth of divinities, of various local position, function, and rank. We read of gods, angels, demons, and heroes, of twelve heavenly gods whose number is increased to thirty-six or three hundred and sixty, and of seventy-two other gods proceeding from them, of twenty-one chiefs (ἡγεμόνες) and forty-two nature-gods (θεοὶ γενεσιουργοί), besides guardian divinities, of particular individuals and nations. The world is thus peopled by a crowd of superhuman beings influencing natural events, possessing and communicating knowledge of the future, and not inaccessible to prayers and offerings.

The whole of this complex theory is ruled by a mathematical formulism of triad, hebdomad, &c., while the first principle is identified with the monad, νοῦς with the dyad, and ψυχή with the triad, symbolic meanings being also assigned to the other numbers. "The theorems of mathematics," he says, "apply absolutely to all things," from things divine to original matter (ὕλη). But though he thus subjects all things to number, he holds elsewhere that numbers are independent existences, and occupy a middle place between the limited and unlimited.

Another difficulty of the system is the account given of nature. It is said to be "bound by the indissoluble chains of necessity which men call fate," as distinguished from divine things which are not subject to fate. Yet, being itself the result of higher powers becoming corporeal, a continual stream of elevating influence flows from them to it, interfering with its necessary laws and turning to good ends the imperfect and evil. Of evil no satisfactory account is given: it is said to have been generated accidentally.

In his doctrine of man Iamblichus retains for the soul the middle place between intellect and nature it occupies in the universal order. He rejects the passionless and purely intellectual character ascribed to the human soul by Plotinus, distinguishing it sharply both from those above and those below it. He maintains that it moves between the higher and lower spheres, that it descends by a necessary law (not solely for trial or punishment) into the body, and, passing perhaps from one human body to another, returns again to the supersensible. This return is effected by the virtuous activities which the soul performs through its own power of free will, and by the assistance of the gods. These virtues were classified by Porphyry as political, purifying (καθαρτικαί), theoretical, and paradigmatic; and to these Iamblichus adds a fifth class of priestly virtues (ἱερατικαὶ ἀρεταί), in which the divinest part of the soul raises itself above intellect to absolute being.

Iamblichus does not seem ever to have attained to that ecstatic communion with and absorption in deity which was the aim of earlier Neo-Platonism, and which Plotinus enjoyed four times in his life, Porphyry once. Indeed his tendency was not so much to raise man to God as to bring the gods down to men—a tendency shown still more plainly in the "Answer of Abamon the master to Porphyry's letter to Anebo and solutions of the doubts therein expressed," afterwards entitled the *Liber de Mysteriis*, and ascribed to Iamblichus.

In answer to questions raised and doubts expressed by Porphyry, the writer of this treatise appeals to the innate idea all men have of the gods as testifying to the existence of divinities countless in number and various in rank (to the correct arrangement of which he, like Iamblichus, attaches the greatest importance). He holds with the latter that above all principles of being and intelligence stands the absolute one from whom the first god and king spontaneously proceeds; while after these follow the etherial, empyrean, and heavenly gods, and the various orders of archangels, angels, demons, and heroes distinguished in nature, power, and activity, and in greater profusion than even the imagination of Iamblichus had conceived. He says that all the gods are good (though he in another place admits the existence of evil demons who must be propitiated), and traces the source of evil to matter; rebuts the objection that their answering prayer implies passivity on the part of gods or demons; defends divination, soothsaying, and theurgic practices as manifestations of the divine activity; describes the appearances of the different sorts of divinities; discusses the various kinds of sacrifice, which he says must be suitable to the different natures of the gods, material and immaterial, and to the double condition of the sacrificer as bound to the body or free from it (differing thus in his psychology from Iamblichus); and, in conclusion, states that the only way to happiness is through knowledge of and union with the gods, and that theurgic practices alone prepare the mind for this union —again going beyond his master, who held assiduous contemplation of divine things to be sufficient. It is the passionless nature of the soul which permits it to be thus united to divine beings,—knowledge of this mystic union and of the worship associated with it having been derived from the Egyptian priests, who learnt it from Hermes.

On one point only does the author of the *De Mysteriis* seem not to go so far as Iamblichus in thus making philosophy subservient to priestcraft. He condemns as folly and impiety the worship of images of the gods, though his master held that these "simulacra" were filled with divine power, whether made by the hand of man or (as he believed) fallen from heaven. But images could easily be dispensed with from the point of view of the writer, who not only held that all things were full of gods (πάντα πλήρη θεῶν, as Thales said), but thought that each man had a special divinity of his own—an ἴδιος δαίμων—as his guard and companion.

Bibliography.—Of the five extant books of Iamblichus referred to above, (1) that *On the Pythagorean Life* (περὶ τοῦ Πυθαγορικοῦ βιοῦ) was first edited, in Greek and Latin, by Arcerius Theodoretus, 1598; again by Kuster, 1707; and by Kiessling, Leipsic, 1815-16; while a new edition is promised by E. Rhode, who discusses the sources, &c., of the work in the *Rhein. Museum*, vol. xxvi., 1871, pp. 554 *sq.*; *cf.* vol. xxxiv., 1879, pp. 260 *sq.* (2) The *Exhortation to Philosophy* (λόγοι προτρεπτικοὶ εἰς φιλοσοφίαν) was edited first along with the former in 1598, and again by Kiessling, Leipsic, 1813. (3) The treatise *On the General Science of Mathematics* (π. τῆς κοινῆς μαθηματικῆς) was edited by Villoison, *Anecd. Græca*, ii. 188-225, Venice, 1781; and a useful account of the same is given by J. G. Friis in his *Introductio in Librum Iamblichi Tertium*, 1790. (4) The book *On the Arithmetic of Nicomachus* (π. τῆς Νικομάχου ἀριθμητικῆς εἰσαγωγῆς), along with fragments on fate (π. εἱμαρμένης) and prayer (π. εὐχῆς), was edited in Greek and Latin by S. Tennulius, 1668; and (5) the *Theological Principles of Arithmetic* (θεολογούμενα τῆς ἀριθμητικῆς)—the seventh book of the series—by Ast, Leipsic, 1817. Two lost books, treating of the physical and ethical signification of numbers, stood fifth and sixth, while books on music, geometry, and astronomy followed.

The so-called *Liber de Mysteriis* was rendered into Latin by Marsilius Ficinus, Venice, 1497, fol.,—several times reprinted,—and again by N. Scutellius, Rome, 1556, 4to. The original Greek was edited, with Latin translation and notes, first by T. Gale, Oxford, 1678, fol., and more recently by G. Parthey, Berlin, 1857, 8vo.

There is a monograph on Iamblichus by Hebenstreit (*De Iamblichi, philosophi Syri, doctrina Christianæ religioni, quam imitari studet, noxia*, Leipsic, 1764), and one on the *De Myst.* by Harless (*Das Buch v. d. ägyp. Myst.*, Munich, 1858). The discussion by Meiners on the genuineness of the *De Myst.* has been already referred to, and seems to be conclusive against attributing it to Iamblichus. Thomas Taylor, the English Platonist, translated the *Life of Pythagoras* and the *Egyptian Mysteries* (London, 1818; Chiswick, 1821). The best accounts of Iamblichus are those of Zeller, *Phil. d. Griechen*, iii. 2, pp. 613 *sq.*, 2d ed., and Vacherot, *Hist. de l'École d'Alexandrie*, ii. 57 *sq.* (W. R. SO.)

IBADAN, a large and flourishing town of West Africa, in the Yoruba country, about 80 miles inland from Lagos, and about 50 miles to the north-east of Abeokuta. It occupies the slope of one of the hills of the Kong range, and stretches down into the valley through which the river Ona flows. The site is well drained by natural streams, but their waters are often polluted by the dead bodies flung out to the vultures. The mud walls by which the town is enclosed have a circuit of 18 miles, and it is encompassed by a circle of cultivated land about 5 or 6 miles in breadth. The houses are all low thatched structures, enclosing a square court, and the only break in the mud wall is the door; but the monotony of the streets is relieved by orishas or idol-houses, and open spaces shaded with trees. Most of the population are engaged in agriculture; but for a West-African town there is a great variety of handicrafts. The town is subject nominally to the king of Oya; but in reality it is not only an independent state but has a number of vassal towns. The government is in the hands of two chiefs, a civil and a military, the *bale* and the *balogun*; these together form the highest court of appeal. There is also an *iyaloda* or mother of the town, to whom are submitted all the disputes of the women. Any one causing a fire in the town, whether intentionally or by accident, is deprived of his possessions and put in prison. Ibadan has long had a feud with Abeokuta; and the two towns often engage in war with each other. In 1862 the people of Ibadan destroyed Ijaya, a neighbouring town of 60,000 inhabitants. Mr Hinderer, a missionary of the Church Society, established a station at Kudati on the outskirts of the town in 1853, and laboured there for seventeen years. The native church is still in a flourishing state. The population of Ibadan is not less than 100,000. The great bulk of the population consists of slaves. There are twenty-four mosques and several Mahometan schools in the town.

See *Seventeen Years in the Yoruba Country: Memorials of Anna Hinderer*, London, 1877, where a view of the town is given.

IBARRA, a city of Ecuador in South America, the capital of the province of Imbabura, is situated on a plain about 2000 feet lower than Quito, from which it is 30 miles distant. Before the earthquake of 1868 it was a place of considerable prosperity, with regular streets and well-built houses, and about 13,000 of a population, but in that terrible disaster it is estimated that no fewer than 10,000 of its inhabitants perished. Cotton and woollen stuffs, laces, hats, brandy, cordials, sugar, and salt were among its industrial products. Ibarra was founded in 1597 by Alvaro de Ibarra, the president of Quito. About a league distant was Carranqui, the birthplace of Atahuallpa, the last of the Incas.

IBERIANS (*Iberi*, Ἴβηρες). To the question, Who are the Iberians? it is impossible to give a satisfactory answer in the form of a concise definition. While our knowledge of their actual history is comparatively slight, the position which they have acquired in modern ethnographical theory is at once a prominent and a perplexing one. It is almost impossible to hazard any statement in regard to them which will not find an impugning voice from one quarter or other. Historical, numismatical, linguistic, and anthropological evidences have been brought to bear on the problem of their affinity, and the result is on the whole not so much light as darkness visible.

The name Iberians seems to have been applied by the earlier Greek navigators to the peoples who inhabited the eastern coast of Spain; and there is considerable probability in the suggestion that it originally meant the ripuarians of the Iberus or Ebro.[1] On the other hand, the term Iberia is said to have embraced in older Greek usage the country as far east as the Rhone (see Herodorus of Heraclea, *Fragmenta Historiarum Græcarum*, tom. ii. p. 34), and by the time of Strabo it was the common Greek name for the Spanish peninsula,—Iberians meaning sometimes the inhabitants of the peninsula in general, and sometimes, it would appear, the peoples of a definite race or γένος. Of the tribal distribution of this race, of its linguistic social and political characteristics, and of the history of its relation to the other peoples of Spain, we have only the most general, fragmentary, and in part self-contradictory accounts. On the whole our historical evidence authorizes the assertion that in Spain, when it first became known to the Romans and Greeks, there existed a large number of separate and variously civilized tribes connected with each other by at least apparent identity of race, and by similarity (but not identity) of language, their general characteristics sufficiently differencing them from Phœnicians, Romans, and Celts. The statement that the mingling of these Iberians with the immigrant Celts gave rise to the Celtiberians (Keltiberians) is in itself sufficiently probable, and has been impugned by nothing more precise than the general untrustworthiness of the author by whom it is made (Diodorus Siculus). Varro and Dionysius Afer went so far as to identify the Iberians of Spain with the Iberians of the Caucasus, the one regarding the eastern and the other the western settlements as of earlier date.

The only material relics which have come down to us with the imprint of the ancient Iberian or Celtiberian civilization are a variety of coins and a few inscriptions of dubious interpretation. So difficult has the reading of the legends of the coins been found that the Spanish numismatists have regularly catalogued them as the *desconocidas* or unknown; and the explanation of them has been sought now in Visigothic runes (Olaus Wormius and Olaus Rudbeck), now in Hebrew (L. J. Velasquez), now in Latin, and now in Celtic. By the general consensus of more modern investigators, however, their Iberian character is recognized, though the methods and results of

[1] A very different etymology is offered by Basque-Iberian theorists; M. Boudard, for example, derives the name from *ibay-erri*, the country of the river.

interpretation have been sufficiently various.[1] According to M. Heiss, the Celtiberian coins are found most frequently in the north-east and east of Spain, in smaller numbers in the centre, rarely in the south, and more rarely still in Portugal and Asturias. The legends, he maintains, belong to peoples who inhabited the country at the time when the Greeks were still coining pieces with the type of Apollo and the wheel,—that is, before the completion of the Roman

Fig. 1.—Coin of Illiberis or Granada.

conquest. Their monetary system seems to have been imitated from that of the Roman republic, having a division analogous to that of the denarii and quinarii. The principal type on the reverse is either a horseman galloping with lance in rest or bearing a palm-branch or laurel-branch, or a man leading two horses and brandishing a sword or a bow. The Latin coins of Bilbilis, Osca, Segobriga, &c., retain the type of the galloping horseman. Pieces with inscriptions in the same alphabet and similar images are found in the district of Narbonne.

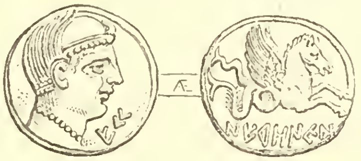


Fig. 2.—Coin of Narbonne.

The following is a list of M. Heiss's proposed identifications, and the accompanying alphabet is that which he has compiled from the coins:—

Ovriasav, Turiaso; klaqriqs, Kalaquri-qos, Calagurris; iak, Jaca; plplis, Pilpilis, Bilbilis; ilovre, Iluro; nerencon, Narbo; pavrp, Perpinianum; clse, Celsa; seqbrics, Segobrica; alaavn, Alavona; setiscon, Setisacon; oligem, Oligito; gli, Gili; aavsescon, Ausa, Ausenses; avsecrt, Osicerda; laavrh, Laurona; cse, Cose; qntrba, Contrebia; seqtzas, Segontia; ebiritz, Bebryces; hrnesqn, Huernes; hlscan, Hiosca, Osca; secisa, Segisa; tmaniav, Dumania; arciliqs, Arcocili, Ocili; oelieqs, Beliones; vrsones, Balsiones.

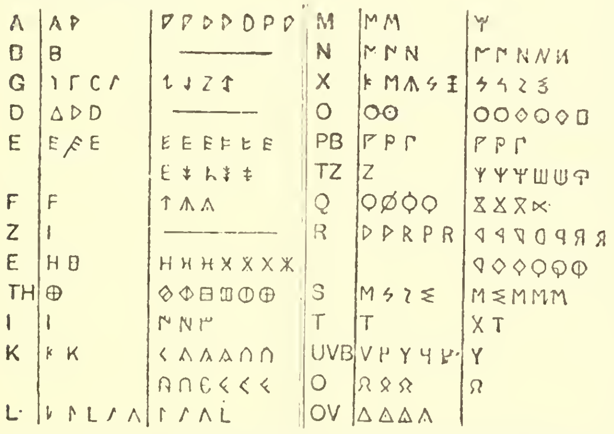


Fig. 3.—Table of alphabets. The first column contains the English characters; the second the archaic Greek; and the third the Celtiberian.

It was not till 1821 that the Iberian problem became an established *pièce de resistance* in the ethnographical programme. In that year Karl Wilhelm Humboldt published his *Prüfung der Untersuchungen über die Urbewohner Hispaniens vermittelst der Waskischen Sprache*, Berlin, 1821. As a matter of course this was a work of exuberant learning and bold hypothesis; and partly through its inherent attractiveness, partly through the prestige of its author, the theory which it expounded met with general acceptance. The main arguments were these:—that the Iberians were one great people, speaking a distinct language of their own; that they were to be found in Sicily, Sardinia, and Corsica, in southern France, and even in the British Isles; and that the Basques of the present day were the distinctly recognizable remnants of the race which had elsewhere been expelled or absorbed. This last was the central and seminal idea of the work, and it has been the point round which the battle of scholarship has mainly raged. The principal evidence which Humboldt adduced in its support was the possibility of explaining a vast number of the ancient topographical names of Spain, and of other asserted Iberian districts, by the forms and significations of Basque. The first serious attack on the theory was made by Graslin (*De l'Ibérie*, Paris, 1839), who maintained that the name Iberia was nothing but a Greek misnomer of Spain, and that there was no proof that the Basque people had ever occupied a wider area than at present; and M. Bladé has since, in his *Origine des Basques* (Paris 1869), taken up the same line of argument and brought to bear on the subject a vast amount of laborious and many-sided erudition. His criticism is almost purely negative. Of the whole structure of the Iberian theory he would not leave one stone upon another. He holds that Iberia is a purely geographical term, that there was no proper Iberian people or race, that the whole Basque-Iberian theory is a modern figment, that the Basques were always shut in by alien races, and that their affinity is still to seek. His main contention has met with some acceptance;[2] but the great current of ethnographical speculation still flows in the direction indicated by Humboldt, though it breaks up into a number of distinct channels. The anthropological researches of Broca, Thurnam and Davis, Huxley, Busk, Virchow, Tubino, and others have proved the existence in Europe of a Neolithic race, small of stature, with long or oval skulls, and accustomed to bury their dead in tombs. Their remains have been found in Belgium and France, in Britain, Germany, and Denmark, as well as in Spain; but they bear a closer resemblance to the Basques than to any other living people. This Neolithic race has consequently been identified with the Basques and the Iberians; and extreme exponents of the theory do not hesitate to speak of the Iberian ancestors of the people of England, recognizing the racial characteristics in the "small swarthy Welshman," the "small dark Highlander," and the "Black Celts to the west of the Shannon," as well as in the typical inhabitants of Aquitania and Brittany. (Compare the interesting *résumé* of the whole question in Boyd Dawkins's *Early Man in Britain*, London, 1880.[3]) Some investigators go even further. M. D'Arbois de Jubainville, for example (*Les premiers habitants de l'Europe*, Paris, 1877), regards the Iberians as the descendants of the Atlantes (*i.e.*, the hypothetical inhabitants of Plato's great western isle the Atlantis, see Atlantis), and maintains that in Europe they possessed Spain, Gaul, Italy, and the British Isles, penetrated into the Balkan peninsula, and occupied a part of northern Africa, Corsica, and Sardinia. And in reviewing M. Jubainville's work in *Revue d'Anthropologie* (1877), M. Hovelacque considers that it has been clearly made out that a race with distinctly marked characteristics was at one time in possession of the south of France (or at least of Aquitania), the whole of Spain from the Pyrenees to the straits, the Canary Islands (the Guanchos), a part of northern Africa, and Corsica. Tubino, in his *Los aborigenes ibericos* (Madrid, 1876), argues that the builders of the megalithic monuments of Spain and northern Africa, the ancient Iberians, and the modern Basques and Andalusian mountaineers, as well as the Berbers[4] in at least one of their main elements, are all of kindred blood; and in so doing he impugns the theory of Broca and his school.

Besides the works already mentioned, reference may be made to Hoffmann, *Die Iberer im Westen und Osten* (Leips. 1838), and to Phillips, *Ueber das iberische Alphabet* (Vienna, 1870), *Die Einwanderung der Iberer in die pyren. Halbinsel* (Vienna, 1870), and several other works by the same writer.

IBEX, the common name of several closely allied species of ruminant mammals, belonging to the genus *Capra* or goats, inhabiting the loftiest regions of Europe, Asia, and Africa. The European ibex or steinboc (*Capra ibex*) abounded during the Middle Ages among the higher

[1] The most important contributions to the subject are P. A. Boudard's *Études sur l'Alphabet ibérien*, Paris, 1852, and *Numismatique ibérienne*, Béziers, 1859; and Aloiss Heiss, *Notes sur les monnaies celtibériennes*, Paris, 1865, and *Description générale des monnaies antiques de l'Espagne*, Paris, 1870.

[2] W. van Eys, for example, "La langue Ibérienne et la langue Basque," in *Revue de linguistique*, goes against Humboldt; but Prince Napoleon and to a considerable extent A. Luchaire maintain the justice of his method and the value of many of his results. See Luchaire, *Les origines linguistiques de l'Aquitaine*, Paris, 1877.

[3] Mr Dawkins even accepts the very questionable identification of the Iberians of Spain with the Iberians of the Caucasus.

[4] The connexion of the Iberians with the Berbers was suggested by Bory de Saint Vincent in *Essai géologique sur le genre humain*.

mountain ranges of Germany, Switzerland, and the Ural, but has since disappeared from the greater part of this area, being now almost wholly confined to the Alps which separate Valais from Piedmont, and to the lofty peaks of Savoy, where its continued existence is mainly due to the action of protective game laws. The ibex is a handsome animal, measuring about $4\frac{1}{2}$ feet in length and $2\frac{1}{2}$ feet high; its skin is covered in summer with a short fur of an ashy grey colour, and in winter with much longer yellowish-brown hair concealing a dense fur beneath. A short beard is present in the male in winter, but, as it disappears altogether in spring, Darwin regards this appendage as rudimentary. The horns, especially in the male, form a striking feature: rising from the crest of the skull, they bend gradually backwards, attaining a length in old specimens of about 2 feet; they are thick and flat, and have the anterior face ridged with knotty transverse bands. In the female the horns never exceed half a foot in length, and are much less rugose than in the male. The front legs are somewhat shorter than those behind, which enables the

Ibex.

ibex to ascend the mountain slopes with more facility than it can descend, while its hoofs, according to Tschudi, are "as hard as steel, rough underneath, and when walking over a flat surface capable of being spread out." These, together with its powerful sinews, enable it to take prodigious leaps, to balance itself on the smallest foothold, and to scale almost perpendicular rocks. The ibex lives habitually at a greater height than the chamois or any other of the Alpine mammals, its vertical limit being the line of perpetual snow. There it rests in sunny nooks during the day, descending at night to the highest woods to graze, and retiring at sunrise to its snowy fastnesses. This return journey forms the ibex hunter's opportunity. To get within gunshot the huntsman has usually to approach from above; accordingly he ascends to the limit of perpetual snow, and there passes the night among the daily haunts of the ibex, lying in wait from early dawn for its return. The ibexes are gregarious, feeding in herds of ten to fifteen individuals; the old males, however, generally live apart from, and usually at greater elevations than, the females and young. They are said to give out a sharp whistling sound not unlike that of the chamois, but when greatly irritated or frightened they make a peculiar snorting noise. The period of gestation in the female is ninety days, after which she produces—usually at the end of June—a single young one, which is able at once to follow its mother. These when caught young and fed on goat's milk can, it is said, be readily tamed; and in the 16th century young tamed ibexes were, according to Tschudi, frequently driven to the mountains along with the goats, in whose company they would afterwards voluntarily return. Even wild specimens have thus been known to stray among the herds of goats, although, strange to say, they at all times shun the society of the chamois. The ibex was formerly hunted largely for its flesh and skin; but, although the latter, owing to its scarcity, now commands a high price, the difficulty arising from the operation of the game laws, and above all the difficulty and danger inseparable from the sport, have reduced the number of hunters to a few hardy mountaineers, who find in the pursuit of the ibex the keenest enjoyment of life. For weeks the sportsman will follow a track across fields of ice, along narrow ledges, over precipices, and across chasms, nearly frozen to death at night, and often with little more than a crust of bread for sustenance, yet considering himself more than repaid by the sight at last of his prey grazing within range of his rifle. Its flesh is said to resemble mutton, but has a flavour of game.

IBIS, one of the most sacred birds of the ancient Egyptians, which in modern times was identified by Bruce (*Travels*, v. p. 173, pl.) with the *Abou-Hannes* or "Father John" of the Abyssinians, and in 1790 received from Latham (*Index Ornithologicus*, p. 706) the name of *Tantalus æthiopicus*. This determination was placed beyond all question by Cuvier (*Ann. du Muséum*, iv. pp. 116–135) and Savigny (*Hist. Nat. et Mythol. de l'Ibis*) in 1805. They, however, shewed the removal of the bird from the Linnæan genus *Tantalus* to be necessary, and, Lacépède having some years before founded a genus *Ibis*, it was transferred thither, and is now generally known as *I. æthiopica*, though some speak of it as *I. religiosa*. No useful purpose would be served by dwelling on the vain attempts of older writers to discover what the much venerated bird was, or on the other synonyms applied to it by later ornithologists, some of whom (and among them the most recent) have shewn little acquaintance with the literature of the subject. Nor can the Ibis be here treated from a mythological or antiquarian point of view. Savigny's memoir above noticed contains a great deal of very interesting matter on the subject. Wilkinson (*Ancient Egyptians*, ser. 2, ii. pp. 217–224) has thereto added some of the results of modern research, and latest of all Mr Renouf in his *Hibbert Lectures* concisely explains the origin of the myth.

The Ibis is chiefly an inhabitant of the Nile basin in Nubia, from Dongola southward, as well as of Kordofan and Sennaar; whence (according to Savigny, whose opportunities for observation seem to have been greater than those enjoyed by any European since his time) about midsummer, as the river rises, it moves northwards to Egypt, and reaches the delta,[1] passing over the intermediate districts, in a way not unknown elsewhere among migratory birds. In Lower Egypt it bears the name of *Abou-mengel*, or "Father of the Sickle," from the form of its bill, but it does not stay long in that country, disappearing by all accounts when the inundation has subsided. Hence doubtless arises the fact that almost all European travellers have failed to meet with it there,[2] since their acquaintance with

[1] It has been said to occur occasionally in Europe (Greece and southern Russia), but further evidence is needed before the assertion can be taken as proved.

[2] Mr E. C. Taylor remarked some years ago (*Ibis*, 1859, p. 51), that the Buff-backed Heron, *Ardea bubulcus*, was made by the tourists' dragomans to do duty for the "Sacred Ibis," and this seems to be no novel practice, since by it, or something like it, Hasselqvist was misled, and through him Linnæus.

the birds of Egypt is mostly limited to those which frequent the country in winter, and consequently writers have not been wanting to deny to this species a place in its modern fauna (*cf.* Shelley, *Birds of Egypt*, p. 261); but, in December 1864, Von Heuglin (*Journ. für Ornithologie*, 1865, p. 100) saw a young bird which had been shot at Gata in the delta, and subsequently Mr E. C. Taylor (*Ibis*, 1878, p. 372) saw an adult which had been killed near Lake Menzaleh in November 1877. The old story told to Herodotus of its destroying snakes is, according to Savigny, devoid of truth,[1] and that naturalist found, from dissection of the examples he obtained, that its usual food was fresh-water univalve mollusks; but Cuvier asserts that he discovered partly digested remains of a snake in the stomach of a mummied Ibis which he examined, and there can be little doubt that insects and crustaceans, to say nothing of other living creatures, enter on occasion into the bird's diet.

The Ibis is somewhat larger than a Curlew, *Numenius arquata*, which bird it in appearance calls to mind, with a much stouter bill and stouter legs. The head and greater part of the neck are bare and black. The plumage is white, except the primaries which are black, and a black plume, formed by the secondaries, tertials, and lower scapulars, and richly glossed with bronze, blue, and green, which curves gracefully over the hind-quarters. The bill and feet are also black. The young lack the ornamental plume, and in them the head and neck are clothed with short black feathers, while the bill is yellow. The nest is placed in bushes or high trees, the bird generally building in companies, and in the middle of August Von Heuglin (*Orn. Nord Ost Afrika's*, p. 1138) found that it had from two to four young or much incubated eggs.[2] These are of a dingy white, splashed, spotted, and speckled with reddish-brown.

Congeneric with the typical Ibis are two or three other species, the *S. melanocephala* of India, the *S. molucca*, or *S. strictipennis*, of Australia, and the *S. bernieri* of Madagascar, all of which closely resemble *S. æthiopica*; while many other forms not very far removed from it, though placed by authors in distinct genera,[3] are also known. Among these are several beautiful species such as the Japanese *Geronticus nippon*, the *Lophotibis cristata* of Madagascar, and the Scarlet Ibis,[4] *Eudocimus ruber*, of America; but here there is only room to mention more particularly the Glossy Ibis, *Plegadis falcinellus*, a species of very wide distribution in both hemispheres, being found throughout the West Indies, Central and the south-eastern part of North America, as well as in many parts of Europe (whence it not unfrequently strays to the British islands), Africa, Asia, and Australia. This bird, which is no doubt the second kind of Ibis spoken of by Herodotus, is rather smaller than the Sacred Ibis, and mostly of a dark chestnut colour with brilliant green and purple reflexions on the upper parts, exhibiting, however, when young little of this glossiness. One of the most remarkable things about this species is that it lays eggs of a deep sea-green colour, having wholly the character of Heron's eggs, and it is to be noticed that it often breeds in company with Herons, while the eggs of all other Ibises whose eggs are known resemble those of the Sacred Ibis. Congeneric with the Glossy Ibis, some three or four other species, all from South America, have been described; but the propriety of deeming them distinct is questioned by some authorities.

Much as the Ibises resemble the Curlews externally, there is no real affinity between them. The *Ibididæ* are more nearly related to the Storks, *Ciconiidæ*, and still more to the Spoonbills, *Plataleidæ*, with which latter many systematists consider them to form one group, the *Hemiglottides* of Nitzsch. They belong to the *Pelargomorphæ* of Professor Huxley, one of the divisions of his *Desmognathæ*, while the Curlews are Schizognathous. The true Ibises above spoken of are also to be clearly separated from the Wood-Ibises, *Tantalidæ*, of which there are four or five species, by several not unimportant structural characters, which cannot here be particularized for want of space. Fossil remains of a true Ibis, *I. pagana*, have been found in considerable numbers in the middle Tertiary beds of France.[5] (A. N.)

IBN BATUTA (1304–78), whose proper name was Abu-Abdullah Mahommed, one of the most remarkable of travellers and autobiographers, was born at Tangier in 1304. He entered on his travels at the age of twenty-one (1325), and closed them in 1355. Their compass was so vast that we can but give the barest outline of them.

He began by traversing the whole African coast of the Mediterranean from Tangier to Alexandria, finding time to marry two wives on the road. After some stay at Cairo, then probably the greatest city in the world (excluding China), and an unsuccessful attempt to reach Mecca from Aidháb on the west coast of the Red Sea, he visited Palestine, Aleppo, and Damascus. He then made the pilgrimage to the holy cities of the Hedjaz, and visited the shrine of Ali at Meshed-Ali, travelling thence to Bussorah, and across the mountains of Khuzistan to Ispahan, thence to Shiraz, and back to Kufa and Baghdad. After an excursion to Mosul and Diarbekr, he made the *háj* a second time, staying at Mecca three years. He next sailed down the Red Sea to Aden (then a place of great trade), the singular position of which he describes, noticing its dependence for water-supply upon those great cisterns for preserving the scanty rainfall which have been cleaned out and restored in our own time. He continued his voyage down the African coast, visiting, among other places, Mombas, and Quiloa in 9° S. lat. Returning north he passed by the chief cities of Oman to New Hormuz, as he calls the city which had, not many years before, been transferred to the island where it became so famous. After visiting other parts of the gulf, he crossed the breadth of Arabia to Mecca, making the *háj* for the third time. Crossing the Red Sea he made a journey of great hardship to Syene, and thence along the Nile to Cairo. After this, travelling through Syria, he made an extensive circuit among the petty Turkish sultanates into which Asia Minor was divided after the fall of the kingdom of Rúm (or Iconium). He now crossed the Black Sea to Caffa, then mainly occupied by the Genoese, and apparently the first Christian city the Moor had seen, for he was much perturbed by the bell-ringing. He next travelled into Kipchak, or the country of the Mongol khans on the Volga, and joined the camp of the reigning khan Mahommed Uzbek, from whom the great and heterogeneous body that we know as *Uzbeks* is believed to have taken a name. Among other places in this empire he travelled to Bolgar (54° 54′ N. lat.) in order to witness the shortness of the summer night, and desired to continue his travels north into the "Land of Darkness," of which wonderful things were told, but was obliged to forego this. Rejoining the

[1] The suggestion that the "flying serpents" whose remains were seen by Herodotus were locusts is perhaps plausible, but there is considerable difficulty in accepting it.

[2] The Ibis has more than once nested in the gardens of the Zoological Society, and even reared its young there (*Ibis*, 1878, pp. 449–451, pl. xii.).

[3] For some account of these may be consulted Dr Reichenow's paper in *Journ. für Ornithologie*, 1877, pp. 143–156; Mr Elliot's in *Proc. Zool. Society*, 1877, pp. 477–510; and that of M. Oustalet in *Nouv. Arch. du Muséum*, ser. 2, i. pp. 167–184.

[4] It is a popular error—especially among painters—that this bird was the Sacred Ibis of the Egyptians. It was of course utterly unknown in the Old World until the discovery of the New.

[5] It will explain what to the uninitiated may be a puzzle to state that the name "*Ibis*" was selected as the title of an ornithological magazine, frequently referred to in this and other articles, which made its first appearance in 1859, and has since continued to be published.

sultan's camp, he was allowed to join the cortege of one of the Khátúns, who was a Greek princess by birth (probably an illegitimate one), and who was about to visit her own people. In her train he travelled to Constantinople, where he had an interview with the emperor Andronicus the Elder, whom he calls *Jirjis* (George). He tells us how, as he passed the city gates in the lady's train, he heard the guards muttering *Sarakinú! Sarakinú!* Returning to the court of Uzbek, at Sarai on the Volga, he took his way across the steppes to Khwarizm and Bokhara, and thence through Khorasan and Cabul. On this journey he crossed the HINDU KUSH (*q.v.*), to which he gives that name, its first occurrence. Travelling on, he reached the Indus,—according to his own statement, in September 1333. This closes the first part of his narrative.

From Sind, which he traversed to the sea and back again, he proceeded by Multan, and eventually, on the invitation of Mahommed Tughlak, the reigning sovereign, to Delhi. Mahommed was a singular character, full of pretence at least to many accomplishments and virtues, the founder of public charities, and a profuse patron of scholars, but a parricide, a fratricide, and as madly capricious, bloodthirsty, and unjust as Caligula. As Ibn Batuta pithily sums up the contradictions of his character, "there was no day that the gate of his palace failed to witness alike the elevation of some object to affluence and the torture and murder of some living soul." He appointed the traveller to be kází of Delhi, with a present of 12,000 silver dínárs (rupees) and an annual salary of the same amount, besides an assignment of village lands. In the sultan's service he remained eight years; but his good fortune only stimulated his natural extravagance, and at an early period his debts amounted to four or five times his salary. At last he fell into disfavour, and retired from the court, only to be summoned again on a congenial duty. The emperor of China, the last of the Mongol dynasty, had sent a mission to Delhi which was to be reciprocated, and the Moor was to go as one of the envoys. The account of the journey through Central India to Cambay is full of interest. Thence the party went by sea to Calicut, which is classed by the traveller with the neighbouring Kaulam (Quilon), Alexandria, Sudák in the Crimea, and Zayton (or CHINCHEW, *q.v.*) in China, as one of the greatest trading havens in the world,—an interesting enumeration from one who had seen them all. The mission party was to embark in Chinese junks (the word used) and smaller vessels, but that carrying the other envoys and the presents, which started before he was ready, was wrecked totally; the vessel that he had engaged went off with his property, and he was left on the beach of Calicut. Not daring to return to Delhi with such a tale, he remained about Honore and other cities of the western coast, taking part in various adventures, among others the capture of Sindábúr (or Goa), till he took it into his head to visit the Maldive Islands. There he was made welcome, was nominated kází, married four wives, and remained some months. But before long he was deep in quarrels and intrigues, and in August 1344 he left for Ceylon. In this island he made the pilgrimage to Adam's Peak ("The Footmark of our Father Adam," he calls it), of which he gives an interesting account. Thence he betook himself to Ma'abar (the Coromandel coast), where he joined a Musulman adventurer who had made himself master of much of that region, with his residence at Madura. After once more visiting Malabar, Canara, and the Maldives, he departed for Bengal, a voyage of forty-three days, landing at Sadkáwán (Chittagong). The chief circumstance of his sojourn in Bengal was a visit made to a Musulman saint of singular character and pretensions, Shaikh Jaláluddín, who dwelt in a hermitage among the Silhet hills, and where his shrine (at Silhet) is still maintained as a place of sanctity under the name of *Shah Jalál*. Returning to the delta, he took ship at Sunárgánw (near Dacca) on a junk bound for Java (*i.e.*, *Java Minor* of Marco Polo, or Sumatra). Touching on the coast of Arakan or Burmah, he reached Sumatra in forty days, and was hospitably received at the court of Malik al-Dháhir, a zealous disciple of Islám, which had then recently spread among the states on the northern coast of that island. The king provided him with a junk in which to prosecute his voyage to China. Some of the places which he describes on this line are hard to identify, but apparently one of them was the coast of Camboja. The port which received him in China was Zayton, famous in Marco Polo's book, and identified with the modern Chinchew. He also visited Sín-Kalán ("Great China" or Máchín), a name by which Canton was then known to the Arabs, and professes to have visited also Khansá (*Kinsay* of Marco Polo, *i.e.*, Hangchau), and Khánbálik (*Cambaluc* or Peking). The truth of his visit to these two cities, and especially to the last, is very questionable. The traveller's own history singularly illustrates the power of the freemasonry of Mahometanism in carrying him with a welcome over all the known world, and some anecdotes of his adventures in China illustrate this even more forcibly.

We cannot follow in detail his voyage back, or tell how he saw the great bird *Rukh* (evidently, from his description, an island lifted by refraction). Revisiting Sumatra, Malabar, Oman, Persia, Baghdad, he crossed the great desert to Tadmor and Damascus, where he got his first news of home, and heard of his father's death fifteen years before. Diverging to Hamath and Aleppo, on his return to Damascus he found the Black Death raging, so that two thousand four hundred died in one day. Revisiting Jerusalem and Cairo, he made the *háj* for a fourth time, and finally turned westward, reaching Fez, the capital of his native country, 8th November 1349, after an absence of twenty-four years. It was, he says, after all, the best of all countries. "The dirhems of the West are but little ones, 'tis true; but then you get more for them."

After going home to Tangier, he crossed into Spain and made the round of Andalusia, including Gibraltar, which had just then stood a siege from Alphonso XI. (whom the traveller calls "the Roman tyrant Adfunus"). In 1352 the restless man started for Central Africa, passing by the oases of the Sahara (where the houses were built of rock-salt, as Herodotus tells, and roofed with camel skins) to Timbuctoo and Gogo on the Niger, a river which he calls the Nile, believing it to flow down into Egypt, an opinion maintained by some up to the date of Landor's discovery. Being then recalled by his own king, he returned by Takadda, Hogar, and Tawat to Fez, which he reached in the beginning of 1354. This is the end of his recorded wanderings, which extended over a space of twenty-eight years, and in their main lines alone exceeded 75,000 miles.

By royal order his history was written down from his dictation by Mahommed Ibn Juzai, the king's secretary, a work concluded on the 13th December 1355. This editor ends the work with this appropriate colophon:—"Here ends what I have put into shape from the memoranda of the Shaikh Abu-Abdallah Mahommed Ibn Batúta, whom may God honour! No person of sense can fail to see that this Shaikh is the Traveller of Our Age; and he who should call him The Traveller of the whole Body of Islám would not exceed the truth!" The traveller died in 1377–78, aged seventy-three.

Ibn Batuta's travels have only been known in Europe during the present century, and were known then for many years only by Arabic abridgments existing in the Gotha and Cambridge libraries. Notices or extracts had been published by Seetzen (*c.* 1808), Kozegarten (1818), Apetz (1819), and Burckhardt (1819), when in 1829 Dr S. Lee published for the Oriental Translation Fund a version from the abridged MSS. at Cambridge, which attracted much interest. The French capture of Constantina at last afforded MSS. of the complete work, one of them the autograph of Ibn Juzai. And from these, after versions of fragments by various French scholars, was derived at last (1858–59) a careful edition and translation of the whole by M. Défrémery and Dr Sanguinetti, with a valuable index and other apparatus, in 4 vols. 8vo.[1]

Though there are some singular chronological difficulties in the narrative, and a good many cursory inaccuracies and exaggerations, there is no part of it except the voyage to China in which its substantial veracity is open to doubt. Nor can it be questioned, we think, that he really visited China, though it is probable that his visit was confined to the ports of the south. The whole of the second part of his story especially is full of vivacity and interest. His accounts, *e.g.*, of the Maldive Islands, and of the Negro countries on the Niger, are replete with interesting particulars, and appear to be accurate and unstrained. The former agrees surprisingly with that given by the only other foreign resident we know of, viz., Pyrard de la Val, two hundred and fifty years later. His full and curious statements and anecdotes regarding the showy virtues and very solid vices of Sultan Mahommed Tughlak are in entire agreement with Indian historians, and add many fresh details.

To do justice to the traveller's own character, as he has unconsciously drawn it, would require the hand of Chaucer and his freedom of speech. Not deficient either in acuteness or in humanity; full of vital energy and enjoyment; infinite in curiosity; daring, restless, impulsive, sensual, inconsiderate, extravagant; superstitious in his regard for the Moslem saints and quacks, and plying devout observances when in difficulties; an agreeable companion, for he is always welcomed at first, but clinging like a horseleech when he finds a full-blooded subject, and hence apt to disgust his patrons, and then to turn to intrigue against them,—such is the picture we form of this prince of Moslem travellers. (H. Y.)

IBN EZRA. See ABENEZRA.

IBN KHALDOUN (1332–1406), a celebrated Arabic historian, poet, and philosopher, was born at Tunis on the 1st Ramadhan 732 A.H. (February 8, 1332). His name was Abu Zeid Abdarrahmán, that of Ibn Khaldoun being a patronymic derived from an ancestor Khaldoun ibn Othmán, who came over with a band of Arab warriors and settled at Carmona in Spain. The family afterwards established itself in Seville, which it quitted for Tunis on the approach of Ferdinand III. Ibn Khaldoun at an early age applied himself to the study of the various branches of Arabic learning with very great success, and entered the employment of the sultan as private secretary at the age of twenty-one. Not believing, however, in the stability of his master's throne, he soon afterwards took refuge with and obtained employment under the Merinide sultan Abu Einán at Fez. In the beginning of the year 1356, his integrity having been suspected, he was thrown into prison until the death of Abu Einán in 1358, when the vizier El Hasan ibn Omar set him at liberty, and reinstated him in his rank and offices. He here continued to render great service to Abu Salem, Abu Einán's successor, but, having offended the prime minister, his position became less pleasant at court, and he sought and obtained permission to emigrate to Spain, where, at Granada, he was received with great cordiality by Ibn el Ahmer, who had been greatly indebted to his good offices when an exile at the court of Abu Salem. The favours and honours he received from the sovereign soon, however, excited the jealousy of the vizier, and he was driven back to Africa, where he was received with great cordiality by the sultan of Bujaiye, Abu Abdallah, who had been formerly his companion in prison. Jealousies and intrigues again drove him forth, this time to take refuge with the lord of Biskera, Ahmed ibn el Mozni. In answer to an appeal from the sultan of Tlemeen, Ibn Khaldoun raised a large force amongst the desert Arabs of the district, and passed over to the service of that prince. A few years later he was taken prisoner by Abd el Aziz, who had defeated the sultan of Tlemeen and seized upon the throne. He then entered a monastic establishment, and occupied himself with scholastic duties, until in the year 1370 he was sent for to Tlemeen by the new sultan, Abd el Aziz. After the death of Abd el Aziz he resided at Fez, enjoying the patronage and confidence of the regent. After some further vicissitudes he entered the service of the sultan of his native town of Tunis, where he devoted himself almost exclusively to his studies. Having received permission to make the pilgrimage to Mecca, he set out and reached Cairo, where his reputation had already preceded him, and was presented to the sultan, El Melek ed Dhaher Berkouk, who insisted on his remaining there, and in the year 1384 promoted him to the high rank of grand cadi of the Malekite rite for Cairo. This office he filled with great prudence and probity, and succeeded in removing a mass of abuses with which the administration of justice in Egypt was overgrown. A terrible misfortune now fell upon him; the ship in which his wife and family, with all his property, were coming to join him, was shipwrecked, and every one on board lost. He endeavoured to find consolation in fresh devotion to his studies, and to the completion of his great work the *History of the Arabs of Spain*, in which he had long been engaged. At the same time he was removed from his office of cadi, which gave him still more leisure for his work. Three years later he made the pilgrimage to Mecca, and on his return lived in strict retirement at the village of Faiyoum until 1399, when he was again called upon to resume his functions as cadi. He was removed and reinstated in the office no less than five times.

In the month of Rabia I. 803 A.H. (October to November 1400 A.D.), he was sent to Damascus, in connexion with the expedition intended to oppose the celebrated Timur or Tamerlane. When Timur had become master of the situation, Ibn Khaldoun let himself down from the walls of the city by a rope, and presented himself before the conqueror, who, charmed with his dignified appearance and his learned discourse, permitted him to return to Egypt. Ibn Khaldoun died on the 25th Ramadhan 808 A.H. (16th March 1406), at the age of sixty-four.

The great work by which he is known is a "Universal History," but it deals more particularly with the history of the Arabs of Spain and Africa. Its Arabic title is *Kitáb el 'Iber, wa diwán el Mubtadá wa 'l Khaber, fí aiyám el 'Arab wa 'l 'Ajam wa 'l Berber*; that is, "The Book of Examples and the Collection of Origins and Information respecting the History of the Arabs, Foreigners, and Berbers." It consists of three books, an introduction, and an autobiography. Book i. treats of the influence of civilization upon man; book ii. of the history of the Arabs and other peoples from the remotest antiquity until the author's own times; book iii. of the history of the Berber tribes and of the kingdoms founded by that race in North Africa. The introduction is an elaborate treatise on the science of history and the development of society, and the autobiography contains the history, not only of the author himself, but of his family and of the dynasties which ruled in Fez, Tunis, and Tlemeen during his lifetime. An admirable edition of the Arabic text has been printed at Boulak (Cairo), and a part of the work has been translated by the late Baron de Slane under the title of *Histoire des Berbères* (Algiers, 1852–56); it contains an admirable account of the author and analysis of his work. (E. H. P.)

IBN KHALLIKAN (1211–1282). Abu 'l Abbás Ahmed, better known as Ibn Khallikan,[2] author of the celebrated Arabic biographical dictionary, was born at Arbela on the 22d September 1211. Some of his biographers trace his descent to Jaafer the Barmecide, the well-known unfortunate friend and vizier of Haroun Alraschid. His life was that of a scholar and literary man, and he was promoted in his later years to the office of cadi of Damascus. He died in the Najibiyeh College of that city on the 29th October 1282. His great work is the *Kitáb Wafayát el 'Aiyán*, "The Obituaries of Eminent Men," and contains brief sketches of the lives of all the most important

[1] P. Jose de S. Antonio Moura previously published at Lisbon a Portuguese translation from a MS. obtained by him at Fez many years before.

[2] By some scholars this surname is written Ibn Khillikan; but his own autograph signature recently found upon a manuscript in the University Library, Cambridge, gives the usually accepted form.

personages of Muslim history and literature, with many appropriate anecdotes illustrative of their personal character, and extracts from the works of such of them as were authors or poets. It is the most complete and at the same time the most universal and comprehensive biographical dictionary in the Arabic language, and is the indispensable companion of the student of Mahometan literature. Ibn Khallikan has many imitators, the best-known work of the kind being the *Fuwát el' Wafayát*, "Omissions of the Wafayat," by Saláh ed dín Muhammed ibn Shákir, which has been published, as well as the work which it is intended to supplement, at the Boulak press.

Ibn Khallikan's work has been published in Arabic with an English translation by Baron MacGuckin de Slane for the Oriental Translation Fund of Great Britain and Ireland (Paris, 1842), and this edition, which is found in most public libraries, is the best and the most accessible one extant.

IBN SINA. See Avicenna.

IBO, Ibu, Igbo, or Eboe, a district of West Africa, situated in the delta of the Niger, and mainly on the left or eastern bank of the river. The chief town, which is frequently called by the same name, but is more correctly designated Abo or Áboh, lies on a creek which falls into the main stream about 150 miles from its mouth, and contains from 6000 to 8000 inhabitants. The Ibo are a strong well-built Negro race. Their women are distinguished by their embonpoint, which is considered by the people themselves as the perfection of beauty. The language of the Ibo is one of the most important in the Niger delta, and is gradually extending its area. The Rev. J. F. Schön began its reduction in 1841, and in 1861 he published a grammar of it (*Oku Ibo Grammatical Elements*, London, Church Miss. Soc.). Isoama is the dominant dialect, being spoken by the Aboh, Elugu, Aro, and Abadja tribes.

See Captain W. Allen's *Narrative*, London, 1848; M. Burdo, *Niger et Benué*, Paris, 1880 (English trans. by Mrs Strange, 1880).

IBRAHIM PASHA (1789-1848), viceroy of Egypt, a real or adopted son of Mehemet Ali, was born at Cavalla in Roumelia in 1789. Early associated with the Egyptian army, he won a name for himself by successful operations against the rebel tribes of Upper Egypt and the fugitive Mamelukes in Nubia, before he entered his twenty-fifth year. In an expedition which he led in 1816 against the Wahhábees of Arabia, the young general was seriously hampered by the want of organized discipline among his troops, and on his triumphant return to Cairo in 1819 he eagerly availed himself of the services of some French officers in his efforts to convert the Oriental turbulence of his forces into the disciplined steadiness of the West. Ibrahim's next campaign was in Greece, whither he was ordered in August 1824 to support the Turkish sultan's attempts to restrain the risings of Hellenic nationality. The defeat of the Turkish and Egyptian fleet at Navarino (October 20, 1827) by the united English, French, and Russian squadrons was the signal for Ibrahim's recall from the Morea, which had suffered keenly at the hands of the cruel Oriental. In Egypt he at once set himself afresh to the work of reorganization in army and navy, and in 1831, when Mehemet Ali ordered an almost unprovoked invasion of Syria, Ibrahim was again at the head of the Egyptian army. Unchecked by the loss of 5000 men from cholera before leaving Egypt, he appeared suddenly on the Syrian coast, took Gaza, Jaffa, and Kaiffa by surprise, and by the 29th of November had invested Acre. There he met with a stubborn resistance; twice in vain he attempted to carry the seaport by storm, and in the midst of the siege he was called away, to meet an army of relief, commanded by 'Osmán Pasha, governor of Aleppo. Near Tripoli he surprised 'Osmán, who decamped without fighting, and returning hastily to Acre, he threw his whole force on the place, carrying it (27th May 1832) with a loss of 1400 men. Without a pause he marched on Damascus, which offered no resistance. At Hims (July 28) he encountered and defeated a Turkish army of 30,000 men, with a force of 16,000, and passing swiftly through the defiles of Beylán, overtook and completely routed the retreating enemy at Adaneh. Another victory followed at Oulou-Kislák, and then, near Konieh, Ibrahim was met by the vizier Resheed Pasha at the head of 60,000 men. Favoured by a murky day—an advantage which helped to counterbalance the great disparity of his forces—he contrived to throw the Turkish army into confusion, and, by the capture of the vizier, converted an impending disaster into the most brilliant of his victories. Meantime his fleet, equally successful, had chased that of the sultan back to the Bosphorus, and the victor, without an army to oppose him, was within six marches of Constantinople. At the critical moment the order came from Mehemet Ali to await reinforcements. But before these arrived the golden opportunity was lost. The Russian army and fleet advanced to the protection of the Ottoman capital; the other Western powers combined in the effort to effect peace; and by treaty in February 1833 Syria and Adana were handed over to Mehemet on the condition of his paying tribute for them. As governor, Ibrahim reduced the new territory to order, and gave a strong impulse to industrial enterprise. But war again broke out in 1839, and at Nezeeb (24th June) Ibrahim dealt a second deadly blow to the Turkish power. Again the commands of Mehemet forbade him to follow up his success, and the campaign, cut short by the interference of the British, ended in the restoration of Syria to the Porte in 1841. After his retreat from Damascus, achieved with martial skill, although accompanied with serious losses, Ibrahim laid down his sword. Retiring to his estates in the plain of Heliopolis, he occupied himself in establishing cotton and olive plantations, till in 1844 he was called to succeed his father as viceroy. He died at Cairo, 9th November 1848, only a few months after the formal confirmation of his rank of viceroy. The finest qualities of a great commander were his, who out of semi-barbarous hordes fashioned a formidable army, and twice by his individual prowess threatened the overthrow of the Ottoman empire. His cruelty, the one blot on his valour, may be regarded as an accident of his life rather than as a fixed trait in his character. In times of peace, at least, he displayed the sagacity as well as the firmness of an enlightened administrator. See Egypt, vol. vii. p. 764.

IBRAILA, Braila, Brahilow, or Brailow, a town, formerly of Wallachia, now of Roumania, situated on the left bank of the Danube, about 9 miles south of Galatz and 102 miles from the Sulina mouth of the river. It has a railway station within a quarter of a mile to the north-west on the Bucharest and Galatz line—a branch line coming down to the harbour; and it is the seat of a chamber of commerce, a tribunal of commerce, and an agency of the Danube Navigation Company. Most of the town lies about 45 or 50 feet above the level of the sea, there being only a very narrow strip of low-lying ground (some 60 or 100 feet) between the edge of the river and the steep and lofty bank by which at this part its course is defined. Ibraila is one of the most regular places in Roumania, standing, indeed, in this respect, next after Bucharest itself. Few of the houses, however, are more than two stories high. Towards the land it has the shape of a crescent, the curve of the outer streets being controlled by the direction of the old fortifications, which were dismantled in 1828. A wide and tree-planted boulevard—the Strada Bulivardului—separates the town proper from the suburban portion. There is a public garden along the brow of the bank towards the river. Besides the cathedral of St

Michael, a large but ungainly building of grey sandstone, there are seven Greek churches, a Roman Catholic church, a Protestant church, a Jewish synagogue, and a church belonging to the strange Russian sect of the Lipovani or Skoptsi. Ibraila has long had a large share in the trade of the Danube. In 1836 it was visited by 382 ships. In 1870 there entered 4936 vessels and 6697 cleared, with a respective total burden of 867,189 tons and 821,274 tons. In 1877 the exports included 87,002 quarters of wheat, 87,314 of maize, 80,938 of barley, 11,964 of rye, besides a large quantity of grain which appears under the returns for Galatz. The railway between Ibraila and Galatz takes a wide circuit, instead of following the direct line of the river. The population, according to Henke (*Rumänien: Land und Volk*, Leipsic, 1877), is 42,000, of whom 53 per cent. are Roumanians, 20 per cent. Greeks, 15 per cent. Jews, and the remainder Germans, &c. According to the *Bulet. Soc. Geogr. Romine*, 1876, the total is 28,000.

In the latter part of the 18th century Ibraila was several times taken by the Russians, and on one occasion (1770) it was burned. By the peace of Bucharest (1812) the Turks retained the right of garrisoning the fortress. In 1828 it was gallantly defended by Soliman Pasha, who, after holding out from the middle of May till the end of June, was allowed to march out with the honours of war. At the peace of Adrianople the place was definitively assigned to Wallachia. It was the spot chosen by Gortschakoff for crossing the Danube with his division in 1854.

IBYCUS, a Greek lyric poet, who flourished about the 60th Olympiad—540 B.C.—was a native of Rhegium in Italy, but spent the greater part of his life at the court of Polycrates, tyrant of Samos. A curious story, not always accepted, is told in connexion with his death. While travelling in the neighbourhood of Corinth, the poet was waylaid and mortally wounded by robbers. As he lay dying on the ground, he saw a flock of cranes flying overhead, and called upon them to avenge his death. The murderers betook themselves to Corinth, and soon after, while sitting in the theatre, saw the cranes hovering above. One of them, either in alarm or jest, ejaculated, "Behold the avengers of Ibycus," and thus gave the clue to the detection of the crime. The phrase, "the cranes of Ibycus," passed into a proverb among the Greeks. Of the seven books of lyrics by Ibycus, which Suidas mentions, only a few fragments have come down to us, but these afford sufficient evidence to support Cicero's estimate of the author whom he pronounces (*Tusc.*, iv. 33) from his writings "maxime vero omnium flagrasse amore." Even from his mythical and heroic pieces, in which he was less successful, Ibycus did not exclude the erotic element. The dialect in which he wrote partook both of the Doric and of the Æolic peculiarities. The best edition of the fragments is *Ibyci Rhegini Carminum Reliquiæ*, edited by Schneidewin, and published at Göttingen in 1833.

ICA, YCA, or ECCA, an inland city of Peru, capital of a district in the department of Lima, situated 170 miles south-south-east of the city of Lima, and 48 miles south-south-west of Pisco on the Pacific Ocean, with which it is connected by a railway. Between Pisco and Ica the country is a desolate and barren desert, but Ica itself lies in a fruitful valley surrounded by corn-fields and vineyards. On account of the frequent earthquakes the town has a very ruinous appearance, but it enjoys considerable prosperity, and exports by way of Pisco large quantities of wheat, maize, cotton, cochineal, wine, and spirits. Originally the city, when founded in 1563, was built 4 miles south-east from where it now stands, the change of site taking place after a great earthquake in 1571. Another severe earthquake in 1664 led to a new town being built close to the old one. The population is about 7000.

ICE is the solid crystalline form which water assumes when exposed to a sufficiently low temperature. It is frequently precipitated from the air as hoarfrost, snow, or hail; and in the glaciers and snows of lofty mountain systems or of regions of high latitude it exists on a gigantic scale, being especially characteristic of the seas and lands around the poles, which consequently have hitherto been practically inaccessible to man. Also in various parts of the world, especially in France and Italy, great quantities of ice form in caves, which, in virtue of their depth below the earth's surface, their height above the sea-level, or their exposure to suitable winds, or to two or more of these conditions in combination, are unaffected by ordinary climatic changes, so that the mean annual temperature is sufficiently low to ensure the permanency of the ice. The great ice supply for the island of Teneriffe is obtained from such a cave, which is 100 feet long, 30 feet broad, and from 10 to 15 feet high, and which is situated on the Peak some 10,000 feet above the sea-level. According to the Rev. S. Browne (*Brit. Ass. Report*, 1864), such cave-ice is generally peculiar in its columnar appearance, and apparently less easy to melt than ordinary surface ice.

In the mutual transformations of water and ice, many remarkable physical phenomena occur. Thus, during the process of melting a block of ice or of freezing a quantity of water, no change of temperature can take place so long as there is a thorough mixture of water and ice. Consequently, the "freezing-point" or temperature at which water freezes is a temperature so readily determined that it is conveniently employed as one of the standard temperatures in the graduation of ordinary thermometer scales, such as the centigrade, the Fahrenheit, and the Réaumur. The centigrade scale, whose zero corresponds to this freezing-point of water, is the temperature scale that is employed throughout this article. In the act of freezing, water, though its temperature remains unchanged, undergoes a remarkable expansion or increase of bulk, so that ice at 0° C. is less dense than water—a fact demonstrated at once by its power of floating. "Ground-ice" or "anchor-ice," which forms in certain circumstances at the bottom of streams, is only an apparent exception to this relation between the densities of water in its solid and liquid states, being retained there by the cohesion between it and the stones or rocks which compose the river's bed. When forcibly released from this contact with the bottom, the ice at once ascends to the surface. Ground-ice may thus be the lowest stratum of the once completely frozen mass of water, adhering to the bottom during the thawing and melting of the ice at the surface; or it may even be formed under favourable conditions below briskly flowing water, probably by the action of eddies, which draw the surface water down through the warmer but denser liquid, and thus cool the stones and rocks at the bottom. As water then expands on freezing, so conversely ice contracts on melting; and the ice-cold water thus formed continues to contract when heated until it has reached its point of maximum density. Joule, from a series of careful experiments, determined the temperature at which water attains its maximum density to be 39°·1 Fahr., or very nearly 4° C. Hence water contracts as its temperature rises from 0° C. to 4° C.; but at higher temperatures it behaves like the great majority of other substances, expanding with rise of temperature. At no temperature, however, does water in the liquid state become less dense than ice, as the following table of relative densities shows:—

Density of ice	at 0° C.	=	·9175
,, water	at 0° C.	=	·99988
,, ,,	4° C.	=	1·00000
,, ,,	10° C.	=	·99976
,, ,,	100° C.	=	·95866

Under the influence of heat, ice itself behaves as most solids do, contracting when cooled, expanding when heated.

According to Plücker, the coefficient of cubical dilatation at moderately low temperatures is ·0001585. From a series of elaborate experiments, Person deduced ·505 as the specific heat of ice, or about half that of water; in other words, the heat required to raise 1 ℔ of water 1° C. will raise 2 ℔ of ice through the same range of temperature or 1 ℔ of ice through 2° C.

Though no rise of temperature accompanies the melting of ice, there is yet a definite quantity of heat absorbed, and a corresponding amount of work done—mainly in altering the physical condition of the substance. The heat which disappears is transformed into other and less evident forms of energy,—as, for example, the energy of translatory motion, which is the chief characteristic, according to the recognized molecular theory of matter, of the molecule in the liquid as compared with the molecule in the solid. The heat which is thus absorbed during the melting of unit mass of ice is called the latent heat of water, and its value in ordinary heat-units is 79·25, according to the determination of Person. Hence as much heat is required to transform 1 ℔ of ice at 0° C. into water at the same temperature as would raise in temperature 1 ℔ of water through a range of 79°·25 C., or 79·25 ℔ of water through a range of 1° C. The same amount of heat which is absorbed when ice becomes water is evolved when water becomes ice, so that the melting of ice is accompanied by the abstraction of heat from surrounding objects, that is, by a cooling effect; and the freezing of water by a heating effect. These thermal effects are generally masked by the processes whereby the change of state is effected; but the cooling which accompanies the melting of ice may be observed when pressure is used as the agent for accomplishing the change. That ice can be so melted by increase of pressure was first pointed out by Professor James Thomson (now of Glasgow) in a paper published in the *Transactions of the Royal Society of Edinburgh* for 1849; previous to that time the temperature of melting ice was believed to be absolutely constant under all conditions. Thomson showed that, since water expands on freezing, the laws of thermodynamics require that its freezing-point must be lowered by increase of pressure; and, by an application of Carnot's principle, he calculated that for every additional atmosphere of pressure the freezing-point of water was lowered by ·0075 of a degree centigrade. This remarkable result was soon after verified, even to its numerical details, by his brother, Sir William Thomson (*Proceedings of the Royal Society of Edinburgh*, 1850). The Thomsons and Helmholtz have since then successfully applied this behaviour of ice under pressure to the explanation of many curious properties of the substance. When two blocks of ice at 0° C. are pressed together or even simply laid in contact, they gradually unite along their touching surfaces till they form one block. This regelation, as it is called, is due to the increased pressure at the various points of contact causing the ice there to melt and cool. The water so formed tends to escape, thus relieving the pressure for an instant, refreezing, and returning to the original temperature. This succession of melting and freezing, with their accompanying thermal effects, goes on until the two blocks are cemented into one. Thus it is that a snowball is formed; and in virtue of the same succession of phenomena does the glacier mould itself to its rocky bed and flow down the valley, behaving in many respects like a viscous fluid.

Ice forms over fresh water if the temperature of the air has been for a sufficient time at or below the freezing-point; but not until the whole mass of water has been cooled down to its point of maximum density, so that the subsequent cooling of the surface can give rise to no convection currents, is the freezing possible. Sea-water, in the most favourable circumstances, does not freeze till its temperature is reduced to about – 2° C.; and the ice, when formed, is found to have rejected four-fifths of the salt which was originally present. In the upper provinces of India, water is made to freeze during cold clear nights by leaving it overnight in porous vessels, or in bottles which are enwrapped in moistened cloth. The water then freezes in virtue of the cold produced by its own evaporation or by the drying of the moistened wrapper. In Bengal the natives resort to a still more elaborate forcing of the conditions. Shallow pits are dug about 2 feet deep and filled three-quarters full with dry straw, on which are set flat porous pans containing the water to be frozen. Exposed overnight to a cool dry gentle wind from the north-west, the water evaporates at the expense of its own heat, and the consequent cooling takes place with sufficient rapidity to overbalance the slow influx of heat from above through the cooled dense air or from below through the badly conducting straw.

Ice ma

The growing demand for ice for domestic, medicinal, and other purposes has led, not only to the development of a regularly organized ice trade, but also to the invention of machines for the manufacture of ice in countries which do not possess a sufficient home supply. The various types of machines which have been or are in use call for a brief description. Freezing-mixtures, such as the familiar snow and salt or the mixture of sulphate or phosphate of sodium and dilute nitric acid, may be dismissed with a word, since they are restricted in use to the production of intense cold for a brief period of time, and are incapable of economic application to the formation of large quantities of ice.

All ice-machines which have proved of practical utility may be grouped under two great classes:—those which utilize the lowering of temperature that accompanies the rapid expansion of a compressed gas, and those which make use of the like thermal effect that results from the volatilization of some liquid. In machines of the first type, the gas usually employed is atmospheric air, which is first compressed to three or four atmospheres, and kept cool by circulating water or by other suitable means. It is then allowed to expand, and the heat necessarily absorbed during the expansion is drawn either from the water to be frozen or from a solution of brine which does not freeze at the ordinary freezing temperature, and thus becomes, so to speak, a vehicle for the cold. In 1849 Gorrie constructed such a machine, which, however, was unsatisfactory in its action, probably because the compressed air was not sufficiently cooled and dried. More efficient in their action were Kirk's machine (patented in 1863), and Windhausen's (1870), one of which at the Vienna exhibition produced 30 cwts. of ice per hour, at the cost of 1s. per cwt. The mode of action of Windhausen's is as follows. A piston works to and fro in a cylinder, compressing the air in the one end and allowing it to expand in the other. The compressed and therefore heated air forces its way through a valve to the cooling chambers, from which it is led towards the other end of the cylinder. Here the inlet valve is so arranged that it closes at a certain position of the receding piston, thus permitting what air has entered to expand and cool. At the return stroke this cooled air is forced out through easily opening valves,—part going to cool the chambers into which the heated compressed air enters from the cylinder, and part passing to the refrigerator, from which after serving its purpose it is pushed on by the fresh supply of cooled air to the compressing end of the piston chamber. Such machines, to work economically, require large cylinders, tight-fitting pistons working with little friction, and perfect regulation in the motions of the various parts—conditions so difficult to fulfil that refrigeration by means of compressed air may be regarded as a practical failure. The machines constructed by the Bell-Coleman Mechanical Refrigeration

Company (Glasgow) utilize as the cooling agent a mixture of certain hydrocarbon gases which are obtained from the distillation of carbonaceous shale. The gas is compressed to a pressure of about 8 atmospheres, and, after being cooled by expansion, is carried off and consumed as fuel. These machines are not specially intended for the production of ice; but, as refrigerators, they are successfully employed for preserving meat on board ship.

Among machines of the second group there is a great variety of construction, because of the great differences which exist in the properties of the liquids used. Thus water, sulphuric ether, bisulphide of carbon, ammonia, methylic ether, sulphurous acid, and other substances have been employed as refrigerating agents. In all cases, it is the so-called latent heat of vaporization that is utilized; and did the efficiency of the method depend only on this, water would undoubtedly be the best material on account of the great latent heat of its vapour. But as important from a practical point of view are the vapour pressures that come into play throughout the range of temperature employed. Thus at 10° C. the pressure of water vapour is so small, only ·012 of an atmosphere (and at lower temperatures of course it is still smaller), that, to make the evaporation of water an efficient means of refrigeration, the process must be conducted under a very much diminished pressure. As early as 1755, Dr Cullen managed to freeze water by its own evaporation in a vacuum; but this method, though greatly developed by Nairne, Leslie, and Vallance, can be applied to the production of ice in small quantities only.

The same objection applies, of course, to sulphuric ether, bisulphide of carbon, or any substance which boils under ordinary atmospheric pressure at a temperature above that of the air. Ether boils at 34°·8 C., and bisulphide of carbon at 46°·2 C.; and their vapour pressures at 10° C. are respectively ·377 and ·267 of an atmosphere. They thus volatilize much more readily than water, and require a comparatively slight vacuum to render their evaporation sufficiently rapid for refrigerating purposes. In the ether machine, which may be taken as a type, the ether, on being vaporized in the refrigerator under a partial vacuum, is drawn over and compressed to the liquid state in the condenser, which is kept cool by circulating water. From the condenser it is then led back to the refrigerator, to be re-evaporated. Perkins's machine (1834), Twining's patent of 1850, Harrison's machine (1857), Siebe's machine (1862), and Siddeley and Mackay's apparatus are ether-machines; and all except the first, which is hardly adapted for extensive freezing, surround the refrigerator with brine, which when cooled flows easily around and between the cases containing the water to be frozen. Van der Weyde (1869) substituted naphtha, gasolin, or chimogene for the ether; and in Johnston and Whitelaw's machine bisulphide of carbon is used somewhat similarly. The great difficulty in machines of the ether type is to prevent leakage, so as to keep the partial vacuum really efficient; and moreover ether, which is in most respects superior to all the other substances employed, has an awkward tendency, under the influence of frequent condensations and rarefactions, to transform itself into less volatile isomers.

The great characteristic of ice-machines which employ ammonia, methylic ether, or sulphurous acid, as compared with those of the ether type, is that they work at increased instead of diminished pressures, since these substances are gaseous at ordinary temperatures and pressures, and require for their liquefaction either the production of a low temperature or the application of a high pressure. For facility of reference the boiling points and vapour pressures at three different temperatures for these substances are given in the following table.

Name of Substane	Boiling Point.	Vapour-Pressures estimated in Atmospheres.		
		At 10°.	At 20°.	At 30°.
Ammonia	−38°·50 C.	6·1	8·5	11·6
Methylic ether	−23°·65	3·5	4·8	6·5
Sulphurous acid	−10°·08	2·3	3·2	4·5

The best known of the ammonia machines is Carré's (1859), the principle and construction of which are remarkably simple. Two strong metal vessels, the boiler and refrigerator, are connected above by a tube. In the boiler a saturated solution of ammonia is raised to 130°–150° C. The ammonia is driven over under high pressure into the refrigerator, round which cold water circulates, and in which the ammonia is condensed to a liquid. The boiler is then placed in cold water, and as its temperature falls the pressure in the apparatus is relieved and the liquid ammonia in the refrigerator vaporizes rapidly, thereby producing intense cold, and redissolves in the boiler. The temperature to which the boiler must be raised at first is determined by the condition that the pressure in the boiler must correspond to the pressure of the ammonia vapour at the temperature of the condenser. Now the pressure of ammonia vapour increases from $8\frac{1}{2}$ atmospheres at 20° C. to $11\frac{1}{2}$ at 30° C.; and this higher pressure is extremely difficult to keep up in such an apparatus as Carré's, because of inevitable leakage. In warm countries, accordingly, the ammonia-machine is practically useless because of the high pressures required; and in temperate climates, where natural ice can be stored throughout summer, an ice-machine is not in such great demand. One great drawback to the efficient working of Carré's machine is the difficulty of keeping the refrigerating liquid free of water—only 75 per cent. of it being ammonia. To remedy this defect Reece invented his machine (1869). The essential part of this ingenious apparatus is an upright cylinder in which a descending current of strong ammonia solution, drawn originally from the boiler, is met by an ascending current of steam. The ammonia is thus separated from the water, and is driven off into a rectifier, from which, after being freed from any small quantity of water it may have carried along with it, it passes into a condenser where it is kept liquid by its own pressure. It is then allowed to collect in the refrigerator, where at the required moment the pressure is relieved, permitting the ammonia to vaporize and escape to a separate chamber to be redissolved. Brine flowing through a coiled tube within the refrigerator is used as the vehicle for the cold produced; or even mere water may suffice if the object is simply to get a diminished temperature without freezing. Linde's ice-making machine, some twenty-two of which were in operation at the Düsseldorf Exhibition of 1880, is the latest form of ammonia machine; and its inventor claims for it superiority over all others as an economical refrigerator. The danger of explosion, one of the great disadvantages of ammonia, is obviated by carrying the liquefied gas through narrow iron tubes and by employing only a small quantity of the substance at one time. Blocks of ice are formed between the spokes of a revolving drum, which, cooled internally by the evaporating liquid, dips into a tank of water. Methylic ether is in some respects better than ammonia, having a higher boiling point, and requiring smaller pressures, without the necessity of heating. In Tellier's machine (described in the *Annales de Chimie et de Physique* for 1874), which is specially suitable for use on board ship, the methylic ether evaporates in a closed metallic vessel, the sides of which are in immediate contact with the water to be frozen or chilled.

Sulphurous acid, first successfully employed as a refrigerating agent by Pictet of Geneva (1876), and thereafter applied by Gamgee to the formation of his glaciarium or artificial skating rink, is in many respects far superior to any other known refrigerator. Thus it is more easily liquefied than ammonia and methylic ether, exerting a vapour pressure of only 4½ atmospheres at 30° C.; it has no chemical action upon metals or fats; it is incombustible; it is obtainable at small expense; and it has, besides, good lubricating properties;—in short, it seems to possess all the essentials of an efficient and economical refrigerator. In Pictet's machine, the liquid sulphurous acid passes under pressure from the condenser to the refrigerator, where on the pressure being relieved it vaporizes, cooling to −7° C. a current of brine which then flows round the tanks containing the water to be frozen. The sulphurous acid gas in the refrigerator is drawn over by an aspirating force-pump and recondensed in the condenser, which is kept cool by an ample supply of cold water. By a special modification of the sulphurous acid machine, Pictet obtained as low a temperature as −73° C.; under this low temperature he then compressed carbonic acid gas to a liquid, by the evaporation of which he produced such intense cold as to enable him to liquefy the so-called permanent gases under a pressure of several hundreds of atmospheres (*Bibliothèque Universelle*, 1878). Gamgee uses as his congealing liquid a solution of 4 parts of glycerin in 6 parts of water, which is conveyed in pipes beneath the water-surface to be frozen.

Machines which are capable of freezing water may in certain circumstances be much more efficiently employed to produce cooling without freezing. For instance, in curing-houses, breweries, sugar refineries, provision stores in hot climates, and in ships engaged in the transport of meat, where it is of importance to have the temperature moderately cool, it is usually by no means necessary to obtain ice. In many such cases, indeed, the production of ice would be a mere waste of labour. In tropical and subtropical climates refrigeration is of high importance from a sanitary point of view; and there seems little doubt that if a simple, economical, and thoroughly efficient means of cooling were discovered, houses would be cooled in warm weather with the same care and regularity with which they are when necessary heated. At present, however, the manufacture of ice and the artificial production of cold are arts still in their infancy, which have a powerful rival in the extensive and increasing ice-trade that has sprung up within the last half century.

Ice trade.

The idea of trading in ice first occurred to a Boston merchant, named Tudor, who in 1805 shipped ice to Martinique. In 1833 American ice began to be imported into Calcutta, where it was sold for 3d. per pound—exactly half the price of the Bengal manufactured ice. In America, which was for long the great ice-exporting country of the world, supplying especially the West Indies, India, and China, the cutting and storing of ice form an important industry during the winter months. When the ice is sufficiently thick, 9 to 12 inches for home consumption, 20 inches for exportation, the surface is scraped free of all porous ice, and is marked out into squares of 5 feet each way. Along these lines the ice is grooved to a depth of 3 inches by means of a plough. An instrument like a harrow is drawn over the grooves so as to deepen them; and, after the surface has been divided into smaller squares, the ice is cut up into blocks by means of handsaws. The blocks are then removed to large double-walled storehouses, many of which are capable of containing thousands of tons of ice. It is estimated that, in America, 2,000,000 tons of ice are cut and stored annually by companies supplying New York and the middle States. New York city alone consumes as much as 500,000 tons per annum. A considerable quantity of ice from Wenham Lake near Boston was at one time imported into Britain, but now the whole supply comes from Drobak near Christiania in Norway. The Norwegian ice is remarkably solid and pure, and is superior in its staying power to English ice or to manufactured ice. The total quantity imported into the United Kingdom may be estimated roughly at 150,000 tons per annum, of which the greater part is consumed in London, where it is retailed at from 2s. 6d. to 3s. 6d. per cwt. At present Norway is undoubtedly the great ice-store for the Old World; and quite recently (1880) Norwegian ice has been sold in the United States more cheaply than native ice. The transport on board ship offers practically no difficulty, since, as long as the hold is kept dry and cool, there is very little loss, and in the lading no special care need be taken. For the storing in houses, see ICE-HOUSE. (C. G. K.)

ICEBERG, a floating mass of ice, which has broken off from such ice-sheets as cover Greenland, Spitzbergen, and other polar lands, constituting vast glacier systems ever creeping out and down from the central heights to the shores. As the glacier is pushed out to sea, the lower margin is exposed to the destructive action of the waves, and breaks up into fragments of endless variety of form. These severed blocks, many of which are hundreds of millions of tons in mass, drift to lower latitudes under the influence of polar currents, and gradually melt away in the warmer water. Such is the natural history of icebergs, which, in their freshwater origin, are to be distinguished from the ice-fields, ice-floes, pack ice, and ice-hummocks, so familiar to the polar voyager. The iceberg, as it drifts along, melts most rapidly under water; and this unequal wasting must be accompanied by a change in the position of the centre of mass and a consequent shifting of the iceberg into its new position of equilibrium. Undermining and fracture also result; so that at length the mass of ice, however square-shaped or symmetrical it may have been originally, assumes a form irregular and fantastic in the extreme. The densities of ice and sea-water are nearly ·92 and 1·03 respectively, so that only $\frac{11}{103}$ or nearly $\frac{1}{9}$th of the iceberg is above water and visible. An iceberg observed by Sir John Ross and Lieutenant Parry was 2½ miles long, 2⅕ miles broad, and 153 feet high. Assuming the form to have been approximately a cone erected upon an elliptic base, the mass above water would be roughly 150 million tons—giving a total mass of nearly 15 hundred million tons. This iceberg, however, was by no means of extraordinary dimensions. In the southern seas, great fleets of icebergs have been observed as far north as the latitude of Cape Horn; and some of these ice masses have towered to a height of 700 or 800 feet. The limiting latitude to which icebergs drift is lower in the southern than in the northern hemisphere, probably because of the comparative scarcity of land in the south polar regions. Thus, icebergs have been observed off the Cape of Good Hope in 34° S. lat., while none has been noticed in the northern hemisphere lower than the 36th parallel. Generally speaking, the limiting latitudes may be fixed at 40° N. lat. and 35° S. lat. In the North Atlantic the distribution of icebergs is very remarkable, and indicates, in its peculiar way, the general set of ocean currents. Icebergs, of course, can only drift along with some polar current,—such, for example, as the Labrador current, which flows in a generally southerly direction round the coasts of Newfoundland and Nova Scotia. To the east of this track, in which icebergs abound during the early summer months, lies the region which is warmed by the waters of the Gulf Stream as it flows to the Scandinavian coast, and here floating ice is rarely seen. The same considerations regarding prevailing currents determine the distribution and limit of icebergs in the southern oceans, the great antarctic current that cools the coasts of Chili and Peru bearing upon its broad expanse the fragments of the shining ice-cliffs of South Victoria. The climatic effect of an iceberg is sometimes very marked; and not unfrequently the lowering of the temperature indicates to the mariner the presence of floating ice even before it is near enough to be visible. Geologically considered, icebergs, like glaciers, are great transporting agents, bearing away to the deep sea rocks, boulders, and stones, which are strewn along the ocean bed as the ice gradually melts. By this cause, rather than by the glacier in its integrity, some erratic blocks may doubtless have been transported at a time when the land was under water and exposed to ice-drift.

ICE-HOUSE. An ice-house, to supply ice for domestic use during the summer months, is one of the desirable adjuncts of a country residence. The old form of ice-house was a well several feet deep, dug out on sloping ground or against a bank. The bottom was made to slope towards a sunk drain, covered by an iron grating, to permit the water from the melted ice to pass away quickly; while a dip in the drain or a bend in the pipe prevented air from entering at the bottom of the well. The ice was filled in through an opening in the dome, which had to be carefully closed.

A good form of ice-house is that recommended many years ago by Mr Bailey, gardener at Nuneham Park, Oxford, and described in the *Gardener's Magazine of Botany* (i. 82). This house is shown in section and plan in fig. 1, where the dotted line indicates the ground level. The well or receptacle for the ice *a* is 10 feet 6 inches wide at the base, and 3 feet wider near the top; the walls are hollow, the outer portion being built of dry rough stone, and the inner wall and dome *f* of brick. The outer wall *e* might be replaced by a puddling of clay, carried up as the work proceeds. Over the top is a mound of clay and soil *g*, which is planted with shrubs to keep the surface cool in summer. The drain *i* carries off the water formed by the melted ice, and is provided with a trap *h* to prevent the ingress of air through the drain. There is a porch or lobby *b* provided with an outer and an inner door *c*, *c*; and there are apertures at *d*, *d*, to get rid of the condensed moisture, which, if not removed, would waste the ice. These ventilating doors should be opened every night, and closed again early in the morning. The most important conditions to be secured are dryness of the soil and of the enclosed atmosphere, compactness in the body of ice, which should be broken fine and closely rammed, and the exclusion as far as possible of air.

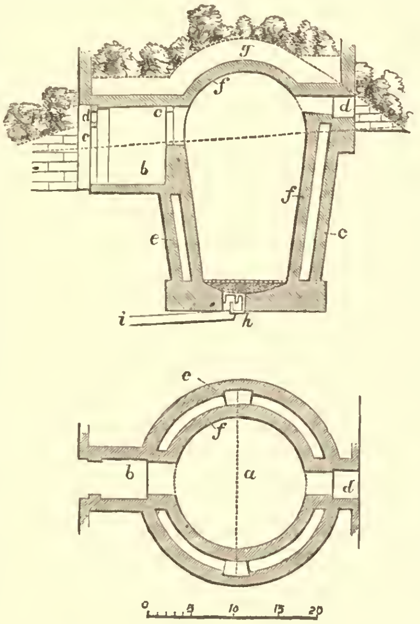


Fig. 1.

The Americans, who use large quantities of ice, always store it above ground. One of their ice-houses, of which the elevation is shown in fig. 2 and the plan in fig. 3, described in Allan's *Rural Architecture*, is both simple and ornamental in character. The house may be 12 feet square, or any larger size. A series of posts in pairs are set up $1\frac{1}{2}$ feet apart and 8 feet high, about 1 foot being inserted firmly in the ground; the distance between each pair is 3 feet. The tops being cut level all round, a plate 6 inches wide and 4 to 6 inches deep is spiked on to each line of posts, the two plates being strongly stayed by cross pieces so as to form a double frame. The inner face of each line of posts is now boarded up closely, leaving a space $6\frac{1}{2}$ feet by 3 feet at the sides, which are also boarded, to form a door-casing on each side. The spaces between the two lines of boards thus form a continuous box, which is to be completely filled up with moist tan, bark, or sawdust, well packed throughout. There must be a drain to carry off all water from the interior. Within the enclosed space some level joists are laid down, and on them loose planks to form a floor, which when covered 1 foot thick with straw is ready to receive the ice. The roof is formed of rafters, 4 inches by 3, long enough to project at least 4 feet outside the plates, to which they must be well secured by spikes. The rafters are to be boarded over and covered with shingle, and a small opening left at the top to admit a pipe 8 inches in diameter for a ventilator, over which a small ornamental cap, supported on four little posts, is to be placed. As a finish to the projecting roof, brackets of 3 by 4 inch scantling, if the joists are of sawed stuff, or of rough limbs of trees to match the posts, if these are rough, may be introduced. After the ice is stored, a close floor of boards should be laid on joists resting loosely on the wall plate (to admit of this upper floor being removed while the house is being filled), and they must be covered with 6 inches of tan or sawdust, or failing these with straw. A good layer of tan or sawdust should also be placed on the top of the ice when it is put in. There should be two doors, inside and outside the lining, both opening outwards. A shady place is desirable, but not essential.


Fig. 2.

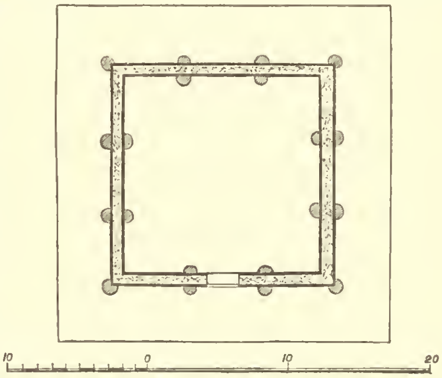


Fig. 3.

A still less expensive way of storing ice has been described by the late Mr Pearson of Kinlet in the *Gardener's Journal* (iii. 10). In this case the ice-stack was made on sloping ground close to the pond whence the ice was derived. The ice was beaten small, well rammed, and gradually worked up into a cone or mound 15 feet high, with a base of 27 feet, and protected by a compact covering of fern 3 feet thick. A dry situation with a sloping surface is necessary where this plan is adopted, and a small ditch should surround the heap, to drain away any water that may come from melted ice or from other sources.

ICELAND

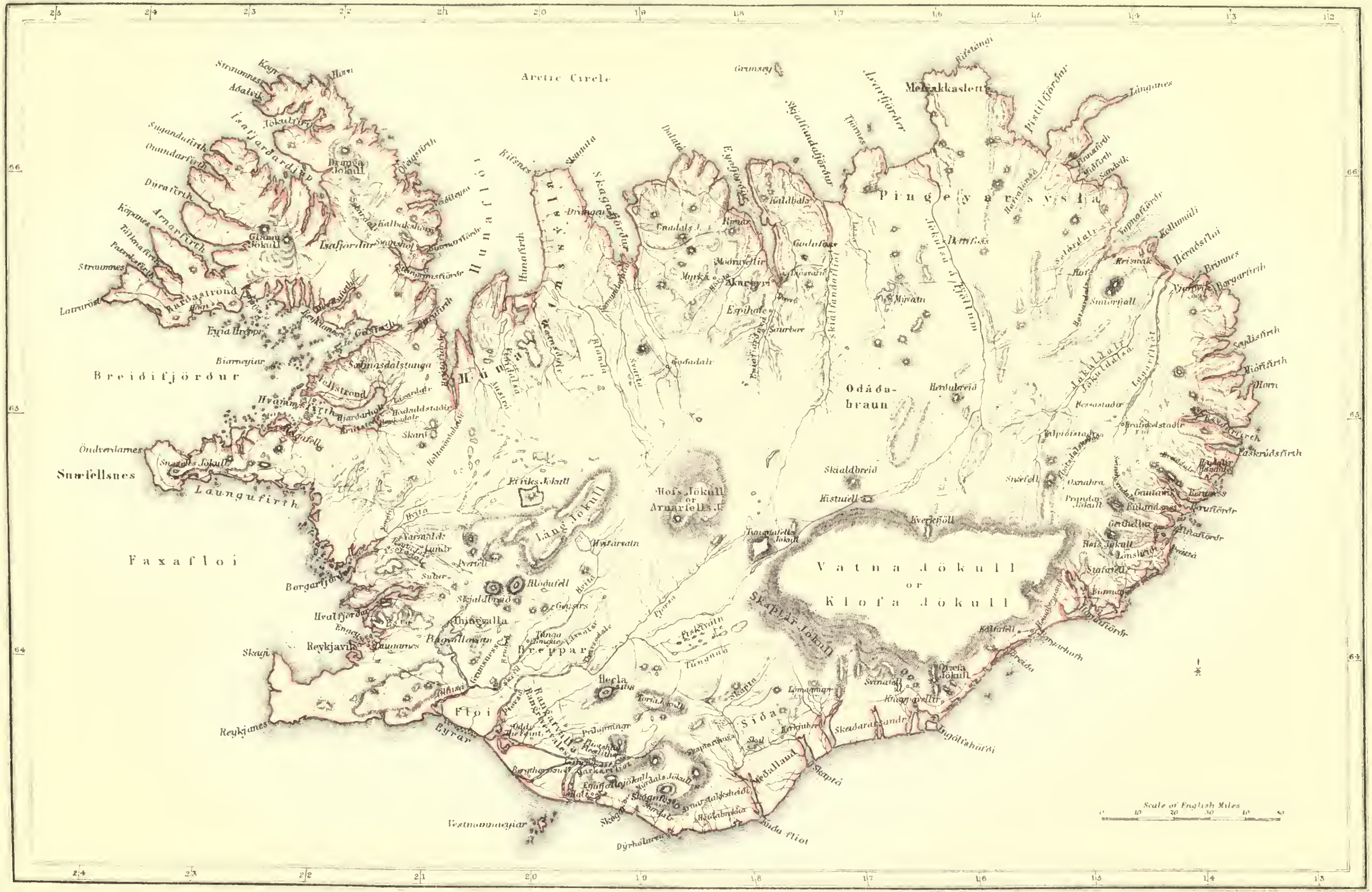
Plate IV. ICELAND (in Danish, *Island*) is an island in the North Atlantic Ocean, immediately to the south of the polar circle. It extends from 63° 23′ to 66° 33′ N. lat., and from 13° 22′ to 24° 35′ W. long. Its distance from the north of Scotland is 500 miles, from Norway 600 miles, and from Greenland 250 miles. The greatest length of the island is 300 miles, from east to west, and its greatest breadth 200 miles. The area is estimated at 39,200 square miles, 7000 more than that of Ireland.

The geological formation of the island is throughout volcanic. It rests on a foundation of palagonite, or palagonite tufa, called in Icelandic "móberg"; and on this foundation are raised plateaus of basalts, and mountains of trachyte and other volcanic ejections. The whole island seems to have been filled up by volcanic agency. In some of the mountains the lavas occur in tolerably regular parallel strata or terraces, separated here and there by layers containing lignite, as in the similar volcanic plateaus of Faroe and Greenland.

Coast. The whole of the south coast, from Hornafjörður in the south-east to Reykjanes in the south-west, is entirely unbroken by bays or firths. If such ever existed, they have been filled up by the glaciers and the sand and mud carried down from the volcanic ice-mountains situated close to the south coast. The coast-line is not, however, a straight line, but a broad arch, as the land swells out in the middle southwards to a considerable extent. On the north of Reykjanes a broad bay called Faxaflói (Faxi's Bay) cuts into the land; it is bounded on the north side by Snæfellsnes, and has an area of 54 miles by 30 On the north side of Snæfellsnes the long Breiðifjörður (Broadfirth) nearly cuts off the north-west peninsula from the rest of the island; it is 80 miles long and 40 broad. The Breiðifjörður is noted for its great number of small islands, most of them inhabited, and all of them affording breeding places for the eider duck. To the north of the Breiðifjörður, innumerable bays cut into the peninsula at every turn, giving it somewhat the look of the outstretched hand of a man; the longest of these is Ísafjarðardjúp (Icefirthdeep), 45 miles long. On the north side of the island, between Horn (Cape North) on the west and Melrakkaslétta (Fox Plain) on the east, there are several large firths. Furthest to the west is Húnaflói (Bearcubs' Bay), about 60 miles long, which nearly meets the Breiðifjörður running in from the west; the tongue of land which separates them and connects the north-west peninsula with the rest of the island is hardly 5 miles broad. The other firths on the north side are Skagafjörður, Eyafjörður (Firth of the Isles) 36 miles long, Skjálfandafjörður, and Axarfjörður (Axefirth). The Melrakkaslétta is separated from Langanes, the north-east point of Iceland, by the Þistilfjörður (Thistlefirth). The whole of the east coast of the island is indented by numerous narrow firths like those found in the north-west peninsula, but none of them are of any great length. Sailing round the island from point to point, the distance is 900 miles, but if we follow the coast-line it is not less than 2000 miles.

Interior. The centre of the island is a table-land, or rather a broad flattened ridge, sloping down to the north and the south, the average height of which above the level of the sea is about 2000 feet. It consists of arid sands and rugged tracts of lava, the most important of which bear the names of Ódáðahraun (the Lava of Evil Deeds), Sprengisandur (Bursting Sand), and Stórisandur (Big Sand). This wilderness is frequently broken by high and extensive ice-hills called jökull (plur. jöklar). The ice hills rise to the greatest height in the south-east, where the most extensive ice-field in the island, called Vatnajökull, covers about 4000 square miles. The outliers of this ice-field come close down to the water, hardly leaving room for passage between them and the sea; some of these are the loftiest summits in the island, as Öræfajökull, which is 6466 feet high. South of the west end of the Vatnajökull, called Skaptárjökull, stretches an inhabited slope, interrupted by several small hills, and intersected by considerable streams. The eastmost part is called Síða; then follow Landbrot, Meðalland, and Alptaver. West of this the land rises again in the Mýrdalsjökull and the Eyafjallajökull, the latter being 5593 feet high, and here again the mountains come close down to the sea. West of the Eyafjallajökull is the largest plain in the island, stretching westward to the mountain chain terminating in the low cape of Reykjanes, and backed on the north side by several isolated mountains, among which the far-famed Hecla is prominent; its height approaches 5000 feet. This plain consists of stretches of grass land and marshes, affording abundance of grass for pasture and haymaking.

The southern and part of the eastern coasts of Faxaflói, as far as Reykjavík, are very barren and desolate, being almost entirely rugged lava tracts; but the lower parts of the hills then begin to be clothed with grass, affording pasture for sheep, cattle, and horses. North of Reykjavík is a long and narrow firth called Hvalfjörður (Whalefirth), and further on a shorter one called Borgarfjörður (Burghfirth). Between the extremity of the latter and the central highlands there is a large and fertile district, consisting of grassy valleys, divided by low hills, and an extensive plain covered with marshy grasslands. This district is a fair specimen of many of the inhabited parts of Iceland. The level land, the valley bottoms along the river banks, and in many cases the slopes of the hills, are covered with grass, but the soil is too frequently boggy and marshy. The hills are partly covered with heather, and in a few places with stunted dwarf birch. Districts similar in character to Borgarfjörður are the Dalir (Dales) on the south side of Breiðifjörður, the Húnavatnssýsla on the south side of Húnaflói, the Skagafjörður, the Fljótsdalshérað on the east side of the island, and the western half of the plain lying between Eyafjallajökull and the Reykjanes range of mountains. The north-west peninsula consists, as already stated, of narrow firths divided by high and narrow mountain ridges, seldom lower than 2000 feet. In some places the top is a thin rocky edge; in others it consists of sharp-pointed peaks, denuded of all vegetation. Even at a considerable distance the different rocky strata may be distinguished. Sometimes these hills, or rather cliffs, rise perpendicularly out of the water to a height of a couple of thousand feet, affording breeding-places to an immense number of sea-fowl. More frequently the lower parts of these razor-backed hills slope towards the firths, the stony slopes being partly covered with grass or heather. The farms are therefore found along the shores and in short valleys cutting into the hills from the ends of the firths. The east coasts of Iceland present exactly the same character as that of the north-west peninsula. From the end of Eyafjörður a long and fertile valley, bounded on both sides by lofty mountains, runs due south into the country for about 25 miles. The north-east corner of the island, called Þingeyarsýsla, has good sheep pasturage, although its hills and slopes are covered with heather instead of grass to a greater extent than most other districts of the island. It will thus be seen that the inhabited parts run round the coasts, and from



This map with certain amendments belongs to the Story of Burnt Njal by Sir George W. Dasent who has kindly allowed its reproduction here

the end of the bays into the interior, the farms farthest inland being about 50 miles from the sea.

As the snow-line is at an altitude of from 2500 to 3000 feet, all the highest mountain-tops are cones covered with perpetual snow. Besides the ice-mountains already mentioned, there are several on the western part of the central highlands, such as Hofsjökull, Langjökull, Eiríksjökull, &c.; Snæfellsjökull, at the point of the peninsula separating the Faxaflói and Breiðifjörður, reaches the height of 4713 feet. All these mountains are snow-capped. Most parts of the island are studded with hills ranging in height from 2000 to 3000 feet. The tops are usually bare and rocky, but the slopes are to some extent covered with grass and heather.

Most of the mountains of Iceland have been volcanoes, and at least twenty-five of them have been active within the historical period of the island, that is, the last 1000 years. It was observed by Mackenzie that there are two volcanic formations in the island, one consisting of flat sheets of basalt, the other of more irregular hilly accumulations of trachyte, obsidian, ashes, and other volcanic masses. The former of these, there can be little doubt, is of Tertiary age—a part of the great Miocene volcanic plateaus, which on the one hand extend southwards through the Faroe Islands and the west of Scotland to the north of Ireland, and on the other stretch northwards and westwards far into Greenland. The other volcanic masses are of recent date. Iceland has thus been the theatre of volcanic activity at two widely separated periods, though we do not yet know whether during the interval the activity was wholly dormant. Of the existing volcanic mountains the best known is Hecla, from which eighteen eruptions have been recorded; the last took place in 1845–46. The intervals between the eruptions have varied greatly; sometimes it has remained quiet for six years only, at other times for seventy-two years. As with most other volcanoes, the height of this mountain varies with the eruptions. Thus before the eruption of 1845 its height was given on Gunlaugsson's map as 4951 feet, while Kjerulf measured the mountain in 1850, and found it to be only 4532 feet. The earliest historical eruption, that of 1104, is celebrated as the "sand-rain winter," the second, in 1158, as the "great darkness," from the quantity of ashes ejected. One feature of the Icelandic eruptions, not from Hecla only, but from other orifices in the island, has been the prodigious quantity of fine dust discharged and the great distance to which this material has been carried. Thus in the year 1766 a column of ashes rose out of the crater of Hecla to a height of 16,000 feet into the air. Volcanic dust from the Icelandic vents has frequently been borne by upper air currents so as to fall upon the Faroe Islands, and has even been carried in considerable quantities as far as Norway on the one side and the north of Scotland on the other. Next to Hecla, the Katla, or Kötlugjá, in Mýrdalsjökull may be mentioned; its last eruption (the thirteenth known) took place in 1860. The most tremendous volcanic outbreak in Iceland was that which took place in 1783 in or near the Skaptárjökull, on the north-west border of the Vatnajökull. Two principal lava streams flowed from it: one of them was 50 miles in length, from 12 to 15 miles in breadth, and 100 feet deep, and the other was 40 miles in length. It has been calculated that these two streams cover an area of 420 square miles. This eruption destroyed directly or indirectly one-sixth of the inhabitants of the whole island, or one-half of all the live stock. From nearly all the outliers of the Vatnajökull eruptions now and then take place. To the north of Vatnajökull a range of volcanic centres extends as far as Myvatn. The last outbreak here took place in 1875, when fine volcanic dust was discharged in great quantity, some of it being carried as far as Norway. The sea around the coasts of Iceland has been frequently disturbed by volcanic outbreaks, especially off Cape Reykjanes.

Hot springs. On account of the same volcanic activity, hot springs are frequently met with throughout the island. The common name for them in Icelandic is "hverr" (cauldron). The chief of these hot springs is Geysir (Gusher). See Geysers.

Minerals. The only mineral worked to any extent in Iceland is sulphur; the principal mines are those of Krísuvík and Mývatn. Of the Iceland spar used for polarizing optical instruments, only one mine has been worked, that of Helgustaðir in the east of the island. Limestone is found near Reykjavík, and has been worked a few years. Iron-ore is found in many parts of the island, but not in paying quantities, as suitable fuel is wanting. Aluminium occurs near Cape Reykjanes, but no attempt has been made to work the mine. Coal has also been found in one place, but has not been worked. There are considerable quantities of lignite, called in Icelandic surtarbrandur, in the north-west peninsula; some successful attempts have been made to use it as fuel, but it has not been worked to any extent. Peat is found, and is used as fuel, in most parts of the island.

Rivers. Iceland is rich in streams and rivers, some of them carrying a large volume of water; as, however, the fall is steep in every case, they are not navigable even by small boats. The longest are Þjórsá, running southwards from the central highlands, and Skjálfandafljót and Jökulsá á Fjöllum in the north-east, running northward. The last-named river is 113 miles in length, the other two 108 miles each. Of other rivers may be mentioned the Hvítá, part of which is called Ölfusá, running nearly parallel with Þjórsá, Hvítá in Borgarfjörður, Blanda running into Húnaflói, Héraðsvötn in Skagafjörður, and Lagarfljót in the east. There are several rivers named Hvítá (white river), so called from their milky waters, caused by the glacial mixtures carried down from the highlands. The principal waterfalls are—Skógafoss and Seljalandsfoss, south of Eyafjallajökull, Godafoss in Skjálfandafljót, and Dettifoss in Jökulsá á Fjöllum. Of the lakes Þingvallavatn, about 25 miles north-east of Reykjavík, and Mývatn in the north-east of Iceland are the largest. The former is 25 miles in circumference, and the latter 36 miles; its waters are studded with thirty-four small islands, affording breeding-places to a large number of water-fowl.

Climate. The climate of Iceland is not nearly so severe as might be supposed from the latitude. At Reykjavík the mean temperature of the year is 39° Fahr., of the summer 53° and of the winter 29° 18′. The temperature of Akureyri is 32° for the year, that of the summer 45° 5′ and the winter 20° 7′. There is therefore great difference between the north and the south of the island. Another difference may also be noticed; while the climate of the south is wet and variable, that of the north is dry and regular. The mean temperature of different years sometimes varies as much as 10°, and the mean temperature of the same month has been known to vary as much as 27°. One feature in the climate has been noticed by all travellers, that is, the clearness and purity of the atmosphere, rivalling that of Italy, mountains being seen distinctly at a distance of 100 miles. The rainfall is considerable in the south and the east of the island, and snow-storms and gales are frequent in winter. Thunderstorms occur mostly in winter.

Vegetation. No cereal is grown in Iceland, but in some places there is found a kind of wild oats (*Avena arenaria*), called in Icelandic "melur." Potatoes, carrots, turnips, and several kinds of cabbage have lately been cultivated with considerable success. The grasses, wild and cultivated, are of the greatest importance to the inhabitants. The only trees found are the dwarf birch, rarely higher than 12 feet, and some willow and juniper bushes. The wild flora of Iceland is small and delicate, with bright bloom, the heaths being especially admired. Wild crowberries and bilberries are the only kind of fruit found in the island.

Animals. The only wild animal in Iceland is the fox, of which both white and blue varieties occur; they are hunted for their skins, and also because they often attack the sheep. The domestic animals are the cow, the horse, the sheep, the dog, and the cat. The cows are of a small breed, resembling English shorthorns in general, and especially Alderneys. The horses are also of a small breed, the average height being twelve hands; they are hardy and enduring; many of them are never housed, and forage for themselves as best as they can throughout the winter. They are exported to Great Britain in considerable numbers, for use in the coal mines. The sheep generally are of nearly the same size as the Scotch blackfaced sheep; they are not unfrequently seen with three or four horns. The genuine Iceland dog, with his pointed snout, short ears, curled tail, and short legs, has some resemblance to the Esquimaux dog and the Scotch collie. Reindeer were imported in the last century, but they fled to the mountains and became wild; they are now nearly extinct. There are said to be ninety different species of birds, fifty-four of them being water-fowl. The most remarkable of the birds of prey are the Icelandic falcon (*Falco islandicus*) and the eagle. The only game bird is the ptarmigan, which is brown in summer and white in winter. Of the water-fowl the eider duck is of the greatest importance on account of its valuable down; the killing of it is therefore forbidden by law. Immense numbers of gulls, puffins, and guillemots are seen near their breeding places on the small islands and on the cliffs round the coasts. The hooper, or whistling swan, is found in large numbers in Iceland. The sea round the coast teems with cod, haddock, holibut, and the basking shark; the fin-backed-whale and seals of various kinds are also met with, but in smaller numbers. In the lakes and rivers salmon and trout are caught in considerable quantities.

Tillage. As no corn is grown, there is no agriculture to speak of, and only a little spade husbandry connected with the cultivation of kitchen gardens, where potatoes, turnips, and carrots are grown. The area thus under cultivation covers, according to the latest official returns, about 215 English acres throughout the island. The cultivation of the soil in Iceland can hardly indeed be said to have been attempted; such experiments, however, as have been made, have given good hope of success. Around every farmhouse is a field called "tún," which is but rarely enclosed or fenced. This is the only part of the land which is cultivated at all, and all that is done there is to spread dung on the top of the soil in autumn and scrape it off in spring. Even this most primitive cultivation makes the grass twenty-five to fifty per cent. better than elsewhere. The haymaking season extends from the middle of July to the 20th of September. The grass is cut with small scythes, first in the home field, and then on the uncultivated grass-lands belonging to the farms. Many of the fishermen hire themselves to the farmers during the haymaking season; and during the fishing season the farmers send their servants to the sea-coast to fish.

Live stock. According to the latest official returns the cattle in the island numbered 20,378, the horses (ponies) 31,312, and the sheep 415,339. It is obvious, however, from the quantities of wool exported that the number of sheep must be at least double that stated in the returns.

Manufactures. The manufactures are confined to spinning, weaving, and knitting the wool of the sheep. A sort of tweed, called in Icelandic "vaðmál," is the principal clothing of the inhabitants. The spinning of the yarn is done by the women in winter, and almost every farm has an old-fashioned loom. In the north considerable quantities of jackets and stockings are knitted and exported.

Trade. The trade with Iceland is entirely in the hands of Danish traders and a few Icelanders—who mostly reside in Copenhagen. It consists almost entirely in exchange, or barter. The principal exports of the Icelanders are cod fish, about 6,000,000 lb annually; train oil, 9500 barrels; wool, 1,500,000 lb; eider down, 7000 lb; and feathers, 20,000 lb. Ponies are now exported to Scotland,—about 2000 a year; and a few cargoes of live sheep have been sent over during the last two years. All bread stuffs have to be imported, as well as groceries, spirits, wines, and beer, tobacco, salt, building materials, and other items. Since 1854 the trade has been open to all nations; but any vessel trading with Iceland had to take out a sea pass at the cost of 2s. 3d. per ton down to 1879, when this duty was abolished. On the other hand, a trifling duty has been laid on spirits and tobacco.

Communication. There being no roads in the island, but merely tracks trodden down by the feet of the ponies, there are no carts nor carriages of any description. In the firths boats are chiefly used for conveying goods and passengers; but all inland communication and conveyance is by ponies. These hardy animals carry each a burden of about 200 lb weight, under which they walk about 25 miles a day. All travelling is also on ponies; two are considered necessary for every traveller, and on them he can make from 30 to 40 miles a day.

Divisions. Formerly Iceland was divided into four quarters, the east, the south, the west, and north. Now the north and the east are united under one governor, and the south and the west under another. The island is further divided into 18 sýslur (counties), and these again into 169 hreppur (rapes) or poor law districts. Ecclesiastically Iceland constitutes one bishopric, divided into 20 deaneries, and these again into 290 parishes.

Government. Iceland is subject to the king of Denmark. According to the constitution granted to Iceland in 1874, the king shares the legislative power with the Al-thing, an assembly of 36 members, 30 of whom are elected by household suffrage, and 6 nominated by the king. The Al-thing meets every second year, and sits in two divisions, the upper and the lower. The upper division consists of the 6 members nominated by the king and 6 elected by the representatives of the people out of their own body. The lower division consists of the remaining 24 representative members.

The secretary for Iceland, who resides in Copenhagen, is responsible to the king and the Al-thing for the maintenance of the constitution, and he submits to the king for confirmation the legislative measures proposed by the Al-thing. The king appoints a governor-general, who is resident in the island and carries on the government on the responsibility of the secretary in Copenhagen. Under the governor-general (landshöfðingi) are two under governors, one for the south and west, another for the north and east. Under these are the sheriffs (sýslumenn), who act as tax gatherers, notaries public, and judges of first instance; the sheriff has in every "hreppur" an assistant, called "hreppstjóri." In every hreppur there is also a representative committee, consisting of from three to five members, who administer the poor laws, and look after the general concerns of the hreppur. These committees are controlled by the committees of the sýslur (county boards), and these again are under the control of the amtsráð (quarter board), consisting of three members.

Justice. The administration of justice is carried out in the first instance by the sheriffs. From the sheriff courts appeals lie to the superior court at Reykjavík, consisting of three judges. Appeals may be taken in all criminal cases and most civil cases from this court to the supreme court at Copenhagen.

The state church of Iceland is the Lutheran; and all the Icelanders, without exception, belong to it. One bishop and 141 clergymen minister to the spiritual wants of the islanders. The bishop is appointed by the king. The parishes are 290, but the livings are only 141, from which it may be seen that many ministers have to serve two, and some even three parishes. The king appoints some of the ministers, and the governor-general others, with the advice of the bishop. The ministers are paid partly from the revenues of church property, and partly from tithes.

luca- on.

The Icelanders have long been famous for their education and learning, and it is no exaggeration to say that in no other country is such an amount of information found among the classes which occupy a similar position. A child of ten unable to read is not to be found from one end of the island to another. A peasant understanding several languages is no rarity, and the amount of general information which they possess might be envied by many who have had greater facilities for acquiring knowledge. Till within the last few years there were no elementary schools in the island; all children were taught by their parents or near neighbours. Now a few elementary schools have been started, but their number is still too small to make any general difference in the education. For classical and general education there is a college at Reykjavík, with seven professors and about one hundred students. There is also a college for ministers, with three professors. The general physician of the island, assisted by two medical men, gives lectures to medical students; but those who propose to enter the legal profession have to attend the university of Copenhagen.

tional arac- istics.

There is less difference in the material prosperity of the Icelanders than in that of the inhabitants of more advanced countries. One does not find the abject poverty so often seen in large towns and among the agricultural population of some of the most civilized countries of Europe. On the other hand, wealthy men, or owners of extensive properties, are unknown, the richest man in Iceland deriving only £300 a year from his property. Although no abject poverty is seen, there are more paupers comparatively than in more populous countries, and the poor-rates in many parishes exceed all the other taxes put together. The Icelanders are often too liberal in granting relief, which in many cases breeds idleness, carelessness, and want of forethought. It is also to be noticed that in few countries is it so easy to live with as little labour as in Iceland. On account of the climate, out-of-door work cannot be conducted for more than five months of the year at most, but even this time is not used with so much energy and skill as it might be. The haymaking, carried on for two months in the year, is the only work which is prosecuted with anything like energy. Fishing is prosecuted not continuously but periodically. The want of activity among the Icelanders is to be ascribed partly to their slow temperament, and partly to their utter want of training. They are very fond of gathering any amount of miscellaneous information, but their want of training prevents them from turning it to practical account. There is no doubt that they are endowed with intellectual faculties of a superior kind, and, with proper training, might make far more of their country than they do at present. It appears that the island could easily support eight times the number of the present population, if its resources were properly developed. Crime is rare; and the moral character of the Icelanders is about the same as that of the other countries of the north.

The census of 1870 returned the population of the island as 69,763. In 1801 the population was only 46,240: in 1880 it is estimated to have increased to 73,000. The birth-rate is about 33 per thousand, and the death-rate 24. Nearly the whole of the population live on isolated farms, the number of each family, including servants, being on an average seven. The chief town or village is Reykjavík, with about 2500 inhabitants. It is the seat of the governor-general, the bishop, the colleges, and the superior court. In the north-west is Ísafjörður, with about 400 inhabitants, and in the north Akureyri, with the same number. (J. A. H.)

Table of Icelandic Literature and History.

		I. *The Commonwealth.* 400 *years.*	
Heroic Age.	870–930	Poetry of Western Islands.	Settlement by colonists from Western Isles and Norway.
	930–980	Early Icelandic poets, chiefly abroad.	Constitution worked out—Events of earlier sagas take place.
	980–1030	Icelandic poets abroad.	Christianity comes in—Events of later sagas take place.
Saga Telling.	1030–1100	*First era of phonetic change.*	Peace—Ecclesiastical organization.
The Literary Age.	1100–1150	ARI and his school—THORODD—Vernacular writing begins.	
	1150–1220	SAGA-WRITERS—Second generation of historians.	First civil wars, 1208–22—Rise of Sturlungs.
	1220–1248	SNORRI and his school—Biographers.	Second civil wars, 1226–58—Fall of Great Houses.
	1248–1284	STURLA—*Second era of phonetic change.*	Change of law, 1271—Submission to Norwegian kings.
		II. *Mediævalism.* 250 *years.*	
Continental Influence, chiefly Norse.	1284–1320	Collecting and editing—Foreign romances.	Foreign influence through Norway.
	1320–1390	Annalists—Copyists—New Mediæval poetry begins.	Great eruptions, 1362 and 1389—Epidemics—Danish rule, 1380.
	1390–1413	Death of old traditions, &c.	Epidemics—Norse trade—Close of intercourse with Norway.
Dark Age.	1413–1530	Only Mediæval poetry flourishes.	Isolation from Continent—English trade.
		III. *Reformation—Absolute Rule—Decay.* 320 *years.*	
Reformation.	1530–1575	ODD—Printing—*Third era of phonetic change.*	Religious struggle—New organization—Hanse trade.
Renaissance.	1575–1610	First antiquarians.	Danish monopoly—Pirates' ravages.
	1610–1700	HALLGRIM—Paper copies taken.	
Gradual Decay.	1700–1730	JON WIDALIN—Arni Magnusson—MSS. taken abroad.	Increasing decay. Small-pox kills one-third population, 1707.
	1730–1768	Eggert Olafsson.	Great famine, 10,000 die, 1759—Sheep plague, 1762—Eruption, 1765.
	1768–1800	Finn Jonsson—Icelandic scholars abroad.	Great eruption, 1783.
	1800–1850	Rationalistic movement—European influences first felt.	Beginnings of recovery—Travellers make known island to Europe—Free constitution in Denmark, 1848
		IV. *Modern Iceland.*	
Recovery of Iceland.	1850–1874	Modern thought and learning—Icelandic scholars abroad.	Increasing wealth and population—Free trade, 1854—Jon Sigurdsson and home rule struggle—Emigration.
	1874		Home rule granted

HISTORY.

With its isolated situation, inclement climate, scant natural advantages, and sparse population, Iceland is yet of high interest to the historian, philologist, and *littérateur*. To the first the excellence and exactitude of its historical records, the curious phases of life to which they bear witness, and the singular circumstances which have determined the existence and life of the Teutonic community for a thousand years apart from the rest of the European family, are all attractive. By the philologist the island is reverenced as the home of a tongue which (though like our own it has suffered deep phonetic change) yet most nearly represents in a living form the tongue of our earliest Teutonic forefathers. And by many more than these students Iceland is fondly regarded as the land where, long before the "literary eras" of England or Germany, a brilliant period of intellectual life produced and elaborated in its own distinct form of expression a literature superior to any north of the Alps before the Renaissance since the downfall of Old Rome in power, purity, and life.

Settlement.

To begin with history, in which we are chiefly concerned with the first and fourth periods of the island's inhabited existence, and first the "settlement." Shortly after the discovery of Iceland by the Scandinavian, *c.* 850 (it had long been inhabited by a small colony of Irish Culdees), a stream of immigration set in towards it, which lasted for sixty years, and resulted in the establishment of some 4000 homesteads scattered round the habitable fringe about the great bays and firths.

In this immigration three distinct streams can be traced. (1) About 870–890 four great noblemen from Norway, Ingolf, Ketil Hæng, Skalla-Grim, and Thorolf, settled with their dependants in the south-west of the new found land. (2) In 890–900 there came from the Western Islands Queen Aud, widow of Olaf the White, king of Dublin, preceded and followed by a number of her kinsmen and relations (many like herself being Christians), Helgi Biolan, Biorn the Eastern, Helgi the Lean, Ketil the Foolish, &c., who settled the best land in the island (west, north-west, and north), and founded families who long swayed its destinies. Besides this most important immigration of all there came from the Western Islands a fellowship of vikings seeking a free home in the north. They had colonized the west in the viking times; they had "fought at Hafursfirth," helping their stay-at-home kinsmen against the centralization of the great head-king, who, when he had crushed opposition in Norway, sailed after these turbulent colonists across the North Sea, and followed up his victory by compelling them to bow to his rule or fly again to fresh haunts whence they could not so easily interfere with his projects. Such were Ingimund the Old, Geirmund Hellskin, Thord Beardie (who had wed St Edmund's grand-daughter), Audun Shackle, Bryniulf the Old, Uni, to whom Harold promised the earldom of the new land if he could make the settlers acknowledge him as king, a hopeless project, and others by whom the north-west, north, and east were almost completely "claimed." (3) In 900–930 a few more incomers direct from Norway completed the settlement of the south, north-east, and south-east. Among them were Earl Hrollaug (half brother of Hrolf Ganger and of the first earl of Orkney), Hialti, Hrafnkell Frey's priest, and the sons of Asbiorn. Fully three quarters of the land was settled from the west, and among these immigrants there was no small proportion of Irish blood. In 1100 there were 4500 franklins, *i.e.*, about 50,000 souls.

Organization.

The unit of Icelandic politics is the homestead with its franklin-owner (*buendi*), its primal organization the hundred-moot (*thing*), its tie the *gođorđ* or chieftainship. The chief who had led a band of kinsmen and dependants to the new land, taken a "claim" there, and parcelled it out freely among them, naturally became their leader, presiding as priest at the temple feasts and sacrifices of heathen times, acting as president and speaker of their moot, and as their responsible representative towards the neighbouring chiefs and their clients. He was not a feudal lord nor a local sheriff, for any franklin could change his gođorđ when he would, and the rights of "judgment by peers" were in full use; moreover, the office could be bequeathed, sold, divided, or pledged by the possessor; still the gođi had considerable power and influence as long as the commonwealth lasted.

At first there was no higher organization, but disputes between neighbouring chiefs and their clients, and uncertainty as to the law, brought about the *Constitution of Ulfliot*, *c.* 930, which appointed a central moot for the whole island, the Al-thing, and a speaker to speak a single "law" (principally that followed by the Gula-moot in Norway); the *Reforms of Thord Gellir*, 964, settling a fixed number of local moots and chieftaincies, dividing the island into four quarters (thus characterized by Ari:—north, thickest settled, most famous; east, first completely settled; south, best land and greatest chiefs; west, remarkable for noble families), to each of which a head-court, the "quarter-court," was assigned; and the *Innovations of Skapti* (ascribed in the saga to Nial) *the Law-Speaker* (d. 1030), who set up a "fifth court" as the ultimate tribunal in criminal matters, and strengthened the community against the chiefs. But here constitutional growth ceased: the law-making body made few and unimportant modifications of custom; the courts were still too weak for the chiefs who misused and defied them; the speaker's power was not sufficiently supported to enable him to be any more than a highly respected lord chief justice, whereas he ought to have become a *justiza* if anarchy was to be avoided; even the ecclesiastical innovations, while they secured peace for a time, provoked in the end the struggles which put an end to the commonwealth.

Christianity was introduced *c.* 1000. Tithes were established in 1096, and an ecclesiastical code made *c.* 1125.

The first disputes about the jurisdiction of the clergy were moved by Gudmund in the 13th century, bringing on a civil war, while the questions of patronage and rights over glebe and mortmainland occupied Bishop Arni and his adversaries fifty years afterwards, when the land was under Norwegian viceroys and Norwegian law. For the civil wars of the 13th century broke down and exterminated the great houses who had monopolized the chieftaincies and abused their power for their own ends; and after violent struggles (in which the Sturlungs of the first generation perished at Orlygstad, 1238, and Reykiaholt, 1241, while of the second generation Thord Kakali was called away by the king in 1250, and Thorgils Skardi slain in 1258) the submission of the island, quarter after quarter, took place in 1262–64, under Gizur's auspices, and the old Common Law was replaced by the New Norse Code "Ironside" in 1271.

The political life and law of the old days is abundantly illustrated in the sagas (especially Eyrbyggia, Hænsa-Thori, Reyk-dæla, Hrafnkell, and Niala), the two collections of law-scrolls (*Codex Regius*, *c.* 1235, and *Stadarhol's Book*, *c.* 1271), the Libellus, the Liber-fragments, and the Landnamabok of Ari, and the Diplomatarium. K. Maurer has made the subject his own in his *Beiträge*, *Island*, *Grágás*, &c.

The mediæval Icelandic church had two bishoprics, Skalholt (S., W., and E.) 1056, and Holar (N.) 1106, and about 175 parishes (two-thirds of which belonged to the southern bishopric). They belonged to the metropolitan see of Bremen, then to Lund, lastly to Nidaros, 1237. There were several religious foundations: Thingore (founded 1133), Thwera (1155), Hitardale (*c.* 1166), Kirkby Nunnery (1184), Stad Nunnery (1296), and Saurby (*c.* 1200) were Benedictine, while Ver (1168), Flatey after Holyfell (1172), Videy (1226), Madderfield Priory (1296), and Skrid Priory (14th century) were Augustinian. The bishops, elected by the people at the Al-thing till 1237, enjoyed considerable power and influence, and were most of them distinguished men; two, Thorlak of Skalholt and John of Holar, were publicly voted saints at the Al-thing after due examination of their claims to that distinction, and one, Gudmund, received the title of "Good" by decree of the bishop and chapter. Full details as to ecclesiastical history will be found in the *Bishops' Lives* (edited by Dr Vigfusson).

Mode of life.

Iceland was not agricultural but pastoral, depending upon flocks and herds for subsistence, for, though rye and other grain would grow in favoured localities, the hay, self-sown, was the only regular crop. In some districts the fisheries and fowling were of importance, but nine-tenths of the population lived by their sheep and cattle, which gave them food, clothing, and such products for export as enabled them to import wood for building, iron for tools, and a few luxuries, as honey, wine, grain for brewing, and foreign clothes, fur, &c. Life on each homestead was regularly portioned out:—out-door occupations—fishing, shepherding, fowling, and the important hay-making and fuel-gathering—occupying the summer; while in-door business—weaving, tool-making, &c., filled up the long winter. The year was broken by the spring feasts and moots, the great Al-thing meeting at midsummer, the marriage and arval gatherings after the summer, and the long yule feasts at midwinter. There were but two degrees of men, free and unfree, though only the franklins had any political power; and, from the very nature of the life, social intercourse was peculiarly unrestrained and unfettered; gođi and thrall lived the same lives, ate the same food, spoke the same tongue, and differed little in clothing or habits. The poorest franklin was the social equal of the proudest chief, and in a few generations the freed man or landless dependant might become their peer in public estimation, provided he got a homestead of his own. The thrall had a house of his own and was rather villein or serf than slave, having rights and a legal price by law. During the heathen days many of the great chiefs passed part of their lives in Norway at the king's court, but after the establishment of Christianity in Iceland they kept more at home, still visiting the Continent, however, for purposes of state, suits with clergy, &c. But the trade was from the first in foreign (Norse) hands almost entirely.

The introduction of a church system brought little change. The great families put their members into orders, and so continued to enjoy the profits of the land which they had given to the church; the priests married and otherwise behaved like the franklins around them in every-day matters, farming, trading, going to law like laymen; so that, in spite of the efforts of the more earnest church reformers, the church was powerless to promote centralization against the feuds and jealousies of the great houses.

Effects of the union and change of law.

The old life in the commonwealth was turbulent and anarchic, but free and varied; it produced men of mark, and fostered bravery, adventure, and progress. The great chiefs were indeed only greater franklins; but their wealth and comparative luxury gave them leisure and opportunities for culture which raised them as examples and leaders above their fellows; the pride of birth preserved a nobility of feeling and high standard of honour amid much of violence and chicane. But all this now ceased, and there was left but a low dead level of poor peasant proprietors without pride in the past, political interest in the present, or ambition of the future, careless of all save how to live by as little labour as possible, and pay as few taxes as they could to their foreign rulers. The island received a foreign governor (*Earl*, *Hirdstjori*, or *Stiptamtsmadr* as he has been successively called), and was parcelled out into local counties (*syslur*), administered by sheriffs (*syslumadr*) appointed by the king. A royal court took the place of the Al-thing courts;

the local business of the local things was carried out by the (*hreppstjori*) bailiff, a subordinate of the sheriff; and the goðorð, things, quarter-courts, trial by jury, &c., were all completely swept away by these innovations, which have continued with mere changes of detail till the present century. The power of the crown was increased by the confiscation of the great Sturlung estates, which were under-leased to farmers, while the early falling off of the Norse trade threatened to deprive the island of the means of existence; for the great epidemics and eruptions of the 14th century had gravely attacked its pastoral wealth and ruined much of its pasture and fishery, for the time at least. The union of the Three Crowns transferred the practical rule of Iceland to Denmark in 1280, and the old Treaty of Union, by which the island had reserved its essential rights, was disregarded by the absolute Danish monarchs; but, though new taxation was imposed, it was rather their careless neglect than their too active interference that damaged Iceland's interests. But for an English trade, which sprung up out of the half-smuggling, half-buccaneering enterprise of the Bristol merchants, the island would have fared badly indeed, for during the whole 15th century their trade with England, exporting sulphur, eider down (which the English taught them the value of), wool, and salt stock-fish, and importing as before wood, iron, honey, wine, grain, and flax goods, was their only link with the outer world. This period of Iceland's existence is torpid and eventless: she had got peace but with few of its blessings; all spirit seemed to have died with the commonwealth; even shepherding and such agriculture as there had been sank to a lower stage; waggons, ploughs, and carts went out of use and knowledge; architecture in timber became a lost art, and the fine carved and painted halls of the heathen days were replaced by turf-walled barns half sunk in the earth, and lasting at best a generation; the large decked luggers of the old days gave way to small undecked fishing-boats; it is needless to add that letters were neglected, and that all remembrance of the commonwealth perished utterly.

ıe Re- rma- on.

The Reformation here as elsewhere had a one-sided effect: it wakened men's minds, opening new vistas of hope and new fields of thought, but it left their bodies and circumstances little changed, or, if at all, for the worse. Its necessary complement, a social and political revolution, never came to Iceland. The Hanse trade replaced the English for the worse; and the wretched Danish monopoly which succeeded it when the Danish kings began to act again with vigour, under the stimulus of European changes, was still less profitable. The glebes and hospital lands were a fresh power in the hands of the crown, and the subservient Lutheran clergy became the most powerful class in the island, while the bad system of under-leasing at rackrent and short lease with unsecured tenant right extended in this way over a great part, at least a quarter, of the better land, stopping any possible progress. The details of the religious change are uninteresting: nearly all who took active part in it on either side were men of low type, moved by personal motives rather than religious zeal; and, though it should be noticed that the fires of martyrdom were never lighted in Iceland, the story of the easily accepted Reformation is not altogether a pleasant one. When it was once accomplished, the little knot of able men who came to the front for two or three generations, stirred by the new life that had been breathed into the age, did nobly in preserving the records of the past for a later time to value and appreciate, while Odd and Hallgrim exhibit the noblest impulses of their time.

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A new plague, that of the English, Gascon, and Algerine pirates, marked the close of the 16th century and opening of the 17th, causing widespread panic and some devastation in 1579, 1613–16, and 1627. Nothing points more to the helplessness of the natives' condition than their powerlessness against these tiresome foes. But the 18th century is the most gloomy in Iceland's annals. Small-pox, famine, sheep disease, and the awful eruptions of 1765 and 1783 follow each other in terrible succession. Against such fearful visitations, which reduced the population by about a fourth, little could be done, and when the only man who might have roused the Icelanders from their misery, distress, and impoverishment, the noble and patriotic Eggert Olafsson, a hero of the old type, was drowned in full career in 1768, it is hardly to be wondered at that things grew from bad to worse, and that a listlessness and torpidity crept over the national character, the effects of which it is only beginning to shake off. The few literary men, whose work was done and whose books were published abroad, were only concerned with the past, and Jon Widalin is the one man of mark, beside Eggert Olafsson, who worked and wrote for his own generation.[1]

odern mes.

Gradually the ideas which were agitating Europe crept through Scandinavia into Iceland, and, now that scholars and travellers of mark and influence had drawn attention to the island, its claims were more respectfully listened to. The Continental system, which, by its leading to the blockade of Denmark, threatened to starve Iceland, was neutralized by special action of the British Government. Trade and fishery grew a little brisker, and at length the turn came.

The rationalistic movement, an unlovely attempt at reform, headed by Magnus Stephenson, a patriotic, narrow-minded lawyer, did little good as far as church reform went, but was accompanied by a more successful effort to educate the people by means of bringing within their reach the practical knowledge of the day. A Useful Knowledge Society, such as Brougham delighted in, was formed and did some honest work. Newspapers and periodicals were published, and the very stir which the ecclesiastical disputes encouraged did good. When free trade came, and when the free constitution of Denmark had produced its legitimate effects, the intelligent and able endeavours of a few patriots such as Jon Sigurdsson were able to push on the next generation a step further, in spite of such physical obstacles as the sheep disease. Questions of a modern political complexion arose; the cattle export controversy and the great home rule struggle began. The intelligence of a people whose love for knowledge and mental attainments have always been high seconded its leaders well, and after thirty years' agitation home rule was conceded in 1874. The absolute *syslumadr* and *hirdstjori* became popular officials assisted by elected boards. The *Al-thing*, a mere council of powerless delegates, was replaced by a representative assembly of two chambers (composed of thirty members chosen by a a popular and wide suffrage, and six crown nominees) with legislative powers, and other reforms were comprised in this grant. Further political changes, such as the introduction of a jury system to replace the Danish umpire-and-assessor procedure, are now being considered by the liberal party. There are many peculiar circumstances present in the condition of Iceland, the absence of towns, equality of society in a sense which exists in no other European community, difficulty of communication, and the intense conservatism and dislike of activity or change which must necessarily characterize a community so long isolated and "forced into lazy habits for lack of opportunity." But that emigration should have begun, and families left the old home for Canada and the United States to seek a better climate, a richer soil, and the hopes of progress which are so distant at home, is certainly remarkable; and, if the difficulties which must surround emigrants who have never seen a road, a tree, or a plough, on their first taking up an agricultural life, are overcome, the results may be very important to the mother country.

Literature.

Poetry

Poetry.—Iceland has always borne a high renown for song, but has never produced a poet of the highest order, a fact for which one can only account by noticing that the qualities which in other lands were most sought for and admired in poetry were in Iceland lavished on the saga, a prose epic, and that Icelandic poetry is to be rated very high for the one quality which its authors have ever aimed at—melody of sound. To these generalizations there are but few exceptions, albeit, in considering the history of this branch of Icelandic literature, we are at once met by an apparent contradiction to them, a group of poems which possess the very qualities of high imagination, deep pathos, fresh love of nature, passionate dramatic power, and noble simplicity of language which Icelandic poetry lacks. The solution is that these poems do not belong to Iceland at all. They are the poetry of the "Western Islands."

Poetry of the Westei Islands

It was among the Scandinavian colonists of the British coasts that in the first generations after the colonization of Iceland therefrom a magnificent school of poetry arose, to which we owe works that for power and beauty can be paralleled in no Teutonic language till centuries after their date. To this school, which is totally distinct from the Icelandic, ran its own course apart, and perished before the 13th century, the following works belong (of their authors we have scarcely a name or two; their dates can be rarely exactly fixed; but they lie between the beginning of the 9th and the end of the 10th centuries), classified into groups:—

a. The *Helgi* trilogy (last third lost save a few verses, but preserved in prose in *Hromund Gripsson's Saga*), the *Raising of Anganty* and *Death of Hialmar* (in *Hervarar Saga*), the fragments of a *Wolsung Lay* (part interpolated in earlier poems, part underlying the prose in *Volsunga Saga*), all by one poet, to whom Dr Vigfusson would also ascribe *Völuspá*, *Vegtamskriða*, *Thrymskviða*, *Grötta Song*, and *Volundar-kriða*.

b. The Dramatic Poems:—*Flyting of Loki*, the *Lay of Skirni*, the *Lay of Harbard*, and several fragments, all one man's work, to whose school belong, probably, the *Lay* underlying the story of Ivar's death in *Skioldunga Saga*.

c. The Didactic Poetry:—*Grimnismal*, *Vafthrudnismal*, *Alvismal*, &c.

d. The Genealogical and Mythological Poems:—*Hyndla-Lioð*, written for one of the Haurda-Kari family, so famous in the Orkneys; *Ynglinga-tal* and *Haust-löng*, by Thiodulf of Hvin; *Rig's Thul*, &c.

e. The Dirges and Battle Songs,—such as that on *Hafur-firth Battle*, by Thiodulf of Hvin or Hornklofi, shortly after 870; *Eirik's Dirge*, between 950 and 969; the *Dart-Lay on Clontarf Battle*, 1014; *Biarka-mal* (fragments of which we have, and paraphrase of more is found in *Hrolf Kraki's Saga* and in Saxo).

There are also fragments of poems in *Half's Saga*, *Asmund Kappa-Bana's Saga*, in the Latin verses of Saxo, and the *Shield Lays* by

[1] For the periods succeeding the union, Danish state papers and the *History* of Finn Jonsson are the best authority.

Bragi, &c., of this school, which closes with the *Sun-Song*, a powerful Christian Dantesque poem, recalling some of the early compositions of the Irish Church, and with the 12th century *Lay of Ragnar*, *Lay of Starkad*, *The Proverb Song* (*Havamal*), and *Krakumal*, to which we may add those singular Gloss-poems, the *Thulur*, which also belong to the Western Isles.

Poetry of Greenland.

To Greenland, Iceland's farthest colony, founded in the 10th century, we owe the two *Lays of Atli*, and probably *Hymiskriða*, which, though, as was to be expected, of a weirder harsher cast, yet belong to the Western Isles school and not to Iceland. In form all these poems belong to two or three classes:—*kriða*, an epic "cantilena"; *tal*, a genealogical poem; *drapa*, songs of praise, &c., written in modifications of the old Teutonic metre which we know in Beowulf; *galdr* and *lokkr*, spell and charm songs in a more lyric measure; and *mal*, a dialogue poem, and *liod*, a lay, in elegiac measure suited to the subject.

The characteristics of this Western school are no doubt the result of the contact of Scandinavian colonists of the viking-tide, living lives of the wildest adventure, tossed by war and storm, with an imaginative and civilized race, that exercised upon them a very strong and lasting influence (the effects of which were also felt in Iceland, but in a different way). The frequent intermarriages which mingled the best families of either race are sufficient proof of the close communion of Northmen and Celts in the 9th and 10th centuries, while there are in the poems themselves traces of Celtic mythology, language, and manners.[1]

Poetry of the commonwealth.

When one turns to the early poetry of the Scandinavian continent, preserved in the rune-staves on the memorial stones of Sweden, Norway, and Denmark, in the didactic *Havamal*, the *Great Wolsung Lay* (*i.e.*, Sigurd II., Fafnis's Lay, Sigrdrifa's Lay), and *Hamdismal*, all continental, and all entirely consonant to the remains of our own Old English poetry in metre, feeling, and treatment, one can see that it is with this school that the Icelandic "makers" are in sympathy, and that from it their verse naturally descends. The only difference between them is that, while the fundamental characteristics of shrewdness, plain straightforwardness, and a certain stern way of looking at life are common to both, the Icelandic school adds a complexity of structure and ornament, an elaborate mythological and enigmatical phraseology, and a regularity of rhyme, assonance, luxuriance, quantity, and syllabification, which it caught up from the Latin and Celtic poets, and adapted with exquisite ingenuity to its own main object, that of securing the greatest possible beauty of sound.

The first generations of Icelandic poets were very remarkable men, and resemble in many ways the later troubadours; the books of the kings and the sagas are full of their strange lives. Men of good birth (nearly always, too, of Celtic blood on one side at least), they leave Iceland young and attach themselves to the kings and earls of the north, living in their courts as their henchmen, sharing their adventures in weal and woe, praising their victories, and hymning their deaths if they did not fall by their sides—men of quick passion, unhappy in their loves, jealous of rival poets and of their own fame, ever ready to answer criticism with a satire or with a sword-thrust, but clinging through all to their art, in which they attained most marvellous skill.

Such men were Egill, the foe of Eirik Bloodaxe and the friend of Æthelstan; Kormak, the hot-headed champion; Eyvind, King Hakon's poet, called Skaldspoiler, because he copied in his dirge over that king the older and finer *Eiriks-mal*; Gunnlaug, who sang at Æthelred's court, and fell at the hands of a brother bard Hrafn; Hallfred, Olaf Tryggvason's poet, who lies in Iona by the side of Macbeth; Sighvat, Saint Olaf's henchman, most prolific of all his comrades; Thormod, Coalbrow's poet, who died singing after Sticklestad battle; Ref, Ottar the Black, Arnor the earls' poet, and, of those whose poetry was almost confined to Iceland, Gretti, Biorn the Hitdale champion, and the two model Icelandic masters, Einar Skulason and Markus the Lawman, both of the 12th century.

It is impossible to do more here than mention the names of the most famous of the long roll of poets which are noted in the works of Snorri and in the two *Skalda-tal*. It is evident that they must differ greatly in style and tone, as they range from the rough and noble pathos of Egill, the mystic obscurity of Kormak, the pride and grief of Hallfred, and the marvellous fluency of Sighvat, to the florid intricacy of Einar and Markus.

The art of poetry, which stood to the Icelanders in lieu of music, was, and is still, much cultivated in the island; scarcely any prominent man but knew how to turn a mocking or laudatory stanza, and down to the fall of the commonwealth the accomplishment was in high request. In the literary age the chief poets belong to the great Sturlung family, Snorri and his two nephews, Sturla and Olaf, the White Poet, being the most famous "makers" of their day. Indeed, it is in Snorri's *Edda*, a poetic grammar of a very perfect kind, that the best examples of the whole of northern poetry are to be found. The last part, *Hattatal*, a treatise on metre, was written for Earl Skuli about 1222, in imitation of Earl Rognvald and Hall's *Hattalykill* (*Clavis metrica*), of 1150. The second part, *Skaldskapar-mal*, a gradus of synonyms and epithets, which contains over 240 quotations from 65 poets, and 10 anonymous lays,—a treasury of verse—was composed *c.* 1230. The first part, an exquisite sketch of northern mythology, *Gylfa-ginning*, was probably prefixed to the whole later.[2] There is some of Sturla's poetry in his *Islendinga Saga*, and verses of Snorri occur in the *Grammatical Treatise* on figures of speech, &c., of Olaf, which contains about one hundred and forty quotations from various authors, and was written about 1250.

Besides those sources, the *Kings' Lives* of Snorri and later authors contain a great deal of verse by Icelandic poets. King Harold Sigurdsson, who fell at Stamford Bridge 1066, was both a good critic and composed himself. Many tales are told of him and his poet visitors and henchmen. The Icelandic sagas also comprise much verse which is partly genuine, partly the work of the 12th and 13th century editors. Thus there are genuine pieces in *Nial's Saga* (chaps. 34, 78, 103, 126, 146), in *Eyrbyggia*, *Laxdæla*, *Egil's Saga* (part only), *Grettla* (two and a half stanzas, *cf. Landnamabok*), *Biorn's Saga*, *Gunnlaug's Saga*, *Havard's Saga*, *Kormak's Saga*, *Viga-Glum's Saga*, *Erik the Red's Saga*, and *Fostbrædra Saga*. In *Nial's*, *Gisli's*, and *Droplaug's Sons' Sagas* there is good verse of a later poet, and in many sagas worthless rubbish foisted in as ornamental wherever there was a chance of doing so.

To these may be added two or three works of a semi-literary kind, composed by learned men, not by heroes and warriors. Such are *Konunga-tal*, *Hugsvinnsmal* (a paraphrase of Cato's Distichs), *Merlin's Prophecy* (paraphrased from Geoffrey of Monmouth by Gunnlaug the monk), *Jomsviking -drapa* (by Bishop Ketil), and the *Islendinga-drapa*, which has preserved brief notices of several lost sagas concerning Icelandic worthies, with which *Gudmundar-drapa*, though of the 14th century, may be also placed.

Mediæval poetry.

Just as the change of law gave the death-blow to an already perishing commonwealth, so the rush of mediæval influence, which followed the union with Norway, merely completed a process which had been in force since the end of the 11th century, when it overthrew the old Icelandic poetry in favour of the Rimur.

The introduction of the *Danz*, ballads (or *fornkvædi*, as they are now called) for singing, with a burden, usually relating to a love-tale, which were immensely popular with the people and performed by whole companies at weddings, yule feasts, and the like, had relegated the regular Icelandic poetry to more serious events or to the more cultivated of the chiefs. But these "jigs," as the Elizabethans would have called them, dissatisfied the popular ear in one way: they were, like our own old ballads, which they closely resembled, in rhyme, but void of alliteration, and accordingly they were modified and replaced by the "Rimur," the staple literary product of the 15th century. These were rhymed but also alliterative, in regular form, with prologue or *mansong* (often the prettiest part of the whole), main portion telling the tale (mostly derived in early days from the French romances of the Carlovingian, Arthurian, or Alexandrian cycles, or from the mythic or skrök-sögur), and epilogue. Their chief value to us lies in their having preserved versions of several French poems now lost, and in their evidence as to the feelings and bent of Icelanders in the "Dark Age" of the island's history. The ring and melody which they all possess is their chief beauty.

Of the earliest, *Olafsrima*, by Einar Gilsson (*c.* 1350), and the best, the Aristophanic *Skida-rima* (*c.* 1430), by Einar Fostri, the names may be given. Rimur on sacred subjects was called "Diktur"; of these, on the legends of the saints' lives, many remain. The most notable of its class is the *Lilia* of Eystein Asgrimsson, a monk of Holyfell (*c.* 1350), a most "sweet sounding song." Later the poems of the famous John Arason, last Catholic bishop of Holar (*c.* 1530), *Liomr* ("Gleam") and *Píslargrátr* ("Passion-tears"), deserve mention.

Taste has sunk since the old days; but still this Rimur poetry is popular and genuine, and in such hard and evil days as came upon Iceland after the fall of the old houses had destroyed such traditional history and civilization as had fostered the saga, it is perhaps rather a wonder that the torch was still alight than that its glimmer was feeble and smoky. Moreover, the very prosaic and artificial verse of Sturla and the last of the old school certainly deserved the oblivion which came over them, as a casual perusal of the stanzas scattered through *Islendinga* will surely prove. It is interesting to notice that a certain number of *kenningar* (poetical paraphrases) have survived from the old school even to the present day, though the mass of them have happily perished. The change in the *phonesis*

[1] Many of these poems were Englished in prose by the translator of Mallet, by B. Thorpe in his *Sæmund's Edda*, and two or three by Messrs Morris and Magnussen, as appendices to their translation of *Volsunga Saga*. Earlier translations in verse are those in Dryden's *Miscellany* (vol. vi.), A. Cottle's *Edda*, Mathias's *Translations*, and W. Herbert's *Old Icelandic Poetry*. Gray's versions of *Darradar-liod* and *Vegtamskrida* are well known.

[2] This prose *Edda* (from which the *Eddic Lays* got their name) has been partly turned into English by Sir G. W. Dasent, by the translator of Mallet, and by Mr Anderson, and will be found treated of more at length under EDDA. Mallet's *Northern Mythology*, a book which first drew Englishmen's attention to the religious ideas of their forefathers, is not to be depended on in any way, belonging, as it does, to the pre-scientific age. Bunsen's speculations at a later date are entirely fanciful and visionary.

of the language is well illustrated by the new metres as compared with the old Icelandic *Drott-kvædi* in its varied forms. Most of the older Rimur and Diktur are as yet unprinted. Many of the *fornkvædi* are printed in a volume of the old *Nordiske Literatur-Samfund*.

for- tion riod.

The effects of the Reformation was deeply felt in Icelandic literature, both prose and verse. The name of Hallgrim Petersen, whose *Passion-hymns*, "the flower of all Icelandic poetry," have been the most popular composition in the language, is foremost of all writers since the Second Change of Faith. The gentle sweetness of thought, and the exquisite harmony of wording in his poems, more than justify the popular verdict. His *Hymns* were finished in 1660, and published in 1666, two great Protestant poets thus being contemporaries. A collection of Reformation hymns, adapted, many of them, from the German, the *Holar-book*, had preceded them in 1619. There was a good deal of verse-writing of a secular kind, far inferior in every way, during this period. In spite of the many physical distresses that weighed upon the island, ballads (*fornkvædi*) were still written, ceasing about 1750, Rimur composed, and more elaborate compositions published.

The most notable names are those of the improvisatore Stephen the Blind; Thorlak Gudbrandsson, author of *Ulfar-Rimur*, d. 1707; John Magnusson, who wrote *Hristafla*, a didactic poem; Stefan Olafsson, composer of Psalms, Rimur, &c., d. 1688; Gunnar Pálsson, the author of *Gunnarslag*, often printed with the Eddic poems, *c.* 1791; and the famous Eggert Olafsson, traveller, naturalist, and patriot, whose untimely death in 1768 was a great loss to his country, which his energy and talents might have roused from its torpor. His *Bunadar-balkr*, a Georgic written, like Tusser's *Points*, with a practical view of raising the state of agriculture, has always been much prized. Paul Widalin's ditties are very naive and clever.

dern etry.

The Reformation had produced a real poet, but the material rise of Iceland has not yet done so. Many have written, but few have shown any great talent; perhaps the best has been Sigurd of Broadfirth, many of whose prettiest poems were composed in Greenland, like those of Jon Biarnisson before him, *c.* 1750; John Thorlaksson's translation of Milton's great epic into Eddic verse is praiseworthy in intention, but, as may be imagined, falls far short of its aim. He also turned Pope's *Essay on Man* and Klopstock's *Messiah* into Icelandic. Benedikt Gröndal tried the same experiment with Homer in his *Ilion's Kvædi*, *c.* 1825. There is a fine prose translation of the *Odyssey* by Sweinbiorn Egillson, the lexicographer, both faithful and poetic in high degree. Many poems of varying but little merit will be found in the periodicals of this and last century, the serious verse being pseudo-classic for the most part and falsetto in tone. The satiric verse, such as John Thorlaksson's on Magnus Stephenson's projects and "reforms," and the ditties on all kinds of *sujets d'occasion*, are better, but much of their meaning is lost to a stranger. With the latest school of poets who have begun to imitate foreign metres (unalliterative) and to translate foreign poets, it is hardly worth while to linger. A translation of Shakespeare and of several of Byron's poems may be noticed as curiosities. Of minor poetry there is still an abundant crop; even in Gimli, the far-off Canadian colony, "In Memoriam" verses and wedding-hymns of irreproachable form, but wooden thought, are printed and admired. That Iceland, most idyllic of modern lands, is capable of supplying subject and material for something higher than all this there is no doubt; but, before anything of real worth can be written, the old stock-in-trade of worn-out mythology and pseudo-patriotism must be thrown aside for ever.

e saga.

History and Biography.—The real strength of Icelandic literature is shown in its most indigenous growth, the "Saga." This is, in its purest form, the life of a hero, composed in regular form, governed by fixed rules, and intended for oral recitation. It bears the strongest likeness to the epic in all save its unversified form; in both are found, as fixed essentials, simplicity of plot, chronological order of events, set phrases used even in describing the restless play of emotion or the changeful fortunes of a fight or a storm, while in both the absence of digression, comment, or intrusion of the narrator's person is invariably maintained. The saga grew up in the quieter days which followed the Change of Faith (1002), when the deeds of the great families' heroes were still cherished by their descendants, and the exploits of the great kings of Norway and Denmark handed down with reverence from the mouths of those that had fought and sung by their side. Telling of stories was a recognized form of entertainment at all feasts and gatherings, and it was the necessity of the reciter which gradually worked them into a regular form, by which the memory was relieved and the artistic features of the story allowed to be more carefully elaborated. That this form was so perfect must be attributed to Irish influence, without which indeed there would have been a saga, but not the same saga. It is to the west that the best sagas belong; it is to the west that nearly every classic writer whose name we know belongs; and it is precisely in the west that the admixture of Irish blood is greatest. In comparing the Irish tales with the saga, there will be felt deep divergencies in matter, style, and taste, the richness of one contrasting with the chastened simplicity of the other; the one's half-comic half-earnest bombast is wholly unlike the other's grim humour; the marvellous, so unearthly in the one, is almost credible in the other; but in both are the keen grasp of character, the biting phrase, the love of action, and the delight in blood which almost assumes the garb of a religious passion.

When the saga had been fixed by a generation or two of oral reciters, it was written down; and this stereotyped the form, so that afterwards when literary works were composed by learned men (such as Abbot Karl's *Swerri's Saga* and Sturla's *Islendinga*) the same style was adopted.

Icelandic sagas.

Taking first the sagas relating to Icelanders, of which some thirty-five or forty remain out of thrice that number, we find that they were first written down between 1140 and 1220, in the generation which succeeded Ari and felt the impulse his books had given to writing, on separate scrolls, no doubt mainly for the reciter's convenience; that they then went through all the different phases which such popular compositions have to pass in all lands,—editing and compounding (1220–1260), padding and amplifying (1260–1300), and finally collection in large MSS. (14th century). Sagas exist showing all these phases, some primitive and rough, some refined and beautified, some again diluted and weakened, according as their copyists have been faithful, artistic, or foolish; for the first generation of MSS. have all perished. We have also complex sagas put together in the 13th century out of the scrolls relating to a given locality, such a group as still exists untouched in *Vapnfirdinga* being fused into such a saga as *Niala* or *Laxdæla*. Of the authors nothing is known; we can only guess that some belong to the Sturlung school. According to subject they fall into two classes, those relating to the older generation before Christianity and those telling of St Olaf's contemporaries; only two fall into a third generation.

Of the west.

Beginning with the sagas of the west, most perfect in style and form, the earliest in subject is that of *Gold-Thori* (*c.* 930), whose adventurous career it relates; *Hen-Thori's Saga* tells of the burning of Blund-Ketil, a noble chief, an event which led to Thord Gelli's reforms next year (*c.* 964); *Gisli's Saga* (960–80) tells of the career and death of that ill-fated outlaw; it is beautifully written, and the verses by the editor (13th century) are good and appropriate; it has been Englished by Sir G. Dasent; *Hord's Saga* (980) is the life of a band of outlaws on Whalesfirth, and especially of their leader Hord. Of later subject are the sagas of *Havard* and his revenge for his son, murdered by a neighbouring chief (997–1002); of the *Heath Slaughter* (990–1014), a typical tale of a great blood feud, written in the most primitive prose; of *Gunnlaug and Hrafn* (980–1008), the rival poets and their ill-starred love. The verse in this saga is important and interesting. It has been Englished by Messrs Morris and Magnusson. To the west also belong the three great complex sagas *Egla*, *Eyrbyggia*, and *Laxdæla*. The first (870–980), after noticing the migration of the father and grandfather of the hero poet Egill, and the origin of the feud between them and the kings of Norway, treats fully of Egill's career, his enmity with Eirik Bloodaxe, his service with Æthelstan, and finally, after many adventures abroad, of his latter days in Iceland at Borg, illustrating very clearly what manner of men those great settlers and their descendants were, and the feelings of pride and freedom which led them to Iceland. The style is that of Snorri, who had himself dwelt at Borg, and Dr Vigfusson is inclined to refer it to him. *Eyrbyggia* (890–1031) is the saga of Politics, the most loosely woven of all the compound stories. It includes a mass of information on the law, religion, traditions, &c., of the heathen days in Iceland, and the lives of Eirik, the real discoverer of Greenland, Biorn of Broadwick, a famous chief, and Snorri, the greatest statesman of his day. Dr Vigfusson would ascribe its editing and completion to Sturla the Lawman, *c.* 1250. It is known to many Englishmen from Sir Walter Scott's paraphrase. *Laxdæla* (910–1026) is the saga of Romance. Its heroine Gudrun is the most famous of all Icelandic ladies. Her love for Kiartan the poet, and his career abroad, his betrayal by his friend Bolli, the sad death of Kiartan at his hands, the revenge taken for him on Bolli, whose slayers are themselves afterwards put to death, and the end of Gudrun, who becomes an anchorite after her stormy life, make up the pith of the story. The contrast of the characters, the rich style and fine dialogue which are so remarkable in this saga, have much in common with the best works of the Sturlung school. Mr Morris's *Lovers of Gudrun* is founded upon it.

Of the north.

Of the north there are the sagas of *Kormak* (930–60), most primitive of all, a tale of a wild poet's love and feuds, containing many notices of the heathen times; of *Waterdale* (890–980), relating to the settlement and the chief family in Waterdale; of *Hallfred* the Poet (996–1014), narrating his fortune at King Olaf's court, his love affairs in Iceland, and finally his death and burial at Iona; of *Reek-dale* (990), which preserves the lives of Askell and his son Viga-Skuti; of *Swarf-dale* (980–90), a cruel coarse story of the old days, with some good scenes in it, unfortunately imperfect, chapters 1–10 being forged; of *Viga-Glum* (970–90), a fine story of a heathen hero, brave, crafty, and cruel; it has been Englished by Sir Edmund Head. To the north also belong the sagas of *Gretti* the Strong (1010–31), the life and death of the most famous of Icelandic outlaws, the real story of whose career is mixed up with the mythical adventures of Beowulf, here put down to Gretti, and with late romantic episodes and fabulous folk-tales (Dr Vigfusson would ascribe the best parts of this saga to Sturla; its last editor, whose additions would be better away, must have touched it up about 1300; Messrs Morris and Magnusson have Englished it), and the stories of the *Lightwater Men* and *Liot O' Vall* (1009-60). Gudmund the Mighty and his family and neighbours are the heroes of these tales, which form a little cycle. The *Banda-manna Saga* (1050-60), the only comedy among the sagas, is also a northern tale; it relates the struggles of a plebeian who gets a chieftaincy against the old families of the neighbourhood, whom he successfully outwits; *Öl-kofra Thattr* is a later imitation of it in the same humorous strain. The sagas of the north are rougher and coarser than those of the west, but have a good deal of individual character.

Of the east.

Of tales relating to the east there survive the Weapon-firth cycle,—the tales of *Thorstein the White* (c. 900), of *Thorstein the Staffsmitten* (c. 985), Englished by Mr Morris, of *Gunnar Thidrand's Bane* (1000–1008), and of the *Weapon-firth Men* (975–990), all relating to the family of Hof and their friends and kin for several generations,—and the story of *Hrafnkell Frey's Priest* (c. 960), the most idyllic of sagas and best of the eastern tales. Of later times there are *Droplaug's Sons' Saga* (997-1007), written probably about 1110, and preserved in the uncouth broken style of the original (a brother's revenge for his brother's death is the substance of it; *Brand-krossa Thattr* is an appendix to it), and the tales of *Thorstein Hall of Side's Son* (c. 1014), and his brother *Thidrandi* (c. 996), which belong to the cycle of *Hall o' Side's Saga*, unhappily lost; they are weird tales of bloodshed and magic, with idyllic and pathetic episodes.

Of the south.

The sagas of the south are either lost or absorbed in that of *Nial* (970-1014), a long and complex story into which are woven the tales of *Gunnar, Nial*, and parts of others, as *Brian Boroimhe, Hall o' Side*, &c. It is, whether we look at style, contents, or legal and historical weight, the foremost of all sagas. It deals especially with law, the sole bond of a rough heathen community, and contains in itself, as it were, at once the pith and the moral of all early Icelandic history. Its hero Nial, type of the good lawyer, is contrasted with its villain Mord, the ensample of cunning, chicane, and legal wrong-doing; and a great part of the saga is taken up with the three cases and suits of the divorce, the death of Hoskuld, and the burning of Nial, which are given with great minuteness and care. The number and variety of its dramatis personæ give it the liveliest interest throughout. The women Hallgerda, Bergthora, and Ragnhild are as sharply contrasted as the men Gunnar, Skarphedin, Flosi, and Kari. The pathos of such tragedies as the death of Gunnar and Hoskuld and the burning is interrupted by the humour of the Al-thing scenes and the intellectual interest of the legal proceedings. The plot dealing first with the life and death of Gunnar, type of the chivalry of his day, then with the burning of Nial by Flosi, and how it came about, and lastly with Kari's revenge on the burners, is the ideal saga-plot, and affords ample room for the finest treatment of incident. The author must have been of the east, a good lawyer and genealogist, and have composed it about 1250, to judge from various internal evidence. It has been overworked by a later editor, c. 1300, who inserted many spurious verses. It has been translated by Sir G. Dasent.

Of Greenland and North America.

Relating partly to Iceland, but mostly to Greenland and Wineland (N. America), are the sagas of the *Floe-Men* (985-90), a good story of the adventures of Thorgils and of the struggles of shipwrecked colonists in Greenland, a graphic and terrible picture; and of *Eirik the Red* (990-1000), two versions, one northern (Flatey-book), one western, the better (in *Hawk's Book*, and AM. 557, translated by the Rev. J. Sephton), the story of the discovery of Greenland and Wineland (America) by the Icelanders at the end of the 9th century. Later are the story of *Thormod and Thorgeir, the Foster Brethren* (1015-30), a very interesting story, told in a quaint romantic style, of Thorgeir, the reckless henchman of King Olaf, and how his death was revenged in Greenland by his sworn brother the true-hearted Thormod Coalbrow's poet, who afterwards dies at Sticklestad. The tale of *Einar Sookisson* (c. 1125) may also be noticed. The lost saga of *Poet Helgi*, of which only fragments remain, was also laid in Greenland.

Besides complete sagas, such as have been noticed, there are embedded in the *Kings' Lives* numerous small *thættir* or episodes, small tales of Icelanders' adventures, often relating to poets and their lives at the kings' courts; one or two of these seem to be fragments of sagas now lost. Among the more notable are those of *Orm Storolfsson, Ogmund Dijtt. Halldor Snorrason, Thorstein Oxfoot, Hromund Halt, Thorwald Tasaldi, Svadi* and *Arnor Herlingar-nef, Audunn of Westfirth, Sneglu-Halli, Hrafn of Hrutfiord, Hreidar Heimski, Gisli Illugison, Ivar* the poet, *Gull-Æsu Thord, Einar Skulason* the poet, *Mani* the poet, &c.

The forged Icelandic sagas appear as early as the 13th century. They are very poor, and either worked up on hints given in genuine stories, or altogether apocryphal. Some of them have been composed within the present century.

Histo[ry]

About the year of the battle of Hastings was born one of the blood of Queen Aud, who founded the famous historical school of Iceland, and himself produced its greatest monument in a work which can only be compared for value with the English Domesday Book. Nearly all that we know of the heathen commonwealth may be traced to the collections of Ari. It was he too that fixed the style in which history should be composed in Iceland. It was he that secured and put into order the vast mass of fragmentary tradition that was already dying out in his day. And perhaps it is the highest praise of all to him that he wrote in his own "Danish tongue," and so ensured the use of that tongue by the learned and cultured of after generations, when, had he chosen to imitate the learned of other lands, not only would the freshness and life of the northern history as we have it have been crushed out, but the vernacular literature (heightened and purified by his influence as it has now been) would have sunk and disappeared. Ari's great works are *Konungabók*, or *The Book of Kings*, relating the history of the kings of Norway from the rise of the Yngling dynasty down to the death of Harald Sigurdsson in the year of his own birth. This book he composed from the dictation of old men such as Odd Kolsson, who had preserved traditions in their family and got information from contemporaries, from the genealogical poems, and from the various dirges, battle-songs, and eulogia of the poets. It is most probable that he also compiled shorter *Kings' Books* relating to Denmark and perhaps to England. The *Konungabók* is preserved under the *Kings' Lives* of Snorri, parts of it almost as they came from Ari's hands, for example, *Ynglinga* and *Harold Fairhair's Saga*, and the prefaces stating the plan and critical foundations of the work, parts of it only used as a framework for the magnificent superstructure of the lives of the two Olafs, and of Harald Hardrada and his nephew Magnus the Good. The best text of Ari's *Konungabók* (*Ynglinga*, and the sagas down to but not including Olaf Tryggvason's) is that of Frisbók.

Ari.

The *Book of Settlements* (*Landnamabók*) is a most wonderful performance, both in its scheme and carrying out. It is divided into five parts, the first of which contains a brief account of the discovery of the island; the other four, one by one taking a quarter of the land, describe the name, pedigree, and history of each settler in geographical order, notice the most important facts in the history of his descendants, the names of their homesteads, their courts and temples, thus including mention of 4000 persons, one-third of whom are women, and 2000 places. The mass of information contained in so small a space, the clearness and accuracy of the details, the immense amount of life which is somehow breathed into the whole, can hardly fail to astonish the reader, when he reflects that this colossal task was sketched out and accomplished by one man, for his collaborateur Kolskegg merely filled up his plan with regard to part of the east coast, a district with which Ari in his western home at Stad was little familiar. *Landnamabók* has reached us in two complete editions, one edited by Sturla, who brought down the genealogies to his own grandfather and grandmother, Sturla and Gudny, and one by Hawk, who traces the pedigrees still later to himself.

Ari also wrote a *Book of Icelanders* (*Islendingabók*, c. 1127), which has perished as a whole, but fragments of it are embedded in many sagas and *Kings' Lives*; it seems to have been a complete epitome of his earlier works, together with an account of the constitutional history, ecclesiastical and civil, of Iceland. An abridgment of the latter part of it, the little *Libellus Islandorum* (to which the title of the bigger *Liber—Islendingabók—*is often given), made by the historian for his friends Bishops Ketil and Thorlak, for whom he wrote the *Liber* (c. 1137). This charming little book is, with the much later collections of laws, our sole authority for the Icelandic constitution of the commonwealth, but, "much as it tells, the lost *Liber* would have been of still greater importance." *Kristni-Saga*, the story of the christening of Iceland, is also a work of Ari's, "overlaid" by a later editor no doubt, but often preserving Ari's very words. This saga, together with several scattered tales of early Christians in Iceland before the Change of Faith (1002), may have made up a section of the lost *Liber*. Of the author of these works little personal is known. He lived in quiet days a quiet life; but he shows himself in his works, as Snorri describes him, "a man wise, of good memory, and a speaker of the truth." Surely, if Thucydides is justly accounted the first political historian, Ari may be fitly styled the first of scientific historians.

Sæ[mund]

A famous contemporary and friend of Ari is Sæmund (1056–1133), a great scholar and churchman, whose learning so impressed his age that he got the reputation of a magician. He was the friend of Bishop John, the founder of the great Odd-Verjar family, and the author of a *Book of Kings* from Harald Fairhair to Magnus the Good, in which he seems to have fixed the exact chronology of each reign. It is most probable that he wrote in Latin. The idea that he had anything to do with the poetic *Edda* in general, or the *Sun's Song* in particular, is of course unfounded and modern.

The flame which Ari had kindled was fed by his successors in the 12th century. Eirik Oddsson (c. 1150) wrote the lives of Sigurd

Evil-deacon and the sons of Harold Gille, in his *Hryggiar-Stykki* (Sheldrake), of which parts remain in the MSS. collections of *Kings' Lives, Morkin-skinna*, &c. Karl Jonsson, abbot of Thingore the Benedictine minister, wrote (*c.* 1184) a *Life of Swerri* from the lips of that great king, a fine racy biography, with a style and spirit of its own. *Böglunga-Sögur* tell the story of the civil wars which followed Swerri's death. They are probably by a contemporary.

The Latin *Lives of St Olaf*, Odd's in Latin (*c.* 1175), compiled from original authorities, and the *Legendary Life*, by another monk whose name is lost, are of the mediæval Latin school of Sæmund to which Gunnlaug belonged.

Snorri was known to his contemporaries as a statesman and poet; to us he is above all an historian. His position as a poet and his authorship of the prose *Edda* have been noticed above. Snorri was born in 1178, being on his mother's side sprung from the Myra family of Borg; he was brought up in fosterage with Sæmund's great grandson Jon Loptsson, a great chief. His career begins with his marriage, 1199, which made him a wealthy man. In 1205 he moved from Borg to Reekholt. He was twice lawman, and twice visited Norway, where he gained great influence with the king; but when the civil war broke out he sided with Duke Skuli and disobeyed the king's orders, whereupon letters were sent out to his enemies to slay him (Skuli his patron having fallen), which command was carried out on the night of 22d Sept. 1241, his own friends and kinsmen being his murderers. Snorri wrote the *Lives of the Kings*, from Olaf Tryggvason to Sigurd the Crusader inclusive; and we have them substantially as they came from his hand in the *Great King Olaf's Saga*, which has been interpolated with thættir and bits of other sagas in such a way as that they can be easily omitted; *St Olaf's Saga*, as in *Heimskringla* and the Stockholm MS.; and the succeeding *Kings' Lives*, as in Hulda and Hrokkinskinna, in which, however, a few episodes have been inserted.

These works were no doubt indebted for their facts to Ari's labours, and to sagas written since Ari's death; but the style and treatment of them are Snorri's own. The fine Thucydidean speeches, the dramatic power of grasping character, and the pathos and poetry that run through the stories, along with a humour such as is shown in the *Edda*, and a varied grace of style that never flags or palls, make Snorri one of the greatest of historians.

Here it should be noticed that *Heimskringla* and its class of MSS. (*Eirspennit, Jofraskinna, Gullinskinna, Fris-bok*, and *Kringla*) do not give the full text of Snorri's works. They are abridgments made in Norway by Icelanders for their Norwegian patrons, the *Life of St Olaf* alone being preserved intact, for the great interest of the Norwegians lay in him, but all the other *Kings' Lives* being more or less cut down and mutilated, so that they cannot be trusted for historic purposes; nor do they give a fair idea of Snorri's style. As Englishmen's knowledge of these works is often derived from Mr Laing's translation of a Danish version of *Heimskringla* ("Sea-Kings of Norway"), this caution is needed.

Agrip is a 12th century compendium of the *Kings' Lives* from Harold Fairhair to Swerri, by a scholastic writer of the school of Sæmund. As the only Icelandic abridgment of Norwegian history taken not from Snorri but sources now lost, it is of worth. Its real title is *Konunga-tal*.

Noregs Konunga-tal, now called *Fagrskinna*, is a Norse compendium of the *Kings' Lives* from Halfdan the Black to Swerri's accession, probably written for King Hakon, to whom it was read on his death-bed. It is an original work, and contains much not found elsewhere. As non-Icelandic it is only noticed here for completeness.

Styrmi Karason, a contemporary of Snorri's, dying in 1245, was a distinguished churchman (lawman twice) and scholar. He wrote a *Life of St Olaf*, now lost; his authority is cited. He also copied out *Landnamabok* and *Swerri's Life*, from his MSS. of which our surviving copies were taken.

Sturla, Snorri's nephew, of whom more must be said below, wrote the *Lives of Kings Hakon and Magnus* at the request of the latter, finishing the first *c.* 1265, the latter *c.* 1280. *King Hakon's Life* is preserved in full; of the other only fragments remain. These are the last of the long and valuable series of historic works which Ari's labours began, from which the history of Norway for 500 years must be gathered.

A few books relating the history of other Scandinavian realms will complete this survey. In *Skioldunga-bok* was told the history of the early kings of Denmark, perhaps derived from Ari's collections, and running parallel to *Ynglinga*. The earlier part of it has perished save a fragment *Sogu-brot*, and citations and paraphrases in Saxo, and the mythical *Ragnar Lodbrok's* and *Gongu-Hrolf's Sagas*; the latter part, *Lives of Harold Blue-tooth and the Kings down to Sweyn II.*, is still in existence and known as *Skioldunga*.

The *Lives of St Knut and his Brethren* are of later origin and separate authorships, parallel to Snorri's *Lives of the great Norwegian Kings*, but earlier in date. The *Lives of King Waldimar and his Son*, written *c.* 1185, by a contemporary of Abbot Karl's, are the last of this series. The whole were edited and compiled into one book, often quoted as *Skioldunga*, by a 13th century editor, possibly Olaf, the White Poet, Sturla's brother, guest and friend of King Waldimar II., as Dr Vigfusson has guessed. *Jomsvikinga Saga*, the history of the pirates of Jom, down to Knut the Great's days, also relate to Danish history. Several versions of it exist.

The complex work now known as *Orkneyinga* is made up of the *Earls' Saga*, lives of the first great earls, Turf-Einar, Thorfinn, &c.; the *Life of St Magnus*, founded partly on Abbot Robert's Latin life of him, *c.* 1150, an Orkney work, partly on Norse or Icelandic biographies; a *Miracle-book* of the same saint; the *Lives of Earl Rognwald and Sweyn* the last of the vikings, and a few episodes such as the *Burning of Bishop Adam*. A scholastic sketch of the rise of the Scandinavian empire, the *Foundation of Norway*, dating *c.* 1120, is prefixed to the whole. The Flatey-book text of this work has been translated by Mr Hjaltalin in Mr Anderson's *Orkneyinga Saga*.

Færeyinga tells the tale of the conversion of the Færeys or Faroes, and the lives of its chiefs Sigmund and Leif, composed in the 13th century from their separate sagas by an Icelander of the Sturlung school.

Biographies.

The saga has already been shown in two forms, its original epic shape and its later development applied to the lives of Norwegian and Danish kings and earls, as heroic but deeper and broader subjects than before. In the 13th century it is put to a third use, to tell the plain story of men's lives for their contemporaries, after satisfying which demand it dies away for ever.

Lives of chiefs.

These biographies are more literary and mediæval and less poetic than the Icelandic sagas and king's lives; their simplicity, truth, realism, and purity of style are the same. They run in two parallel streams, some being concerned with chiefs and champions, some with bishops. The former, as more important, will be taken first. They are mostly found embedded in the complex mass of stories known as *Sturlunga*, from which Dr Vigfusson has extricated them, and for the first time set them in order. Among them are the sagas of *Thorgils and Haflidi* (1118–21), the feud and peacemaking of two great chiefs contemporaries of Ari; of *Sturla* (1150–83), the founder of the great Sturlung family, down to the settlement of his great lawsuit by Jon Loptsson, who thereupon took his son Snorri the historian to fosterage,—a humorous story but with traces of the decadence about it, and glimpses of the evil days that were to come; of the *Burning of Onund* (1185–1200), a tale of feud and fire-raising in the north of the island, the hero of which, Gudmund Dyri, goes at last into a cloister; of *Hrafn Sweinbiornsson* (1190–1213), the noblest Icelander of his day, warrior, leech, seaman, craftsman, poet, and chief, whose life at home, travels and pilgrimages abroad (Hrafn was one of the first to visit Becket's shrine), and death at the hands of a foe whom he had twice spared, are recounted by a loving friend in pious memory of his virtues, *c.* 1220; of *Aaron Hiorleifsson* (1200–55), a man whose strength, courage, and adventures befit rather a henchman of Olaf Tryggvason than one of King Hakon's thanes (the beginning of the feuds that rise round Bishop Gudmund are told here), of the *Swinefell-men* (1248–52), a pitiful story of a family feud in the far east of Iceland.

Sturla and his brother Thord.

But the most important works of this class are the *Islendinga Saga* and *Thorgils Saga* of Lawman Sturla. Sturla and his brother Olaf were the sons of Thord Sturlason and his mistress Thora. He was born and brought up in prosperous times, when all was fair for the Sturlungs, but his manhood was passed in the midst of strife and war, in which his family fell one by one, and he himself, though a peaceful man who cared little for politics, was more than once forced to fly for his life. While in refuge with King Magnus, in Norway, he wrote his two sagas of that king and his father. After his first stay in Norway he came back in 1271, with the new Norse law-book, and served a second time as lawman. The *Islendinga* must have been the work of his later years, composed at Fairey in Broadfirth, where he died, 30th July 1284, aged about seventy years. The saga of *Thorgils Skardi* (1252–61) seems to have been the first of his works on Icelandic contemporary history; it deals with the life of his own nephew, especially his career in Iceland from 1252 to 1258. The second part of *Islendinga* (1242–1262), which relates to the second part of the civil war, telling of the careers of Thord Kakali, Kolbein the Young, Earl Gizur, and Hrafn Oddsson. The end is imperfect, there being a blank of some years before the fragmentary ending to which an editor has affixed a notice of the author's death. The first part of *Islendinga* (1202–42) tells of the beginning and first part of the civil wars, the lives of Snorri and Sighvat, Sturla's uncles, of his cousin and namesake Sturla Sighvatsson, of Bishop Gudmund, and Thorwald Gizursson,—the fall of the Sturlungs, and with them the last hopes of the great houses to maintain the commonwealth, being the climax of the story.

Sturla's power lies in his faithfulness to nature, minute observance of detail, and purity of style. The great extent of his subject, and the difficulty of dealing with it in the saga form, are most skilfully overcome; nor does he allow prejudice or favour to stand in the way of the truth, a thing hard to avoid for one writing of contemporary events in which his own kinsmen have been concerned. He ranks below Ari in value and below Snorri in power; but no one else can dispute his place in the first rank of Icelandic writers.

Of the ecclesiastical biographers, an anonymous Skalholt clerk is

Bishops' lives. the best. He wrote *Hunger-waker*, lives of the first five bishops of Skalholt, and biographies of his patron *Bishop Paul*, and also of *St Thorlak*. They are full of interesting notices of social and church life. Thorlak was a learned man, and had studied at Paris and Lincoln, which he left in 1161. These lives cover the years 1056–1193. The *Life of St John*, a great reformer, a contemporary of Thorodd, whom he employed to build a church for him, is by another author (1052–1121). The *Life of Gudmund*, as priest, recounts the early life of this Icelandic Becket till his election as bishop (1160–1202); his after career must be sought out in *Islendinga*. It is written by a friend and contemporary. A later life by Arngrim, abbot of Thingore, written *c*. 1350, as evidence of his subject's sanctity, tells a good deal about Icelandic life, &c. The *Lives of Bishops Arni and Lawrence* bring down our knowledge of Icelandic history into the 14th century. The former work is unhappily imperfect; it is the record of the struggles of church and state over patronage rights and glebes, written *c*. 1315; it now covers only the years 1269–91; a great many documents are given in it, after the modern fashion. The latter, *Lawrence's Life*, by his disciple, priest Einar Haflidason, is a charming biography of a good and pious man, whose chequered career in Norway and Iceland is picturesquely told (1324–31). It is the last of the sagas. *Bishop Jon's Table-Talk* (1325–39) is also worth noticing; it contains many popular stories which the good bishop, who had studied at Bologna and Paris, was wont to tell to his friends.

Annals. The *Annals* are now almost the sole material for Icelandic history; they had begun earlier, but after 1331 they got fuller and richer, till they end in 1430. The best are *Annales Regii*, ending 1306, *Einar Haflidason's Annals*, known as "Lawman's Annals," reaching to 1392, and preserved with others in *Flatey-book*, and the *New Annals*, last of all. The *Icelandic Diplomatarium*, edited by Jon Sigurdsson, contains what remains of deeds, inventories, letters, &c., from the old days, completing our scanty material for this dark period of the island's history.

Literature of foreign origin. After the union and change of law genuine tradition died out with the great houses, and the kings' lives and biographies ceased to please. The ordinary mediæval literature reached Iceland through Norway, and every one began to take delight in it and put it into a vernacular dress, so neglecting their own classics that but for a few collectors like Lawman Hawk they would have perished entirely.

Romantic sagas. The Norwegian kings, Hakon Hakonson, *c*. 1225, and Hakon V., *c*. 1305, employed Icelanders at their courts in translating the French romances of the Alexander, Arthur, and Charlemagne cycles. Some forty or fifty of these *Riddara-Sögur* (Romances of Chivalry) still remain. They reached Iceland and were eagerly read, many Rimur being founded on them. Norse versions of *Mary of Brittany's Lays*, the stories of *Brutus* and of *Troy*, and part of the *Pharsalia* translated are also found. The *Speculum Regale*, with its interesting geographical and social information, is also Norse, written *c*. 1240, by a Halogalander.

Scientific works. The computistic and arithmetical treatises of Stiorn-Odd, Biarni the Number-skilled, d. 1173, and Hawk the Lawman, d. 1334, and the geography of Ivar Bardsson, a Norwegian, *c*. 1340, are of course of foreign origin. A few tracts on geography, &c., in Hawk's book, and a *Guide to the Holy Land*, by Nicholas, abbot of Thwera, d. 1158, complete the list of scientific works.

Mythical sagas. The stories which contain the last lees of the old mythology and pre-history seem to be also non-Icelandic, but stuffed out and amplified by Icelandic editors, who probably got the plots from the Western Islands. *Wolsunga Saga* and *Hervarar Saga* contain quotations and paraphrases of lays by the Helgi poet, and *Half's*, *Ragnar's*, and *Asmund Kappabana's Sagas* all have bits of Western poetry in them. *Hrolf Kraki's Saga* paraphrases part of *Biarkamal; Hromund Gripsson's* gives the story of Helgi and Kara (the lost third of the Helgi trilogy); *Gautrek's*, *Arrow-Odd's*, *Frithiof's Sagas*, &c., contain shreds of true tradition amidst a mass of later fictitious matter of no worth. With the *Riddara-Sögur* they enjoyed great popularity in the 15th century, and gave matter for many Rimur. *Thidrek's Saga*, a late version of the Wolsung story, is of Norse composition, *c*. 1230, from North German sources.

Religious works. The mediæval religious literature of Western Europe also reached and influenced Iceland, and the *Homilies* (like the *Laws*) were, according to Thorodd, the earliest books written in the vernacular, antedating even Ari's histories. The lives of the *Virgin*, the *Apostles*, and the *Saints* fill many MSS. (edited in four large volumes by Professor Unger), and are the works of many authors, chiefly of the 13th and 14th centuries (of course they were known in Latin long before); amongst them are the lives of *SS. Edward the Confessor*, *Oswald of Northumbria*, *Dunstan*, and *Thomas of Canterbury*. Of the authors we know Priest Berg Gunsteinsson, d. 1211; Kygri-Biorn, bishop-elect, d. 1237; Bishop Brand, d. 1264; Abbot Runolf, d. 1307; Bishop Lawrence's son Arni, *c*. 1330; Abbot Berg, *c*. 1340, &c. A paraphrase of the historical books of the Bible was made by Bishop Brand, d. 1264, called *Gydinga Sögur*. About 1310 King Hakon V. ordered a commentary on the Bible to be made, which was completed down to Exodus xix. To this Brand's work was afterwards affixed, and the whole is known as *Stiorn*. The Norse version of the famous *Barlaam and Josaphat*, made for Prince Hakon, *c*. 1240, must not be forgotten.

Post-clas[sical] liter[a]ture. Re[ligious] wor[ks]. The post-classical literature falls chiefly under three heads,—religious, literary, and scientific. Under the first comes foremost the noble translation of the New Testament by Odd Gottskalksson, son of the bishop of Holar. Brought up in Norway, he travelled in Denmark and Germany, and took upon him the new faith before he returned to Iceland, where he became secretary to Bishop Ogmund of Skalholt. Here he began by translating the Gospel of Matthew into his mother-tongue in secret. Having finished the remainder of the New Testament at his own house at Olves, he took it to Denmark, where it was printed at Roskild in 1540. Odd afterwards translated the Psalms, and several devotional works of the day, Corvinus's *Epistles*, &c. He was made lawman of the north and west, and died from a fall in the Laxa in Kios, June 1556. Three years after his death the first press was set up in Iceland by John Matthewson, at Breidabolstad, in Hunafloe, and a *Gospel and Epistle Book*, according to Odd's version, issued from it in 1562. In 1584 Bishop Gudbrand, who had brought over a splendid fount of type from Denmark in 1575 (which he completed with his own hands), printed a translation of the whole Bible at Holar, incorporating Odd's versions and some books (Proverbs and the Son of Sirach, 1580) translated by Bishop Gizar, but supplying most of the Old Testament himself. This fine volume has been the basis of every Bible issued for Iceland till 1826, when it was replaced by a bad modern version. For beauty of language and faithful simplicity of style the finer parts of this version, especially the New Testament, have never been surpassed in any tongue; they stand worthily beside the work of Tyndale, Luther, and Ulfila, foremost monuments of the Teutonic tongues.

The most notable theological work Iceland ever produced is the *Postill-Book* of Bishop John Widalin (1666–1720), whose bold homely style and stirring eloquence made "John's Book," as it is lovingly called, a favourite in every household, till in the present century it has been replaced for the worse by the more sentimental and polished Danish tracts and sermons. Theological literature is very popular, and many works on this subject, chiefly translations, will be found in the lists of Icelandic bibliographers.

Lite[rary] wor[ks]. The Renaissance of Iceland dates from the beginning of the 17th century, when a school of antiquarians arose and betook themselves to the task of reconstructing their country's history from the remains their pious care gathered and preserved. Arngrim Jonsson's *Brevis Commentarius*, 1593, and *Crymogæa*, 1609, were the first-fruits of this movement, of which Bishops Odd, Thorlak, and Bryniulf (worthy parallels to Parker and Laud) were the wise and earnest supporters. The first (d. 1630) collected much material for church history. The second (d. 1656) saved *Sturlunga* and the *Bishops' Lives*, encouraged John Egilsson to write his *New Hunger-waker*, lives of the bishops of the Dark Ages and Reformation, and helped Biorn of Skardsa (d. 1655), a bold and patriotic antiquary (whose *Annals* continue Einar's), in his researches. The last (d. 1675) collected a fine library of MSS., and employed the famous copyist John Erlendsson, to whom and the bishop's brother, John Gizurarsson (d. 1648), we are much beholden for transcripts of many lost MSS.

Torfæus (1636–1719) and Bartholin, a Dane (d. 1690), roused the taste for northern literature in Europe, a taste which has never since flagged; and soon after them Arni Magnusson transferred all that remained of vellum and good paper MSS. in Iceland to Denmark, and laid the foundations of the famous library and bequest, for which all Icelandic students are so much beholden. For over forty years Arni stuck to his task, rescuing every scrap he could lay hands on from the risks of the Icelandic climate and carelessness, and when he died in 1730, aged fifty-seven, only one good MSS. remained in the island. Besides his magnificent collection, there are a few MSS. of great value at Upsala, at Stockholm, and in the old royal collection at Copenhagen. Those in the university library in the latter city perished in the fire of 1728. Sagas were printed at Upsala and Copenhagen in the 17th century, and the Arna-Magnæan fund has been working since 1772. In that year appeared also the first volume of Bishop Finn Johnsson's *Historia Ecclesiastica Islandiæ*, a work of high value and much erudition, containing not only ecclesiastical but civil and literary history, illustrated by a well-chosen mass of documents, 870–1740. It has been continued by Bishop P. Peterson to modern times, 1740–1840. The results, however, of modern observers and scholars must be sought for in the periodicals, *Safn*, *Felagsrit*, *Ny Felagsrit*, and others. John Espolin's *Arbækr* is very good up to its date, 1821.

By far the best history of Icelandic classic literature is the brilliant sketch by Dr Vigfusson, Prolegomena to *Sturlunga Saga*, Oxford, 1879, to which we must here acknowledge our obligations. It replaces much earlier work, especially the *Sciagraphia* of Halfdan Einarson, 1777, and the *Saga-Bibliotek* of Müller. The numerous editions of the classics by the Icelandic societies, the Danish Société des Antiquités, Nordiske Literatur Samfund, and the new Gammel Nordisk Literatur Samfund, the splendid Norwegian editions of Unger, the labours of the Icelanders Sigurdsson and

Gislason, and of those foreign scholars in Scandinavia and Germany who have thrown themselves so heartily into the work of illustrating, publishing, and editing the sagas and poems (men like Munch, Bugge, Bergmann, Möbius, and Maurer, to name only a few), can only be referred to here.

The first modern scientific work is the *Iter per patriam* of Eggert Olafsson and Biarni Paulsson, which gives a careful and correct account of the physical peculiarities—fauna, flora, &c.—of the island as far as could be done at the date of its appearance, 1772. The island was first made known to "the world" by this book and by the sketch of Unno von Troil, a Swede, who accompanied Sir Joseph Banks to Iceland in 1772, and afterwards wrote a series of "letters" on the land and its literature, &c. This tour was the forerunner of an endless series of "travels," of which those of Hooker (1809), Mackenzie (1810), Henderson (1818), Gaimard (1838-43), Paijkull (1867), and, lastly, that of Captain Burton, an excellent account of the land and people, crammed with information of every kind (1875), are the best.

The maps by Olson and his colleagues, by Gunnlaugson, and by the French Admiralty are good. Kalund's work on the historical geography of the island is valuable and interesting. *Safn* and other periodicals above mentioned contain many able papers on scientific and sociological matters. Iceland is an interesting field for the pathologist and physician, and numerous medical treatises, Icelandic and foreign, have attacked it. Dr Hjaltalin, the present medical director, is perhaps the best modern authority.

The cathedral high school merged into a college in 1801, which was fixed at Bessastad during its palmiest days (1805-46), and is now at Reykjavik. Among its lists of masters several distinguished names figure, for example, Sweinbiorn Egilsson, whose Homeric translations were issued as college "programs." A law school has been recently formed at Reykjavik and a technical school at Mödruvellir. The museum and library, both at Reykjavik, still in the rudimentary state, are to be newly housed and extended.

Iceland is emphatically a land of proverbs, which occur on almost every page of the dictionary, while of folk-tales, those other keys to the people's heart, there is plentiful store. Early work in this direction was done by Jon Gudmundsson, Olaf the Old, and John Olafsson in the 17th century, who all put traditions on paper, and their labours have been completed by the magnificent collection of Jon Arnason (1862-64), who, inspired by the example of the Grimms, spent great toil on his self-imposed task. Many tales are but weak echoes of the sagas; many were family legends, many the old fairy tales we all know so well, dressed in a fresh garb suited to their new northern home; but, besides all these, there are a number of traditions and superstitions not found elsewhere, the mass of which is of indigenous growth and origin. Some of Arnason's collections have been put into English by Messrs J. G. G. Powell and E. Magnusson, and Sir G. Dasent.

A few translations of popular and famous books, such as the *Arabian Nights*, one or two classics, and a tale, *Piltr og Stulka* ("Lad and Lass"), 1850, complete the notabilities of Icelandic bibliography. Mr Lidderdale has prepared a list of Icelandic-printed books, which it is hoped may be published; the excellent *Catalogus* of Möbius is of use for dates, &c., of editions.

Unlike England and France, Iceland has had but one golden age of literature upon which all her fame must rest. Of its creations it has been truly said that they fill a place none others could take in the high ranks of Aryan classics. The noblest of them are distinguished by pure and strict form, noble heroic subject, and simple truthful self-control of style and treatment, free alike from overwrought sentiment or extravagant passion, and raised equally above euphemism and commonplace, but ever inspired by a weird Æschylean power, grim and tender, and splendid as that which breathes through those historical books of the Old Testament, to which alone should the masterpieces of Iceland's greatest writers be compared.

Language.

The relations of Icelandic to the other Teutonic tongues may be best shown by a chronological treatment. It presents the following anomalies:—on the one hand, it has a highly inflexional grammar, a pure vocabulary, and a simple syntax, points which would place it side by side with Gothic; but, on the other hand, it shows such strong marks of contraction and such deep phonetic changes, especially in the vowels, as can only be paralleled in the modern English. It is further noteworthy for its unity or lack of dialectic variation, and possesses exceptional advantages for the philologist in the complete series of documents dating from the 11th century downwards in which its history may be most accurately and minutely studied.

There is little doubt but that the Teutonic tribes of the 4th century all spoke one language, that, in fact, of which the remains of Ulfila (which may be supplemented by a few inscriptions, such as those of the Golden Horn and the earliest Danish rune-stones, and a few stray words preserved in classic authors) afford us such a noble specimen. The first differentiation occurred when the English colony separated in the 5th century from the parent stock, and, following its own course of development, already by the time of Bede presented many new and peculiar characteristics in form and vocabulary. With the changes which produced the High German dialects it does not behove us to deal here, so we may pass on to the Viking Tide (775-925), the results of which were felt over a wide area, and are evidenced by the changes which gave to the tongue of those tribes that took part in it a distinctly Scandinavian character.

Just as the earlier movement left its mark in Old English, so this one is clearly seen in the speech of the Scandinavian colonies of the West, especially in Icelandic, but it is still well marked in the Eastern Scandinavian dialects—Swedish, Danish, &c., as the following points common to all east and west, and marking them off clearly from all other Teutonic tongues, will show:—strong stem-contraction reducing all words as far as possible to a trochaic form; *i-umlaut* carried out very fully and consistently; the suffixing of the article; and a peculiar vocabulary which has chosen out of the common Teutonic stock certain words for daily use, rejecting others which are common to all the other sister tongues—*e.g.*, *eld* for *fire*, *ekkia* for *widow*, *gamol* for *old*, *eigi* for *not*, *ok* for *and*, *göra* for *do*, *taka* for *niman*, &c. The later Danish rune-stones and those of Sweden, published by Wimmer, Säve, Dybeck, &c., will be the best documents for this stage of the Scandinavian tongue.

We may now leave the Eastern Scandinavian dialects to follow their own course, which has led them through a path not entirely dissimilar to that which English has taken, and confine ourselves to the Western Colonial dialects. Those in their earliest monuments, the rune-stones of Man, the coins of the "Danish" kings and earls in Ireland and England, the lays of the Western poets in the *Edda* collection, and the earliest poetry of such Icelandic bards as Egill and Kormak, exhibit certain idiosyncrasies which show them to have already started on their own career. Such are the *u-umlaut*, the loss of *w* before *r* and *l*, the simplification of the vowel system (all aggravations, as it were, of the Scandinavian peculiarities noticed above, while their vocabulary is, as one would expect, affected by the introduction of many English, Gaelic, and Latin words, especially those relating to ideas unknown in earlier heathen days, ecclesiastical terms, &c.). Of these western colonies we are only concerned with the most important, Iceland; the Orkneys and Hebrides have no linguistic monuments later than the Edda lays of the 10th and 11th, and epigonic poetry and rhymed gradus-jingles of the 12th century; the influence of the Danes on our dialects and book-English must be left to English philologists; while in Ireland only a few personal and local names now betray to the ear the former presence of the Ostman.

The fact that one of the first Icelandic writers, *c.* 1120, Ari's contemporary, Thorodd, is a grammarian, and one of no mean power, is our greatest help towards ascertaining the phonesis of the tongue during the heroic age; and his evidence is supplemented by the Icelandic poets, whose strict adherence to metres, which depend for their effect on a delicate harmony of sound and a rigid observance of quantity, is absolutely to be trusted. Thorodd's scheme for the proper phonetic representation of Icelandic (which the English student may contrast with that of Orm, our first spelling reformer) is briefly as follows. The letters *b,c,d,f,g,l,m,n,p,r,s,t*, are used in their ordinary classic values (*c* always hard), the capitals B,K,D,F, G,L,M,N,P,R,S,T, being employed for the doubled letters *bb*, &c. (each consonant of these doubles was of course separately and distinctly pronounced as in Italian now, and, as Mr A. J. Ellis has proved, in Latin formerly); þ is used as in Old English for *th*; *h* for the aspirate pure or combined *hl, hn*, &c.; both these are of unvarying form; *x* for *cs, gs*, and ŋ for *ng* can only be found in medial and final positions. Thus we get twenty-eight consonants. The vowels, *a,e,i,o,u,y,æ,œ* long and short, have their ordinary values [pal. a,e,i,o,u,I,E,əi and aa, ee, &c.], and to them Thorodd has added *ao* [æ] long and short. All these vowels may also be nasalized, *ã,ẽ*, &c., making twenty-seven in all; *i* and *u*, whether consonantal or vocal, do not vary in form. The following points characterize the tongue at this period:—adherence to *o* in the terminations, right employment of the subjunctive, which has since gone completely out of use, retention of *s* in inflexion and the substantive verb. Quantity was strictly observed in speaking, and also accent, and no doubt people, as in Old England, spoke much more clearly, slowly, and energetically than they do now. The introduction of quantitative metres measured by syllables is no doubt to be ascribed to Celtic influence, as are the line-rhymes and assonances and rhyme-endings, which, as any reader of Snorri's *Hatta-tal* or Earl Rognwald's *Hatta-lykill* will see at the first glance, completely separated Icelandic poetry from the original Teutonic metric of the Continental rune-stones, of Beowulf, and of Havamal.

Thorodd's scheme was unfortunately never used in its strict completeness, but it is partly employed in the following MSS., which are of the highest authority for this era of the Icelandic:—*Elucidarius*, *c.* 1130, ed. *facsimile*; *Libellus*, *c.* 1150, ed. Möbius; the *Law Scroll-fragments* affixed by W. Finsen to the end of his ed. of *Cod. Regius Grágás*; the *Stockholm Homilies*, *c.* 1145, ed. Wisen; *Physiologus*, AM. 673, ed. *facsimile*; *Agrip*, *c.* 1185, ed.

Dahlerup. For others see Table II. Prolegomena to *Sturlunga Saga*, Oxford, 1879.

13th century changes.

The first era of change, ascribed by Dr Vigfusson to about the lifetime of Snorri, is the mark left by the civil wars and the connexion with Norway (our 14th century Wars of the Roses transition is in many respects its parallel). It is seen in the normal spelling of the editions of the sagas, &c., and is best exemplified by the famous AM. 132, *c.* 1300, and the *Annales Regii*, 1290–1306 (accurately printed in pp. 348-91, vol. ii., *Sturlunga Saga*, Oxford, 1879),—the loss of the *s* replaced by *r*, the vanishing of the *u-umlauted á*, the confusion of *œ* and *æ*, *æ* and *e*, *ao* and *eo* (the latter of each couple prevailing), the hardening of the dental finals and the blurring of *st*, *sk*, &c. into *z*. This stage of spelling and pronunciation is that which should be adhered to in all works which must be printed in an uniform way, dictionaries, grammars, classic editions, &c. The student may be cautioned not to take the vagaries of Norse scribes, or Noricized Icelanders (such as Hawk) for important phonetic variations.

16th century changes.

The second era of change is that which accompanied the Reformation, and witnesses to the mental and physical stir produced by that movement. It is only heard in the spoken tongue (for all books, save a few printed during the last few years, follow the normal type of the 14th and 15th century MSS. with few variations), but it is none the less deep and important. Its leading features are the loss of quantity and intonation, the confusion of the vowels *y* and *u*, *æ* and *ai*, *ey* and *au*, *au* and *á*, *ei i í* and *ey y ý* (the latter taking the sound of the former in each case), the diphthongization of the long vowels *ī*, *ē*, *ō*, *ū*,—all changes which from their symmetry must have taken place at one date,—the differentiation of doubled and touching consonants, *ll*, *nn*, *gn*, &c., and of final *r*. The vocabulary, which during the connexion with Norway and England through the "Dark Age" had been enriched with many French and English words, now received an important augmentation in a new religious terminology from Germany, while the intercourse with Denmark began to leave its mark in loan-words and Danicisms, the stock of which tended greatly to increase, till a reaction arose in the present century, which, though excusable, has been carried to laughable lengths. The metre of Icelandic poetry had begun to show signs of mediæval influence (of French origin) even before the death of Snorri, as a ditty in *Sturlunga* shows. During the Dark Age the Rimur metric system, depending largely on time-ending and burden for new effects though still retaining line rhyme and alliteration (the latter being absolutely essential), revolutionized poetry, and later the hymns of the Reformation, shaking themselves free from the somewhat monotonous beat of the Rimur, contain examples of many new and ingenious metres.

Absence of dialects.

The absence of dialects in Iceland results from the essential unity of life in that island, and the lack of any of the conditions which during the Middle Ages produced dialects in England, Germany, and France, such as town-life with its guilds and varied interests, the great corporations, ecclesiastical, legal, and medical, which by their necessary use of Latin cut off the most highly educated classes from exercising any influence on the vernacular, and the caste influences of chivalry, &c., which sometimes, as in England, allowed the upper classes to use a separate foreign language. In early times before the Danish conquest there were no dialects, because, life being single, king and serf, soldier and peasant, merchant and priest must live and speak alike. So we see in our own days the newspaper, the state school, the railway, the conscription, and the theatre, all tending to bring about in each great European state a sameness of life, thought, and speech through every nook and corner of its area.

The general characteristics of the Icelandic tongue are those of a spoken speech, *par excellence*,—a pure and correct vocabulary well suited to the every-day needs of a pastoral life, a pithy and homely vigour of idiom (this shows especially in the saws and proverbs which often recall those of Spain), a delicacy and regularity of syntax, which can express much with few and simple means, and an accuracy of terminology well becoming a legal-minded people. All these salient characters strike every observer, but the full beauty and power of the tongue as a vehicle of the highest expression can only be tested by a careful study of the masterpieces written in it. No one that has not read the finest chapters of *Niala* or *Olaf Tryggvasson's Life*, the *Tales* of Snorri, or a *Gospel* in Odd's translation, not to speak of other works almost equally worthy of mention, can judge fairly of the capacity, force, and sweetness of this most classic language.

Phil logic worl

A few words are due to those whose labours have rendered the task of mastering it easy and pleasant. The oldest philologist, Thorodd, has been noticed; an anonymous grammarian of the next generation, *c.* 1175, attempted a classification of letters and sounds; Sturla's brother Olaf, the White Poet, applied the figures, &c., of Donatus and Priscian to Icelandic, in which task he was followed by a continuator. All these treatises were published along with the *Thulur*, rhymed glossaries (compiled in the Western Islands, probably in the Orkneys), in vol. ii. of the AM. edition of the *Edda*, to a MS. of which they are found affixed, Copenhagen, 1832.

Of modern works, those of Rask, the founder of modern Icelandic philology, Egillson, the learned author of the *Poetic Lexicon*, otherwise well known by his translation of Homer, and Fritzner, the first real Icelandic lexicographer, deserve reverent mention. But for all practical purposes their labours have been superseded and their designs fulfilled by Dr Gudbrand Vigfusson, whose *Icelandic-English Dictionary*, Oxford, 1869–75, must, whether one looks to its scientific philology, completeness, accuracy, or arrangement, be pronounced the best existing dictionary of any Teutonic tongue. It comprises a grammar and phonology, &c. The university of Oxford has recently published, under the editorship of Messrs Vigfusson and Powell, a very complete *Icelandic Prose Reader*. In the scattered opuscula of Dr Bugge, as well as in his notes to the poetic *Edda*, are to be found many interesting "equations" and observations on the language and comparative mythology of Scandinavia.

To English philologists the study of Icelandic is of high importance, as bearing upon the grammar and vocabulary of our most important dialect, the Northumbrian, to a scientific knowledge of which it is absolutely necessary. A list of words occurring in every-day English which we owe to the Scandinavian settlers of the Danelaw will be found in the Oxford *Icelandic Reader*. To Irish scholars the old northern tongue is also of interest, as not only did those who spoke it borrow much from their Celtic friends and foes, but there was also a certain amount of reflex action which it would be desirable to fully trace out. As the most regular and pure of the Teutonic dialects, its value to the comparative philologist is sufficiently obvious. (F. Y. P.)

ICELAND MOSS, a lichen, *Cetraria islandica* (Achar.), whose erect or ascending foliaceous habit gives it something of the appearance of a moss, whence probably the name. The thallus has a pale chestnut colour, and grows to a height of from 3 to 4 inches, the branches being channelled or rolled into tubes, which terminate in flattened lobes with fringed edges. It grows abundantly in the mountainous regions of northern countries, and specially it is characteristic of the lava slopes and plains of the west and north of Iceland. As met with in commerce it is a light-grey harsh cartilaginous body, almost destitute of odour, and having a slightly bitter taste. It contains about 70 per cent. of lichenin or lichen-starch, a body isomeric with common starch, but wanting any appearance of structure. It also yields a peculiar modification of chlorophyll, called thallochlor, fumaric acid, licheno-stearic acid, and cetraric acid, to which last it owes its bitter taste. In medicine it is used as a mild tonic, and at the same time it forms a nutritious and easily digested amylaceous food, being used in place of starch in some preparations of cocoa. It is not, however, in great request, and even in Iceland it is only habitually resorted to in seasons of scarcity.

I-CHANG, or Y-CHANG, also called Y-LIN in some maps, a town of China, in the province of Hoo-pih, one of the four new ports opened to foreign trade by treaty in 1877. It is situated in 30° 42′ N. lat. and (approximately) 111° 20′ E. long,—363 geographical miles up the Yang-tze-Keang from Hankow. Built on the left bank of the river just where it escapes from the ravines and gorges which for 350 miles have imprisoned its channel, I-chang is exposed to considerable risk of floods; in 1870 the waters rose as much as 20 feet in one day, and the town had many of its houses and about half of its wall swept away. The first English vessels to make the ascent of the river as far as I-chang were those of Admiral Sir James Hope's expedition in 1861. In 1878 the port was visited by 16 Chinese steamers with a burden of 5440 tons, and the net value of the trade was 71,014 Hk. taels (of about 6s.); in the following year the net value had increased to 612,508 Hk. taels. Trepang was one of the principal articles. The

Chinese population is estimated at 33,560 (*Deutsches Handels Archiv*, 1880); and in 1878 there were fifteen foreign residents.

See *Journ. of R. Geogr. Soc.*, 1862; and Blakiston, *Five Months on the Yang-tze-Keang*, 1862.

ICHNEUMON (*Herpestes*), a genus of small carnivorous mammals belonging to the family *Viverridæ*, and resembling the true civets in the elongated weasel-like form of the body and in the shortness of the limbs. There are, according to Gray (*British Museum Catalogue*, 1869), 22 species of ichneumons, the great majority of which are confined to the African continent, the remainder occurring in Persia, India, and the Malay archipelago, and one, the Andalusian ichneumon (*H. Widdringtonii*, Gray), in the Sierra Morena of Spain, the last probably an African straggler. The Egyptian and Indian ichneumons are the forms best known. The former (*Herpestes ichneumon*, L.) is an inhabitant of Egypt and the north of Africa, where it is known to foreign residents as "Pharaoh's rat." When full grown it is about the size of the domestic cat. It is covered with a fur of long harsh hairs of a tawny grey colour, darker on the head and along the middle of the back, its legs reddish and its feet and tail black. It feeds on rats and mice, birds and reptiles, and for this reason is occasionally domesticated. Its fondness for eggs leads it to search for those of the crocodile, buried as these usually are beneath a thin covering of sand on the river banks; and its services in thus checking the multiplication of those reptiles were so appreciated by the ancient Egyptians that they regarded the ichneumon as a sacred animal, and when it died buried it, says Herodotus, "in holy repositories." It is, however, equally fond of poultry and their eggs, and its depredations among fowls considerably detract from its undoubted merits as a vermin-killer. During the inundations of the Nile it is said to approach the habitations of man, but at other seasons it keeps to the fields and to the banks of the crocodile-frequented river. The Indian ichneumon or mungoos (*Herpestes griseus*, Desm.) is considerably smaller than the Egyptian form; its fur is of a pale grey colour, the hairs being largely white-ringed, while the cheeks and throat are more or less reddish. Like the preceding species, it is frequently domesticated, and is then put to a similar use. It is especially serviceable in India as a serpent killer, destroying not only the eggs and young of these creatures, but attacking without hesitation and killing the most venomous adult snakes. The fact that it invariably survives those encounters has led to the belief that it either enjoys immunity from the effects of snake poison, or that after being bitten it has recourse, as the Hindoos have always maintained, to the root of a plant as an antidote. Neither of these suppositions has stood the test of scientific examination, for it has been found that when actually bitten it falls a victim to the poison as rapidly as other mammals, while there is no trustworthy evidence of its seeking a vegetable antidote. The truth seems to be that the mungoos by its exceeding agility and quickness of eye avoids the fangs of the snake while fixing its own teeth in the back of the reptile's neck. The whole Thanatophidia of India stand in awe of this tiny but tenacious mammal, and seek to escape from its presence. The mungoos, on the other hand, never hesitates to attack; the moment he sees his enemy, "his whole nature," says a recent spectator of one of those fights, "appears to be changed. His fur stands on end, and he presents the incarnation of intense rage. The snake invariably attempts to escape, but, finding it impossible to evade the rapid onslaught of the mungoos, he raises his crest and lashes out fiercely at his little persecutor, who seems to delight in dodging out of the way just in time. This goes on until the mungoos sees his opportunity, when like lightning he rushes in and seizes the snake with his teeth by the back of the neck close to the head, shaking him as a terrier does a rat. These tactics are repeated until the snake is killed." The mungoos is equally dexterous in killing rats and other four-footed vermin.

Egyptian Ichneumon.

ICHNEUMON-FLY is a general name applied to parasitic insects of the section *Pupivora* (or *Entomophaga*), order *Hymenoptera*, from the typical genus *Ichneumon*, belonging to the chief family of that section,—itself fancifully so called after the Egyptian mammal (*Herpestes*), notorious for its habit of destroying the eggs of reptiles. The species of the families *Ichneumonidæ*, *Braconidæ*, *Evaniidæ*, *Proctotrypidæ*, and *Chalcididæ* are often indiscriminately called "Ichneumons," but the term is perhaps properly applicable only to the first and second of these, which are respectively equivalent to the *Ichneumones genuini* and *I. adsciti* of older naturalists, chiefly differing in the former having two recurrent nerves to the anterior wing, whilst the latter has only one such nerve. The *Ichneumonidæ* proper are one of the most extensive groups of insects, and have been much studied by entomologists since the time of Linnæus and Gravenhorst. Their sexual differences of colour, &c., are, however, often so great that fresh discoveries are constantly being made with regard to their true specific relations, as well as new species detected by biological observers. Gravenhorst described some 1650 European species, to which considerable subsequent additions have been made; and at the latest computation of the English *Ichneumonidæ* (in 1872, by the Rev. T. A. Marshall), 1186 species, contained in 136 genera, were recognized,—439 *Braconidæ* being also enumerated. There are 6 subfamilies of the *Ichneumonidæ*, viz., the *Ichneumonides*, *Cryptides*, *Agriotypides*, *Ophionides*, *Tryphonides*, and *Pimplides*, differing considerably in size and facies, but united in the common attribute of being in their earlier stage parasitic upon other insects. They have all long narrow bodies; a small free head with long filiform or setaceous antennæ, which are never elbowed, and have always more than sixteen joints; the abdomen attached to the thorax at its hinder extremity between the base of the posterior coxæ, and provided in the female with a straight ovipositor often exserted and very long; and the wings veined, with perfect cells on the disk of the front pair.

The parasitic habits above alluded to render these flies of very great importance in the economy of nature, as they effectually serve to check any inordinate increase in the numbers of injurious insects. Without their aid, indeed, it would in many cases be impossible for the agriculturist to hold his own against the ravages of his minute hexapod foes, whose habits are not sufficiently known to render artificial checks or destroying agents available. The females of all the species are constantly on the alert to discover the proper living food for their own larvæ, which are hatched from the eggs they deposit in or on the eggs, larvæ, or pupæ of other insects of all orders, chiefly *Lepidoptera*, the caterpillars of butterflies and moths being specially attacked (as also are spiders). Any one who has watched insect life, even in a suburban garden, during summer, can hardly have failed to notice the busy way in which the parent ichneumon, a small four-winged fly, with constantly vibrating antennæ, searches for her prey; and the clusters of minute cocoons round the remains of some unfortunate cabbage-butterfly caterpillar, which has had just enough vitality left in it to crawl instinctively to a proper place for undergoing that change to pupa which it will never make, must also have been observed by many. This is the work of *Apanteles* (or *Microgaster*) *glomeratus*, one of the *Braconidæ*, which in days past was a source of disquietude to naturalists, who believed that the life of the one defunct larva had *transmigrated* into the numerous smaller flies reared from it. Ichneumon-flies which attack external feeders have a short ovipositor; but those attached to wood-feeding insects have that organ of great length, for the purpose of reaching their concealed prey. Thus a species from Japan (*Bracon penetrator*) has its ovipositor nine times the length of the body; and the large species of *Rhyssa* and *Ephialtes*, parasitic on *Sirex* and large wood-boring beetles in temperate Europe, have very long instruments (with which when handled they will endeavour to sting, sometimes penetrating the skin), in order to get at their secreted victims. This length of ovipositor is, in the female of a species of *Pelecinus*, common in the boreal parts of North America in pine forests, replaced by an excessively attenuated development of abdomen, causing the insect to resemble a small dragon-fly, and fulfilling the same mechanical purpose. A common reddish-coloured species of *Ophion* (*O. obscurum*), with a sabre-shaped abdomen, is noteworthy from the fact of its eggs being attached by stalks outside the body of the caterpillar of the puss-moth (*Diranura vinula*). Lepidopterists wishing to breed the latter cut off the eggs of the parasite with scissors.

The larvæ of the ichneumon-flies are white fleshy cylindrical footless grubs; the majority of them spin silk cocoons before pupating, often in a mass (sometimes almost geometrically), and sometimes in layers of different colours and texture.

The reader desirous of investigating more fully the structure and habits of this interesting family will, in addition to the older works of Gravenhorst, Esenbeck, Wesmael, and Haliday, find much matter in the recent writings of Brischke, Cresson, Provancher, Holmgren, Woldstedt, Tischbein, Vollenhoven, Förster, Kriechbaumer, Taschenberg, F. Smith, C. G. Thomson, and Rondani. The last-mentioned author has published (in the Bulletin of the Italian Entomological Society, 1871–78) a valuable list of parasitic insects and the species to which they are attached. (E. C. R.)

ICHTHYOLOGY

ICHTHYOLOGY[1] is that branch of zoology which treats of the internal and external structure of fishes, their mode of life, and their distribution in space and time. According to the views generally adopted at present, all those Vertebrate animals are referred to the class of Fishes which combine the following characteristics:—they live in water, and by means of gills or branchiæ breathe air dissolved in water; the heart consists of a single ventricle and single atrium; the limbs, if present, are modified into fins, supplemented by unpaired median fins; and the skin is either naked, or covered with scales or with osseous plates or bucklers. With few exceptions fishes are oviparous. There are, however, as we shall see hereafter, not a few members of this class which show a modification of one or more of these characteristics, and which, nevertheless, cannot be separated from it. The distinction between the class of Fishes and that of Batrachians is very slight indeed.

History and Literature.

The commencement of the history of ichthyology coincides with that of zoology generally. Aristotle. Aristotle (384–322 B.C.) had a perfect knowledge of the general structure of fishes, which he clearly discriminates both from the aquatic animals with lungs and mammæ, *i.e.*, Cetaceans, and from the various groups of aquatic invertebrates. According to him, "the special characteristics of the true fishes consist in the branchiæ and fins, the majority having four fins, but those of an elongate form, as the eels, having two only. Some, as the *Muræna*, lack the fins altogether. The rays swim with their whole body, which is spread out. The branchiæ are sometimes furnished with an operculum, sometimes they are without one, as in the cartilaginous fishes. . . . No fish has hairs or feathers; most are covered with scales, but some have only a rough or a smooth skin. The tongue is hard, often toothed, and sometimes so much adherent that it seems to be wanting. The eyes have no lids, nor are any ears or nostrils visible, for what takes the place of nostrils is a blind cavity; nevertheless they have the senses of tasting, smelling, and hearing. All have blood. All scaly fishes are oviparous, but the cartilaginous fishes (with the exception of the sea-devil, which Aristotle places along with them) are viviparous. All have a heart, liver, and gall-bladder; but kidneys and urinary bladder are absent. They vary much in the structure of their intestines: for, whilst the mullet has a fleshy stomach like a bird, others have no stomachic dilatation. Pyloric cæca are close to the stomach, and vary in number; there are even some, like the majority of the cartilaginous fishes, which have none whatever. Two bodies are situated along the spine, which have the function of testicles; they open towards the vent, and are much enlarged in the spawning season. The scales become harder with age. Not being provided with lungs, fishes have no voice, but several can emit grunting sounds. They sleep like other animals. In most cases the females exceed the males in size; and in the rays and sharks the male is distinguished by an appendage on each side of the vent."

Aristotle's information on the habits of fishes, their migrations, mode and time of propagation, and economic uses, is, so far as it has been tested, surprisingly correct. Unfortunately, we too often lack the means of recognizing the species of which he gives a description. His ideas of specific distinction were as vague as those of the fishermen whose nomenclature he adopted; it never occurred to him that vernacular names are subject to change, or may be entirely lost in course of time, and the difficulty of identifying his species is further increased by the circumstance that sometimes several popular names are applied by him to the same fish, or different stages of growth are designated by distinct names. The number of fishes known to Aristotle seems to have been about one hundred and fifteen, all of which are inhabitants of the Ægean Sea.

That one man should have discovered so many truths, and laid so sure a basis for future progress in zoology, is less surprising than the fact that for about eighteen centuries a science which seemed to offer particular attractions to men gifted with power of observation was no farther advanced. Yet such is the case. Aristotle's disciples, as well as his successors, remained satisfied to be his copiers or commentators, and to collect fabulous stories or vague notions. With very few exceptions (such as Ausonius, who wrote a small poem, in which he describes from his own observations the fishes of the Moselle) authors entirely abstained from original research; and it was not until about the middle of the 16th century that ichthyology made a new step in advance by the appearance of Belon, Rondelet, and Salviani, who almost simultaneously published their great works, by which the idea of species was established definitely and for all time.

[1] From ἰχθύς, fish, and λόγος, doctrine or treatise.

B n. P. Belon travelled in the countries bordering on the eastern part of the Mediterranean, in the years 1547–50; he collected rich stores of positive knowledge, which he embodied in several works. The one most important for the progress of ichthyology is that entitled *De aquatilibus libri duo*, Paris, 1553. Belon knows about one hundred and ten fishes, of which he gives rude but generally recognizable figures. In his descriptions he pays regard to the classical as well as to the vernacular nomenclature, and states the outward characteristics, sometimes even to the number of fin rays; frequently also he gives the most conspicuous anatomical peculiarities. Although Belon but rarely gives definitions of the terms used by him, it is not generally very difficult to ascertain the limits which he intended to assign to each division of aquatic animals. He very properly divides them into such as are provided with blood and those without it,—two divisions corresponding in modern language to vertebrate and invertebrate aquatic animals. The former are classified by him according to size, the further subdivisions being based on the structure of the skeleton, mode of propagation, number of limbs, form of the body, and physical character of the habitat.

iani. The work of the Roman ichthyologist, H. Salviani (1514–72), bears evidence of the high social position which the author held as physician to three popes. Its title is *Aquatilium animalium historia*, Rome, 1554–57, fol. It treats exclusively of the fishes of Italy. Ninety-two species are figured on seventy-six plates, which, as regards artistic execution, are masterpieces of that period, although those specific characteristics which nowadays constitute the value of a zoological drawing were entirely overlooked by the author or artist. No attempt is made at a natural classification, but the allied forms are generally placed in close proximity. The descriptions are quite equal to those given by Belon, entering much into the details of the economy and uses of the several species, and were evidently composed with the view of collecting in a readable form all that might prove of interest to the class of society in which the author moved. Salviani's work is of a high order, very remarkable considering the age in which he lived. It could not fail to convey valuable instruction, and to render ichthyology popular in the country to the fauna of which it was devoted, but it was not fitted to advance ichthyology as a science generally; in this respect Salviani is not to be compared with Rondelet or Belon.

leiet. G. Rondelet (1507–57) had the great advantage over Belon of having received a medical education at Paris, and especially of having gone through a complete course of instruction in anatomy as a pupil of Guentherus of Andernach. This is conspicuous throughout his works—*Libri de piscibus marinis*, Lyons, 1554; and *Universæ aquatilium historiæ pars altera*, Lyons, 1555. Nevertheless they cannot be regarded as more than considerably enlarged editions of Belon's work. For, although he worked independently of the latter, and differs from him in numerous details, of which he had a much more extensive knowledge, the system adopted by him is characterized by the same absence of the true principles of classification. His work is almost entirely limited to European and chiefly to Mediterranean forms, and comprises no less than one hundred and ninety-seven marine and forty-seven freshwater fishes. His descriptions are more complete and his figures much more accurate than those of Belon; and the specific account is preceded by introductory chapters, in which he treats in a general manner of the distinctions, the external and internal parts, and the economy of fishes. Like Belon, he had no conception of the various categories of classification—confounding, for instance, throughout his work the terms "genus" and "species"; but he had an intuitive notion of what his successors called a "species," and his principal object was to collect and give as much information as possible regarding such species.

For nearly a century the works of Belon and Rondelet continued to be the standard works on ichthyology; but the science did not remain stationary during that period. The attention of naturalists was now directed to the fauna of foreign countries, especially of the Spanish and Dutch possessions in the New World; and in Europe the establishment of anatomical schools and academies led to careful investigation of the internal anatomy of the most remarkable European forms. Limited as these efforts were as to their scope, being restricted either to the fauna of some particular district or to the dissection of a single species, they were sufficiently numerous to enlarge the views of naturalists, and to destroy that fatal dependence on preceding authorities which had continued to keep in bonds the minds of such men even as Rondelet and Belon. The most noteworthy of those engaged in these inquiries in tropical countries were W. Piso and G. Margrav, who accompanied as physicians the Dutch governor, Prince Maurice of Nassau, to Brazil (1637–44).

Of the men who left records of their anatomical researches, we may mention Borelli (1608–79), who wrote a work *De motu animalium*, Rome, 1680, 4to, in which he explained the mechanism of swimming and the function of the air-bladder; M. Malpighi (1628–94), who examined the optic nerve of the sword-fish; the celebrated J. Swammerdam (1637–80), who described the intestines of numerous fishes; and J. Duverney (1648–1730), who investigated in detail the organs of respiration.

A new era in the history of ichthyology commences with Ray, Willughby, and Artedi, who were the first to recognize the true principles by which the natural affinities of animals should be determined. Their labours stand in so intimate a connexion with each other that they represent but one great step in the progress of this science.

J. Ray (1628–1705) was the friend and guide of F. Willughby (1635–72). They found that a thorough reform in the method of treating the vegetable and animal kingdoms had become necessary; that the only way of bringing order into the existing chaos was by arranging the various forms according to their structure; that they must cease to be burdened with inapplicable passages and quotations from ancient writers, and to perpetuate the vague and erroneous notions of their predecessors. They therefore substituted facts for speculation, and one of the first results of this change, perhaps the most important, was that, having recognized "species" as such, they defined the term, and fixed it as the starting point of all sound zoological knowledge. Ray and Willughby.

Although they had divided their work so that Ray attended to the plants principally, and Willughby to the animals, the *Historia piscium*, Oxf., 1686, which bears Willughby's name on the title page, and was edited by Ray, is clearly their joint production. A great part of the observations contained in it were collected during the journeys they made together in Great Britain and in the various countries of Europe; and it is no exaggeration to say that at that time these two Englishmen knew the fishes of the Continent, and especially those of Germany, better than any native zoologist.

By the definition of fishes as animals with blood, breathing by gills, provided with a single ventricle of the heart, and either covered with scales or naked, the Cetaceans are excluded. The fishes proper are arranged primarily according to the cartilaginous or the osseous nature of the skeleton, and then subdivided according to the general form of the body, the presence or the absence of ventral fins, the soft or the spinous structure of the dorsal rays, the number of dorsal fins, &c. No fewer than four hundred and twenty species are thus arranged and described, of which about one hundred and eighty were known to the authors from personal examination,—a comparatively small proportion, but descriptions and figures still formed in great measure the substitute for our modern collections and museums. With the increasing accumulation of forms, the want of a fixed nomenclature had become more and more felt.

Artedi. Peter Artedi would have been a great ichthyologist if Ray or Willughby had not preceded him. But he was fully conscious of the fact that both had prepared the way for him, and therefore he did not fail to reap every possible advantage from their labours. Born in 1705 in Sweden, he studied with Linnæus at Upsala; from an early period he devoted himself entirely to the study of fishes, and was engaged in the arrangement and description of the collection of Seba, a wealthy Dutchman who had formed what was perhaps the richest museum at that time, when he was accidentally drowned in one of the canals of Amsterdam in the year 1734, at the age of twenty-nine. His manuscripts were fortunately secured by an Englishman, Count Clifford, and edited by his early friend Linnæus. The work is divided into the following parts:—

(1) In the *Bibliotheca Ichthyologica* Artedi gives a very complete list of all preceding authors who had written on fishes, with a critical analysis of their works. (2) The *Philosophia Ichthyologica* is devoted to a description of the external and internal parts of fishes; Artedi fixes a precise terminology for all the various modifications of the organs, distinguishing between those characters which determine a genus and such as indicate a species or merely a variety; in fact he establishes the method and principles which subsequently have guided every systematic ichthyologist. (3) The *Genera Piscium* contains well-defined diagnoses of forty-five genera, for which he has fixed an unchangeable nomenclature. (4) In the *Species Piscium* descriptions of seventy-two species, examined by himself, are given,—descriptions which even now are models of exactitude and method. (5) Finally, in the *Synonymia Piscium* references to all previous authors are arranged for every species, very much in the manner which is adopted in the systematic works of the present day.

Artedi has been justly called the Father of Ichthyology. So admirable was his treatment of the subject, that even Linnæus. Linnæus could only modify and add to it. Indeed, so far as ichthyology is concerned, Linnæus has scarcely done anything beyond applying binominal terms to the species properly described and classified by Artedi. His classification of the genera appears in the 12th edition of the *Systema* thus:—

A. *Amphibia Nantes.*—*Spiraculis compositis.*—Petromyzon, Raia, Squalus, Chimæra. *Spiraculis solitariis.*—Lophius, Acipenser, Cyclopterus, Balistes, Ostracion, Tetrodon, Diodon, Centriscus, Syngnathus, Pegasus.

B. *Pisces Apodes.*—Muræna, Gymnotus, Trichiurus, Anarrhichas, Ammodytes, Ophidium, Stromateus, Xiphias.

C. *Pisces Jugulares.*—Callionymus, Uranoscopus, Trachinus, Gadus, Blennius.

D. *Pisces Thoracici.*—Cepola, Echeneis, Coryphæna, Gobius, Cottus, Scorpæna, Zeus, Pleuronectes, Chætodon, Sparus, Labrus, Sciæna, Perca, Gasterosteus, Scomber, Mullus, Trigla.

E. *Pisces Abdominales.*—Cobitis, Amia, Silurus, Teuthis, Loricaria, Salmo, Fistularia, Esox, Elops, Argentina, Atherina, Mugil, Mormyrus, Exocœtus, Polynemus, Clupea, Cyprinus.

Two contemporaries of Linnæus, L. T. Gronow and J. T. Klein, attempted a systematic arrangement of fishes; both had considerable advantages for the study, especially in possessing extensive collections; but neither exercised any influence on the progress of ichthyology.

The works of Artedi and Linnæus led to an activity of research, especially in Scandinavia, Holland, Germany, and England, such as has never been equalled in the history of biological science. Whilst some of the pupils and followers of Linnæus devoted themselves to the examination and study of the fauna of their native countries, others proceeded on voyages of discovery to foreign and distant lands. Of these latter the following may be especially mentioned:—O. Fabricius worked out the fauna of Greenland; Kalm collected in North America, Hasselquist in Egypt and Palestine, Brünnich in the Mediterranean, Osbeck in Java and China, Thunberg in Japan; Forskål examined and described the fishes of the Red Sea; Steller, Pallas, S. T. Gmelin, and Güldenstedt traversed nearly the whole of the Russian empire in Europe and Asia. Others attached themselves as naturalists to the celebrated circumnavigators of the last century, such as the two Forsters (father and son) and Solander, who accompanied Cook; Commerson, who travelled with Bougainville; and Sonnerat. Numbers of new and remarkable forms were discovered by those men, and the foundation was laid for a knowledge of the geographical distribution of animals.

Of those who studied the fishes of their native countries, the most celebrated were Pennant (Great Britain), O. F. Müller (Denmark), Duhamel (France), Meidinger (Austria), Cornide (Spain), and Parra (Cuba).

The mass of materials brought together by those and other zoologists was so great that, not long after the death of Linnæus, the necessity made itself felt for collecting them in a compendious form. Several compilers undertook this task; they embodied the recent discoveries in new editions of the classical works of Artedi and Linnæus, but, not possessing either a knowledge of the subject or any critical discernment, they only succeeded in burying those noble monuments under a chaotic mass of rubbish. For ichthyology it was fortunate that two men at least, Bloch and Lacépède, made it a subject of prolonged original research.

Mark Eliezer Bloch (1723–1799), a physician of Berlin, Bloch had reached the age of fifty-six when he commenced to write on ichthyological subjects. To begin at his time of life a work in which he intended not only to give full descriptions of the species known to him from specimens or drawings, but also to illustrate each species in a style truly magnificent for his time, was an undertaking the execution of which most men would have despaired of. Yet he accomplished not only this task, but even more than he at first contemplated.

His work consists of two divisions:—(1) *Oeconomische Naturgeschichte der Fische Deutschlands*, Berl., 1782–84; (2) *Naturgeschichte der ausländischen Fische*, Berl., 1785–95. The first division, which is devoted to a description of the fishes of Germany, is entirely original, and based upon the author's own observations. His descriptions as well as figures were made from nature, and are, with but few exceptions, still serviceable; indeed many continue to be the best existing in literature. Bloch was less fortunate, and is much less reliable, in his natural history of foreign fishes. For many of the species he had to trust to more or less incorrect drawings and descriptions by travellers; frequently, also, he was deceived as to the origin of specimens which he acquired by purchase. Hence his accounts contain numerous confusing errors, which it would have been difficult to correct had not nearly the whole of the materials on which his work is based been preserved in the collections at Berlin.

After the completion of his great work Bloch occupied himself with systematizing. He prepared a general system of fishes, in which he arranged not only those described in his great work, but also those with which he had afterwards become acquainted from the descriptions of others. The work was ably edited and published after Bloch's death by a philologist, J. G. Schneider, under the title *M. E. Blochii Systema ichthyologiæ iconibus CX. illustratum*, Berl., 1801. The number of species enumerated in it amounts to 1519. The system is based upon the number of the fins, the various orders being termed *Hende-*

capterygii, *Decapterygii*, &c. We need not add that an artificial method like this led to the most unnatural combinations and distinctions.

Bloch's *Naturgeschichte* remained for many years the standard work, and, with its great number of excellent illustrations, proved a most useful guide to the student. But as regards originality of thought Bloch was far surpassed by his contemporary, B. G. E. de Lacépède, born at Agen, in France, in 1756, a man of great and general erudition, who became professor at the museum of natural history in Paris, where he died in 1826.

Lacépède.

Lacépède had to contend with great difficulties in the preparation of his *Histoire des Poissons*, Paris, 1798–1803, 5 vols., which was written during the most disturbed period of the French Revolution. A great part of it was composed whilst the author was separated from collections and books, and had to rely on his notes and manuscripts only. Even the works of Bloch and other contemporaneous authors remained unknown, or at least inaccessible, to him for a long time. We need not therefore be surprised that his work abounds in the kind of errors into which a compiler is liable to fall. Not only does the same species appear under two or more distinct specific names, but it sometimes happens that the author so little understands the source from which he derives his information that the description is referred to one genus and the accompanying figure to another. The names of genera are unduly multiplied; and the figures with which the work is illustrated are far inferior to those of Bloch. Thus the influence of Lacépède on the progress of ichthyology was vastly less than that of his fellow-labourer; and the labour laid on his successors in correcting the numerous errors into which he had fallen probably outweighed the assistance which they derived from his work.

The work of the principal cultivators of ichthyology in the period between Ray and Lacépède was chiefly systematizing and describing; but the internal organization of fishes also received attention from more than one great anatomist. Haller, Camper, and Hunter examined the nervous system and the organs of sense; and above all Alexander Monro, *secundus*, published a classical work, *The Structure and Physiology of Fishes explained and compared with those of Man and other Animals*, Edin., 1785. The electric organs of fishes (*Torpedo* and *Gymnotus*) were examined by Réaumur, Allamand, Bancroft, Walsh, and still more exactly by J. Hunter. The mystery of the propagation of the eel called forth a large number of essays, and even the artificial propagation of *Salmonidæ* was known and practised by Gleditsch (1764).

Bloch and Lacépède's works were almost immediately succeeded by the labours of Cuvier, but his early publications were of necessity tentative, preliminary, and fragmentary, so that some little time elapsed before the spirit infused into ichthyology by this great anatomist could exercise its influence on all the workers in this field. Several of such ante-Cuvierian works must be mentioned on account of their importance to our knowledge of certain faunas. The *Descriptions and Figures of Two Hundred Fishes collected at Vizagapatam on the Coast of Coromandel*, Lond., 1803, 2 vols., by Patrick Russel, and *An Account of the Fishes found in the River Ganges and its Branches*, Edin., 1822, 2 vols., by F. Hamilton (formerly Buchanan), were works distinguished by greater accuracy of the drawings (especially the latter) than was ever attained before. A *Natural History of British Fishes* was published by E. Donovan, Lond., 1802–8; and the Mediterranean fauna formed the study of the lifetime of A. Risso (*Ichthyologie de Nice*, Paris, 1810; and *Histoire naturelle de l'Europe Méridionale*, Paris, 1827). A slight beginning in the description of the fishes of the United States was made by S. L. Mitchell, who published, besides various papers, a *Memoir on the Ichthyology of New York*, in 1815.

Cuvier.

G. Cuvier (1769–1832) did not occupy himself with the study of fishes merely because the class formed part of the *Règne Animal*, but devoted himself to it with particular predilection. The investigation of their anatomy, and especially of their skeleton, was taken up by him at an early period, and continued until he had succeeded in completing so perfect a framework of the system of the whole class that his immediate successors required only to fill up those details for which their master had had no leisure. Indefatigable in examining all the external and internal characters of the fishes in a rich collection, he ascertained the natural affinities of the infinite variety of forms, and accurately defined the divisions, orders, families, and genera of the class, as they appear in the various editions of the *Règne Animal*. His industry equalled his genius: he formed connexions with almost every accessible part of the globe; not only French travellers and naturalists, but also Germans, Englishmen, Americans, rivalled one another in assisting him with collections; and for many years the museum of the Jardin des Plantes was the centre where all ichthyological treasures were deposited. Thus Cuvier brought together a collection the like of which had never been seen before, and which, as it contains all the materials on which his labours were based, must still be considered as the most important. Soon after the year 1820, Cuvier, assisted by one of his pupils, A. Valenciennes, commenced his great work on fishes, *Histoire naturelle des Poissons*, of which the first volume appeared in 1828. The earlier volumes, in which Cuvier himself took his share, bear evidence of the enthusiasm with which both authors devoted themselves to their task. After Cuvier's death in 1832, the work was left entirely in the hands of Valenciennes, whose energy and interest gradually slackened, rising to their former pitch in some parts only, as, for instance, in the treatise on the herring. He left the work unfinished with the twenty-second volume (1848), which treats of the Salmonoids. Yet, incomplete as it is, it is indispensable to the student.

Valenciennes.

The system finally adopted by Cuvier is the following:—

A. POISSONS OSSEUX.

I. A Branchies en Peignes ou en Lames.

1. *A Mâchoire Supérieure Libre.*

a. *Acanthoptérygiens.*

Percoïdes.	Sparoïdes.	Branchies labyrinthiques.
Polynèmes.	Chétodonoïdes.	Lophioïdes.
Mulles.	Scomberoïdes.	Gobioïdes.
Joues cuirassées.	Muges.	Labroïdes.
Scienoïdes.		

b. *Malacoptérygiens.*

Abdominaux.	*Subbrachiens.*	*Apodes.*
Cyprinoïdes.	Gadoïdes.	Murenoïdes.
Siluroïdes.	Pleuronectes.	
Salmonoïdes.	Discoboles.	
Clupeoïdes.		
Lucioïdes.		

2. *A Mâchoire Supérieure Fixée.*

Sclérodermes. Gymnodontes.

II. A Branchies en Forme de Houppes.

Lophobranches.

B. CARTILAGINEUX OU CHONDROPTÉRYGIENS.

Sturioniens. Plagiostomes. Cyclostomes.

We have only to compare this system with that of Linnæus if we wish to measure the gigantic stride made by ichthyology during the intervening period of seventy years. The various characters employed for classification have been examined throughout the whole class, and their relative importance has been duly weighed and understood. Though Linnæus had formed a category of "Amphibia Nantes" for fishes with a cartilaginous skeleton, which should coincide with Cuvier's "Poissons Cartilagineux," he had failed to understand the very nature of cartilage, apparently comprising under this term any skeletal framework of less firmness than ordinary bone. Hence he considered *Lophius*, *Cyclopterus*, *Syngnathus* to be cartilaginous fishes. Adopting the position and development of the ventral fins as a highly important character, he had been obliged to associate fishes having rudimentary and inconspicuous ventral fins, like *Trichiurus*, *Xiphias*, &c., with the true eels. The important category of "family" appears now in Cuvier's system fully established as intermediate between genus and order. Important changes in Cuvier's system have been made and proposed by his successors, but in the main it is still that of the present day.

Cuvier had extended his researches beyond the living forms, into the field of palæontology; he was the first to observe the close resemblance of the scales of the fossil *Palæoniscus* to those of the living *Polypterus* and *Lepidosteus*, the prolongation and identity of structure of the upper caudal lobe in *Palæoniscus* and the sturgeons, the presence of peculiar "fulcra" on the anterior margin of the dorsal fin in *Palæoniscus* and *Lepidosteus*, and inferred from these facts that the fossil genus was allied either to the sturgeons or to *Lepidosteus*. But it did not occur to him that there was a close relationship between those recent fishes. *Lepidosteus* and, with it, the fossil genus remained in his system a member of the order of *Malacopterygii abdominales*.

Agassiz. It was left to L. Agassiz (1807–73) to point out the importance of the structure of the scales as a characteristic, and to open a path towards the knowledge of a whole new subclass of fishes, the *Ganoidei*.

Impressed with the fact that the peculiar scales of *Polypterus* and *Lepidosteus* are common to all fossil osseous fishes down to the Chalk, he takes the structure of the scales generally as the base for an ichthyological system, and distinguishes four orders:—

1. *Placoids.*—Without scales proper, but with scales of enamel, sometimes large, sometimes small, and reduced to mere points (Rays, Sharks, and Cyclostomi, with the fossil Hybodontes). 2. *Ganoids.*—With angular bony scales, covered with a thick stratum of enamel: to this order belong the fossil Lepidoides, Sauroides, Pycnodontes, and Cœlacanthi; the recent Polypterus, Lepidosteus, Sclerodermi, Gymnodontes, Lophobranches, and Siluroides; also the Sturgeons. 3. *Ctenoids.*—With rough scales, which have their free margins denticulated: Chætodontidæ, Pleuronectidæ, Percidæ, Polyacanthi, Sciænidæ, Sparidæ, Scorpænidæ, Aulostomi. 4. *Cycloids.*—With smooth scales, the hind margin of which lacks denticulation: Labridæ, Mugilidæ, Scombridæ, Gadoidei, Gobiidæ, Murænidæ, Lucioidei, Salmonidæ, Clupeidæ, Cyprinidæ.

We have no hesitation in affirming that if Agassiz had had an opportunity of acquiring a more extensive and intimate knowledge of existing fishes before his energies were absorbed in the study of fossil remains, he would himself have recognized the artificial character of his classification. The distinctions between cycloid and ctenoid scales, between placoid and ganoid fishes, are vague, and can hardly be maintained. So far as the living and post-Cretacean forms are concerned, he abandoned the vantage-ground gained by Cuvier; and therefore his system could never supersede that of his predecessor, and finally shared the fate of every classification based on the modifications of one organ only. But Agassiz has the merit of having opened an immense new field of research by his study of the infinite variety of fossil forms. In his principal work, *Recherches sur les Poissons fossiles*, Neuchatel, 1833–43, 4to, atlas in fol., he placed them before the world arranged in a methodical manner, with excellent descriptions and illustrations. His power of discernment and penetration in determining even the most fragmentary remains is truly astonishing; and, if his order of Ganoids is an assemblage of forms very different from what is now understood by that term, he was at any rate the first who recognized that such an order of fishes exists.

J. Mü The discoverer of the *Ganoidei* was succeeded by their explorer, Johannes Müller (1801–58). In his classical memoir *Ueber den Bau und die Grenzen der Ganoiden*, Berl., 1846, he showed that the Ganoids differ from all the other osseous fishes, and agree with the Plagiostomes, in the structure of the heart. By this primary character, all heterogeneous elements as Siluroids, *Osteoglossidæ*, &c., were eliminated from the order as understood by Agassiz. On the other hand, he did not recognize the affinity of *Lepidosiren* to the Ganoids, but established for it a distinct subclass, *Dipnoi*, which he placed at the opposite end of the system. By his researches into the anatomy of the lampreys and *Amphioxus*, their typical distinctness from other cartilaginous fishes was proved; they became the types of two other subclasses, *Cyclostomi* and *Leptocardii*.

Müller proposed several other not unimportant modifications of the Cuvierian system; and, although all cannot be maintained as the most natural arrangements, yet his researches have given us a much more complete knowledge of the organization of the Teleosteous fishes, and later inquiries have shown that, on the whole, the combinations proposed by him require only some further modification and another definition to render them perfectly natural.

The discovery (in the year 1871) of a living representative of a genus hitherto believed to be long extinct, *Ceratodus*, threw a new light on the affinities of fishes. The writer of the present article, who had the good fortune to examine this fish, was enabled to show that, on the one hand, it was a form most closely allied to *Lepidosiren*, and, on the other, that it could not be separated from the Ganoid fishes, and therefore that *Lepidosiren* also was a Ganoid,—a relation already indicated by Huxley in a previous paper on "Devonian Fishes." This discovery led to further consideration[1] of the relative characters of Müller's subclasses, and to the system which is followed in the present article.

Having followed the development of the ichthyological system down to the most recent date, we have to retrace our steps to enumerate the most important contributions to ichthyology which appeared contemporaneously with or subsequently to the publication of the great work of Cuvier and Valenciennes. As in other branches of zoology, almost every year was marked by increased activity. For the sake of convenience we may arrange these works under three heads.

I. VOYAGES, CONTAINING GENERAL ACCOUNTS OF ZOOLOGICAL COLLECTIONS. Bibliography

A. *French.*—1. *Voyage autour du monde sur les Corvettes de S. M. l'Uranie et la Physicienne, sous le commandement de M. Freycinet*, "Zoologie—Poissons," par Quoy et Gaimard, Paris, 1824. 2. *Voyage de la Coquille*, "Zoologie," par Lesson, Paris, 1826–30. 3. *Voyage de l'Astrolabe, sous le commandement de M. J. Dumont d'Urville*, "Poissons," par Quoy et Gaimard, Paris, 1834. 4. *Voyage au Pôle Sud par M. J. Dumont d'Urville*, "Poissons," par Hombron et Jacquinot, Paris, 1853–4.

B. *English.*—1. *Voyage of H.M.S. Sulphur*, "Fishes," by J. Richardson, Lond., 1844–45. 2. *Voyage of H.M.SS. Erebus and Terror*, "Fishes," by J. Richardson, Lond., 1846. 3. *Voyage of H.M.S. Beagle*, "Fishes," by L. Jenyns, Lond., 1842. 4. *Voyage of H.M.S. Challenger*, "Fishes," by A. Günther.

C. *German.*—1. *Reise der österreichischen Fregatte Novara*, "Fische," von R. Kner, Vienna, 1865.

II. FAUNÆ.

A. *Great Britain.*—1. R. Parnell, *The Natural History of the Fishes of the Firth of Forth*, Edin., 1838. 2. W. Yarrell, *A History of British Fishes*, 3d edit., Lond., 1859. 3. J. Couch, *History of the Fishes of the British Islands*, Lond., 1862-65.

B. *Denmark and Scandinavia.*—1. H. Kröyer, *Danmark's Fiske*, Copenhagen, 1838–53. 2. S. Nilsson, *Skandinavisk Fauna*, vol. iv. "Fiskarna," Lund, 1855. 3. Fries och Ekström, *Skandinaviens Fiskar*, Stockh., 1836.

C. *Russia.*—1. Nordmann, "Ichthyologie Pontique," in Demidoff's *Voyage dans la Russie méridionale*, tom. iii., Paris, 1840.

D. *Germany.*—1. Heckel und Kner, *Die Süsswasser-fische der*

[1] "Description of Ceratodus," *Phil. Trans.*, 1871, ii.

österreichischen Monarchie, Leips., 1858. 2. C. T. E. Siebold, *Die Süsswasser-fische von Mitteleuropa*, Leips., 1863.

E. *Italy and Mediterranean.*—1. Bonaparte, *Iconografia della Fauna Italica*, tom. iii., "Pesci," Rome, 1832-41. 2. Costa, *Fauna del Regno di Napoli*, "Pesci," Naples, about 1850.

F. *France.*—1. E. Blanchard, *Les Poissons des eaux douces de la France*, Paris, 1866.

G. *Spanish Peninsula.*—The freshwater fish fauna of Spain and Portugal was almost unknown, until F. Steindachner paid some visits to those countries for the purpose of exploring the principal rivers. His discoveries are described in several papers in the *Sitzungsberichte der Akademie zu Wien*. B. du Bocage and F. Capello made contributions to our knowledge of the marine fishes on the coast of Portugal (*Jorn. Scienc. Acad. Lisb.*).

H. *North America.*—1. J. Richardson, *Fauna Boreali-Americana*, part iii., "Fishes," Lond., 1836. The species described in this work are nearly all from the British possessions in the north. 2. Dekay, *Zoology of New York*, part iv., "Fishes," New York, 1842. 3. *Reports of the United States Commission of Fish and Fisheries*, 5 vols., Washington, 1873-79, contain much valuable information. Besides these works, numerous descriptions of North American freshwater fishes have been published in the reports of the various U. S. Government expeditions, and in North American scientific journals, by Storer, Baird, Girard, W. O. Ayres, Cope, Jordan, Brown Goode, &c., but a good general, and especially critical, account of the fishes of the United States is still a desideratum.

I. *Japan.*—1. *Fauna Japonica*, "Poissons," par H. Schlegel, Leyden, 1850.

J. *East Indies*; *Tropical parts of the Indian and Pacific Oceans.*—1. E. Rüppell, *Atlas zu der Reise im Nördlichen Afrika*, Frankf., 1828. 2. E. Rüppell, *Neue Wirbelthiere*, "Fische," Frankf., 1837. 3. R. L. Playfair and A. Günther, *The Fishes of Zanzibar*, Lond., 1876. 4. C. B. Klunzinger, *Synopsis der Fische des Rothen Meers*, Vienna, 1870-71. 5. F. Day, *The Fishes of India*, Lond., 1865, 4to, contains an account of the freshwater and marine species. 6. A. Günther, *Die Fische der Südsee*, Hamburg, 4to, from 1873 (in progress). 7. Unsurpassed in activity, as regards the exploration of the fish fauna of the East Indian archipelago, is P. Bleeker (1819-78), a surgeon in the service of the Dutch East Indian Government, who, from the year 1840, for nearly thirty years, amassed immense collections of the fishes of the various islands, and described them in extremely numerous papers, published chiefly in the journals of the Batavian Society. Soon after his return to Europe (1860) Bleeker commenced to collect the final results of his labours in a grand work, illustrated by coloured plates, *Atlas Ichthyologique des Indes Orientales Néerlandaises*, Amsterd., fol., 1862; the publication of which was interrupted by the author's death in 1878.

K. *Africa.*—1. A. Günther, "The Fishes of the Nile," in Petherick's *Travels in Central Africa*, Lond., 1869. 2. W. Peters, *Naturwissenschaftliche Reise nach Mossambique*, iv., "Flussfische," Berl., 1868, 4to.

L. *West Indies and South America.*—1. L. Agassiz, *Selecta genera et species Piscium, quæ in itinere per Brasiliam collegit J. B. de Spix*, Munich, 1829, fol. 2. F. de Castelnau, *Animaux nouveaux ou rares, recueillis pendant l'expédition dans les parties centrales de l'Amérique du Sud*, "Poissons," Paris, 1855. 3. L. Vaillant and F. Bocourt, *Mission scientifique au Mexique et dans l'Amérique centrale*, "Poissons," Paris, 1874. 4. F. Poey, the celebrated naturalist of Havana, devoted many years of study to the fishes of Cuba. His papers and memoirs are published partly in two periodicals, issued by himself, under the title of *Memorias sobre la Historia natural de la Isla de Cuba* (from 1851), and *Repertorio Fisico-natural de la Isla de Cuba* (from 1865), partly in North American scientific journals. And, finally, F. Steindachner and A. Günther have published many contributions, accompanied by excellent figures, to our knowledge of the fishes of Central and South America.

M. *New Zealand.*—1. F. W. Hutton and J. Hector, *Fishes of New Zealand*, Wellington, 1872.

N. *Arctic Regions.*—1. C. Lütken, "A Revised Catalogue of the Fishes of Greenland," in *Manual of the Natural History, Geology, and Physics of Greenland*, Lond., 1875, 8vo. 2. The fishes of Spitzbergen were examined by A. J. Malmgren (1865).

III. Anatomical Works.

The number of authors who have investigated the anatomy of fishes is almost as great as that of faunists; and we should go beyond the limits of the present article if we mentioned more than the most prominent and successful. M. H. Rathke, J. Müller, J. Hyrtl, and H. Stannius left scarcely any organ unexamined, and their researches had a direct bearing either on the relation of the class of fishes to the other vertebrates, or on the systematic arrangement of the fishes themselves. E. E. von Baer, F. de Filippi, C. Vogt, W. His, W. K. Parker, and F. M. Balfour investigated their embryology; A. Kölliker and G. Pouchet their histology. The osteology was specially treated by G. Bakker, F. C. Rosenthal, L. Agassiz, and C. Gegenbaur; the nervous system by Gottsche, Philipeaux, Stannius, L. de Sanctis, L. Stieda, Baudelot, and Miclucho-Maclay; the organ of hearing by E. H. Weber, C. Hasse, and G. Retzius. The electric fishes were examined by E. Geoffroy, C Matteuci, P. Pacini, T. Bilharz, and Max Schultze. The development and metamorphosis of the lamperns was made the subject of research by H. Müller, M. Schultze, and P. Owsjannikow; Müller's examination of *Branchiostoma* was continued by J. Marcusen, A. Kovalevsky, L. Stieda, W. Müller, C, Hasse, T. H. Huxley, and F. M. Balfour. The most comprehensive accounts of the anatomy of fishes are contained in the subjoined works, which have been chiefly followed in the following anatomical description:—

1. H. Stannius, *Zootomie der Fische*, 2d edit., Berl., 1854. 2. R. Owen, *Anatomy of Vertebrates*, vol. i., Lond., 1866. 3. R. Owen, *Lectures on the Comparative Anatomy and Physiology of the Vertebrate Animals*, part i., "Fishes," Lond., 1846. 4. T. H. Huxley, *Manual of the Anatomy of Vertebrated Animals*, Lond., 1871.

It has been mentioned above that the great work of Cuvier and Valenciennes had been left incomplete. Several authors, therefore, have supplied detailed accounts of the orders omitted in that work. Müller and Henle published an account of the Plagiostomes, and Kaup of the *Murænidæ* and *Lophobranchii*; while A. Duméril commenced an *Histoire naturelle des Poissons ou Ichthyologie générale*, of which, however, only two volumes appeared, containing a complete account of the Plagiostomes (Paris, 1865) and of the Ganoids and Lophobranchs (Paris, 1870).

The activity which had prevailed in ichthyology since the publication of the *Histoire naturelle* by Cuvier and Valenciennes had been so great, and the results of the numerous investigations were scattered over such a multitude of publications, that it ultimately became imperative to collect all these materials in one comprehensive work. This was done in the *Catalogue of Fishes*, published by the trustees of the British Museum, in eight volumes (Lond., 1859-70). Besides the species previously described, many new forms were added, the total number of species referred to in those volumes amounting to 8525. As regards the systematic arrangement, Müller's system was adopted in the main, but the definition of the families was much modified. This, however, need not be further entered on now, as it will become sufficiently apparent in the systematic portion of this article.

For fuller details than can be given here regarding the structure, classification, and life-history of fishes, the reader is referred to the *Introduction to the Study of Fishes*, by A. Günther, Edin., 1880.

External Parts.

In the body of a fish four parts are distinguished,—the head, trunk, tail, and fins; the boundary between the first and second is generally indicated by the gill-opening, and that between the second and third by the vent. The form of the body and the relative proportions of these principal parts are subject to greater variation than is to be found in any other class of vertebrates. In fishes which are endowed with the power of steady and more or less rapid locomotion, a deviation from that form of body which we observe in a perch, carp, or mackerel is never excessive. The body is a simple, equally-formed wedge, compressed or slightly rounded, well fitted for cleaving the water. In fishes which are in the habit of moving on the bottom, the whole body, or at least the head, is vertically depressed and flattened; and the latter may be so enormously enlarged that the trunk and tail appear merely as an appendage. In one family of fishes, the *Pleuronectidæ* or flat-fishes, the body is compressed into a thin disk; they swim and move on one side only, which remains constantly directed towards the bottom, a peculiarity by which the symmetry of all parts of the body has been affected. In fishes moving comparatively slowly through the water, and able to remain (as it were) suspended in it, a lateral compression of the body, in conjunction with a lengthening of the vertical and a shortening of the longitudinal axis, is found. This deviation from the typical form may proceed so far that the vertical axis greatly exceeds the longitudinal in length; generally all the parts of the body participate in this form, but in one kind of fish (the *Orthagoriscus* or sun-fish) it is chiefly the tail that has been shortened, that being reduced so much as to present the appearance of being cut off. An excessive lengthening of the longitudinal axis, with a shortening of the vertical, occurs in eels and eel-like fishes, and in the so-called band-fishes. They are bottom-fish, capable of insinuating themselves into narrow crevices and holes. The form of the body in these long fishes is either cylindrical (snake-like), as in the eels and many codfishes, or strongly compressed, as in the band-fishes (*Trichiurus, Regalecus,* &c.). It is chiefly the tail that is lengthened, but frequently the head and trunk participate more or less in this form. Every possible variation occurs between these and other principal types of form. The old ichthyologists, even down to Linnæus, depended in great measure on them for classification; but, although the same form of body often obtains in the same groups of fishes, similarity of form by no means indicates natural affinity; it only indicates similarity of habits and mode of life.

Head. *The External Parts of the Head.*—The eye divides the head into the ante-orbital and post-orbital portions. In most fishes, especially in those with a compressed head, it is situated on the side and in the anterior half of the length of the head; in many others, chiefly those with a depressed head, it is directed upwards, and sometimes situated quite at the upper side; in a very few, the eyes look obliquely downwards. In the flat-fishes both eyes are on the same side of the head, either the right or the left, always on that which is directed towards the light, and coloured.

Fishes in general, as compared with other Vertebrata, have large eyes. Sometimes these organs are enormously enlarged, indicating either that the fish is nocturnal in its habits, or lives at a depth to which only a part of the sun's rays penetrate. On the other hand, small eyes occur in fishes inhabiting muddy places, or great depths, to which scarcely any light descends, or in fishes in which the want of an organ of sight is compensated by the development of other organs of sense. In a few fishes, more particularly those inhabiting caves or the greatest depths of the ocean, the eyes have become quite rudimentary and hidden under the skin.

In the ante-orbital portion of the head, or the snout, are situated the mouth and nostrils.

Mouth. The mouth is formed by the intermaxillary and maxillary bones or the intermaxillary only in the upper jaw, and by the mandibular bone in the lower. These bones are either bare or covered by integument, to which frequently labial folds or lips are added. As regards form, the mouth offers as many variations as the body itself, according to the nature of the food, and the mode of feeding. It may be narrow, or extremely wide and cleft nearly to the hind margin of the head; it may be semi-elliptical, semicircular, or straight in a transverse line; it may be quite in front of the snout (anterior), on its upper surface (superior), on its lower (inferior), or extending along each side (lateral); sometimes it is subcircular, organized for sucking. The jaws of some fishes are modified into a special weapon of attack (sword-fish, saw-fish); in fact, throughout the whole class of fishes the jaws are the only organ ever specialized for this purpose, weapons on other parts of the body being purely defensive.

Both jaws may be provided with skinny appendages, barbels, which, if developed and movable, are sensitive organs of touch.

Nostrils. In the majority of fishes the nostrils exhibit a double opening on each side of the upper surface of the snout, the openings of each side being more or less close together. They lead into a shallow groove, and only in one family (the Myxinoids) perforate the palate. In this family, as well as in the lampreys, the nasal aperture is single. In

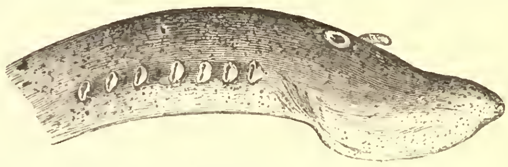


FIG. 1.—Head of *Mordacia mordax*, showing the single nostril and seven branchial openings.

many eels the openings are lateral, the lower perforating the upper lip. In the sharks and rays (figs. 2, 3, 4) they are at the lower surface of the snout, and more or less confluent. And, finally, in the Dipnoi (fig. 35) and other Ganoids, one at least is within the labial boundary of the mouth.

FIG. 2.—Confluent nasal and buccal cavities of *Chiloscyllium trispeculare*; tooth of the natural size.

The space across the forehead, between the orbits, is called the interorbital space; that below the orbits, the infraorbital or suborbital region.

In the postorbital part of the head there are distinguished, at least in most Teleosteous fishes and many Ganoids, the præoperculum, a sub-semicircular bone, generally with a free and often serrated or variously-armed margin; the operculum, forming the posterior margin of the gill-opening; and the suboperculum and interoperculum along its inferior margin. All these bones, collectively called opercula, form the gill-cover, a thin bony lamella covering the cavity containing the gills.

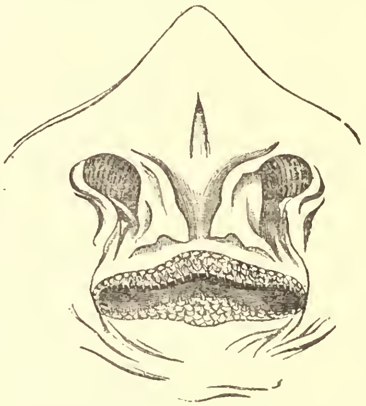


FIG. 3.—Nostrils of *Raia lemprieri*, with nasal flaps reverted.

Gills. The gill-opening is a foramen, or slit, behind or below the head, by which the water that has been taken up through the mouth for the purpose of breathing is again expelled. This slit may extend from the upper end of the operculum all round the side of the head to the symphysis of the lower jaw; or it may be shortened and finally reduced to a small opening on any part of the margin of the gill-cover. Sometimes (*Symbranchus*) the two openings, thus reduced, coalesce, and form what externally appears as a single opening only. The margin of the gill-cover is provided with a cutaneous fringe, in order more effectually to close the gill-opening; and this fringe is supported by one or several or many bony rays, the branchiostegals. The space on the chest between the two rami of the lower jaw and between the gill-openings is called the isthmus.

The sharks and rays differ from the Teleosteous and Ganoid fishes in having five branchial slits (six or seven in *Hexanchus* and *Heptanchus*), which are lateral in the sharks, and at the lower surface of the head in the rays (fig. 4). In *Myxine* only the gill-opening is at a great distance from the head; in that family (*Cyclostomi*) it is either single or there are six or more on each side (fig. 1), as in the lampreys.

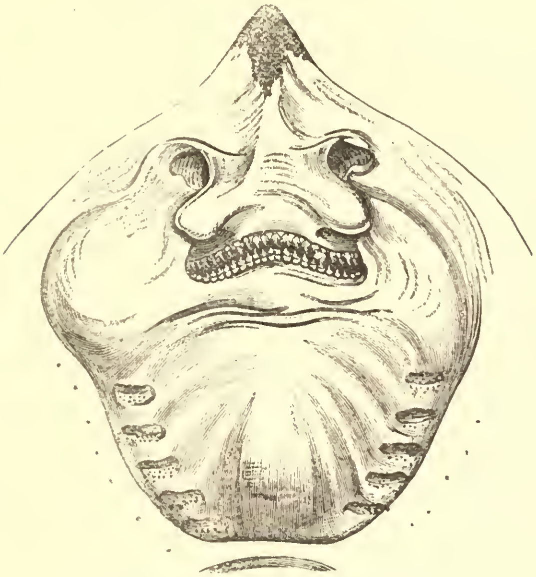


FIG. 4.—Lower aspect of head of *Raia lemprieri*.

The Trunk and Tail.—In the trunk are distinguished the back, sides, and abdomen. It gradually passes in all fishes into the tail, the termination of the abdominal cavity and the commencement of the tail being generally indicated by the position of the vent. The exceptions are numerous: not only may certain abdominal organs, such as the sexual, extend to between the muscles of the tail, but the intestinal tract itself may pass far backwards, or it may even be reflected forwards, so that the position of the vent may be either close to the extremity of the tail or to the foremost part of the trunk.

In many fishes the greater part of the tail is surrounded by fins, leaving finless only a small portion between the dorsal, caudal, and anal fins; this finless part is called the free portion or the peduncle of the tail.

The Fins.—The fins are divided into vertical or unpaired, and horizontal or paired fins. Any of them may be present or absent; and their position, number, and form are most important guides in determining the affinities of fishes.

The vertical fins are situated in the median dorsal line, from the head to the extremity of the tail, and in the ventral line of the tail. In fishes in which they are least developed or most embryonic, the vertical fin appears as a simple fold of the skin surrounding the extremity of the tail. In its further progress of development in the series of fishes, it gradually extends further forwards, and it may reach even the head and the vent. In this embryonic condition the fin is generally supported by fine rays, which are the continuations of, or articulated to, other stronger rays supported by the processes or apophyses of the vertebral column. This form of the vertical fin is very common,—for instance in the eels, and many Gadoid, Blennioid, and Ganoid fishes, in which the rays have ceased, besides, to be simple rods, showing more or less numerous joints (simple articulated rays, fig. 5). Branched rays are dichotomously split, the joints increasing in number towards the extremity.

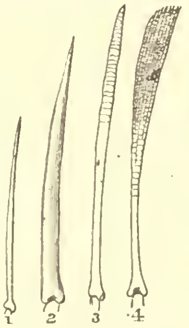


FIG. 5.—1, Simple ray, 2, spine; 3, simple articulated ray (soft); 4, branched ray (soft).

The continuity of the vertical fin, however, is interrupted in the majority of fishes, and three fins are then distinguished: one in the dorsal line—the dorsal fin; one in the ventral line behind the anus—the anal fin; and one confined to the extremity of the tail—the caudal fin.

The caudal fin is rarely symmetrical so that the upper half is equal to the lower; the greatest degree of asymmetry obtains in fishes with a heterocercal termination of the vertebral column. In fishes in which it is nearly symmetrical it is frequently prolonged into an upper and lower

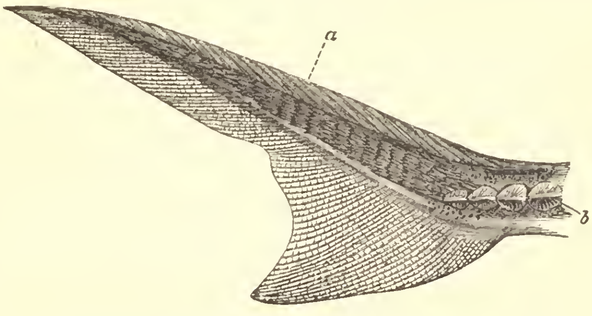


FIG. 6.—Heterocercal tail of *Acipenser*. *a*, fulcra: *b*, osseous bucklers.

lobe, its hind margin being concave or more or less deeply excised; in others the hind margin is rounded, and, when the middle rays greatly exceed in length the outer ones, the fin assumes a pointed form.

Many and systematically important differences are observed in the dorsal fin, which is either spiny-rayed (spinous) (*Acanthopterygian*), or soft-rayed (*Malacopterygian*). In the former, a smaller or greater number of the rays are simple and without transverse joints; they may be flexible, or so much osseous matter is deposited in them that they appear hard and truly spinous (fig. 7); these

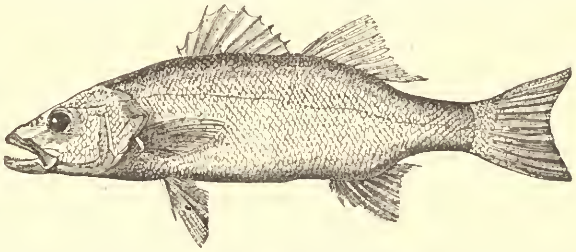


FIG 7.—*Labrax lupus* (Bass), an Acanthopterygian with anterior spinous and posterior soft dorsal fin.

spines form always the anterior portion of the fin, which is either detached from or continuous with the remaining jointed rays. The spines can be erected or depressed at the will of the fish; if in the depressed position the spines cover one another completely, their points lying in the same line, the fish is called homacanth; but if the spines are asymmetrical, alternately broader on one side than on

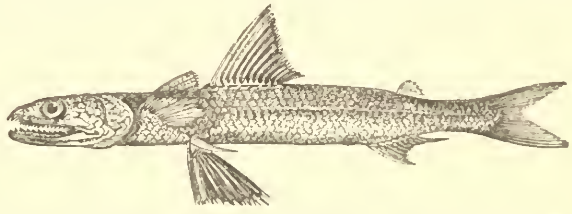


FIG. 8.—*Saurus undosquamis*, a Malacopterygian with anterior soft dorsal and additional adipose fin.

the other, the fish is called heteracanth. The spinous division, as well as the one consisting of jointed rays, may again be subdivided. In the Malacopterygian type all the rays remain jointed; indeed, sometimes the foremost ray, with its preceding short supports, is likewise ossified, and is a hard spine, but the articulations can nearly always be distinctly traced. Sometimes the dorsal fin of Malacopterygian fishes is very long, extending from the head to the end of the tail; sometimes it is reduced to a few rays only; and in a few cases it is entirely absent. In addition to the rayed dorsal fin, many Malacopterygian fishes (as the Salmonoids, many Siluroids, Scopeloids, &c.) have another of greater or lesser extent, without any rays; and as fat is always deposited within this fold, it is called a fatty fin (*pinna adiposa*) (figs. 8 and 9).

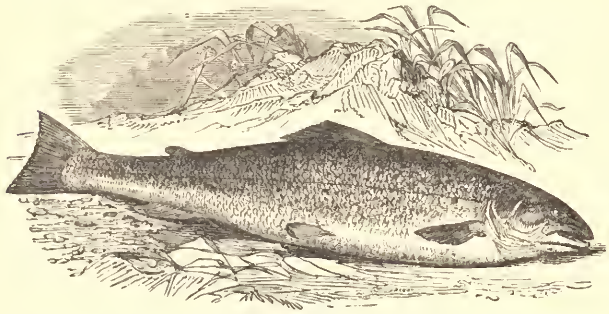


Fig. 9.—*Salmo salar* (Salmon), with abdominal ventral fins.

The anal fin is built on the same plan as the dorsal; it may be single, or there may be more than one; it may also be long or short, or entirely absent; in Acanthopterygians its foremost rays are frequently simple and spinous.

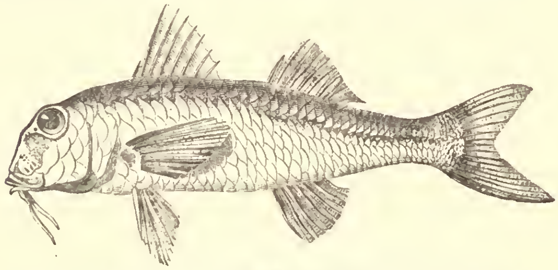


Fig. 10.—*Mullus barbatus* (Red Mullet), with thoracic ventral fins.

The horizontal or paired fins consist of two pairs, the pectorals and ventrals.

The pectoral fins (with their osseous supports) are the homologues of the anterior limbs of the higher Vertebrata. They are always inserted immediately behind the gill opening,—either symmetrical, with a rounded posterior

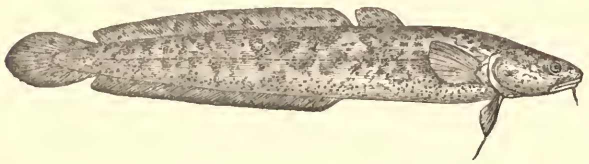


Fig. 11.—Burbot (*Lota vulgaris*), with jugular ventral fins.

margin, or asymmetrical, with the upper rays longest and strongest; in Malacopterygians with a dorsal spine the upper pectoral ray is frequently developed into a similar defensive weapon.

The ventral fins are the homologues of the hind-limbs, and are inserted on the abdominal surface, either behind the pectorals (*Pisces* or *Pinnæ abdominales*) (fig. 9), or below them (*Pisces* or *Pinnæ thoracicæ*) (fig. 10), or in advance of them (*Pisces* or *Pinnæ jugulares*) (fig. 11). They are generally narrow, and composed of a small number of rays, the outer of which is frequently osseous.

For the definition of the smaller systematic groups, and the determination of species, the numbers of the spines and rays are generally of the greatest importance. This holds good especially for the ventral rays, by the number of which the Acanthopterygian affinities of a fish can nearly always be determined. The numbers of the dorsal and anal rays generally correspond to the number of vertebræ in a certain portion of the spinous column, and are therefore constant specific, generic, or even family characters; but when their number is very great, a proportionally wide margin must be allowed for variation, and the taxonomic value of this character becomes uncertain. The numbers of the pectoral and caudal rays are rarely of any account.

The fins are organs of motion, but it is chiefly the tail and the caudal fin by which the fish impels itself forward. To execute energetic locomotion, the tail and caudal fin are strongly bent with rapidity, alternately towards the right and left; whilst a gentle motion forwards is effected by a simple undulating action of the caudal fin, the lobes of which act like the blades of a screw. Retrograde motions can be made by fishes in an imperfect manner only, by forward strokes of the pectoral fins. When the fish wants to turn towards the left, he gives a stroke of the tail towards the right, the right pectoral acting simultaneously, whilst the left remains pressed close to the body. Thus the pectoral fins assist in the progressive motions of the fish, but rather by directing its course than by acting as powerful propellers. The chief function of the paired fins is to maintain the balance of the fish in the water, which is always most unsteady where there is no weight to sink it: when the pectoral of one side, or the pectoral and ventral of the same side, are removed, the fish loses its balance and falls on the side opposite; when both pectorals are removed, the fish's head sinks; on removal of the dorsal and anal fins the motion of the fish assumes a zigzag course; deprived of all fins, it floats like a dead fish, with the belly upwards, the back being the heavier part of the body.

In numerous groups of fishes which live in mud, or are able to pass a longer or shorter time in soil periodically dried and hardened during the hot season, forms occur entirely devoid of, or with only rudimentary, ventral fins (*Cyprinodon*, *Ophiocephalidæ*, *Galaxiidæ*, *Siluridæ*). The chief function of these fins being to balance the body of the fish whilst swimming, it is evident that in fishes moving during a great part of their life over swampy ground, or through more or less consistent mud, this function of the ventral fins ceases, and nature can readily dispense with these organs altogether.

In certain fishes the shape and function of the fins are considerably modified: thus, in the rays, locomotion is almost entirely effected and regulated by the broad and expanded pectoral fins acting with an undulatory motion of their margins, similar to the undulations of the long vertical fins of the flat-fishes; in many blennies the ventral fins are adapted for walking on the sea-bottom; in some Gobioids (*Periophthalmus*), Trigloids, Scorpænioids, and *Pediculati* the pectoral fins are perfect organs of walking; in the gobies, *Cyclopteri*, and *Discoboli* the ventral fins are transformed into an adhesive disk (see fig. 13); and finally in the flying-fish the pectorals act as a parachute. In the eels and other snake-like fishes, the swimming as well as the gliding motions are effected by several curvatures of the body alternately to-

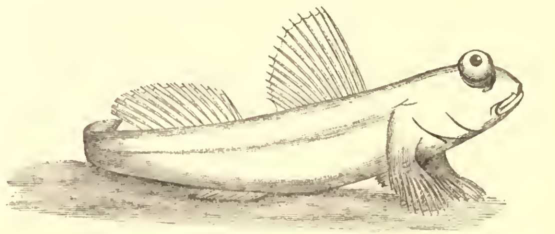


Fig. 12.—*Periophthalmus koelreuteri*.

wards the right and left, resembling the locomotion of snakes. In the *Syngnathi* (pipe-fishes) and *Hippocampi* (sea-horses), whose body admits of but a slight degree of lateral curvature, and whose caudal fin is generally small if present at all, locomotion is very limited, and almost wholly dependent on the action of the dorsal fin, which consists of a rapid undulating movement.


Fig. 13.—Ventrals of *Gobius*.

The Skin and Scales.—The skin of fishes is either covered with scales, or naked, or provided with more or less numerous scutes of various forms and sizes. Some parts, like the head and fins, are more frequently naked than scaly. All fishes provided with electric organs, the majority of eels, and the lampreys are naked. Scales of fishes are very different from those of reptiles,—the latter being merely folds of the cutis, whilst the former are distinct horny elements, developed in grooves or pockets of the skin, like hairs, nails, or feathers.

Very small or rudimentary scales are extremely thin, homogeneous in structure, and more or less imbedded in the skin, and do not cover each other. When more developed, they are imbricated (arranged in the manner of tiles), with the posterior part extruded and free, the surface of the anterior portion being usually covered by the skin to a greater or less extent. On their surface (fig. 14) may be observed a very fine striation concentric with and parallel to the margin, and coarser striæ radiating from a central point towards the hind margin.

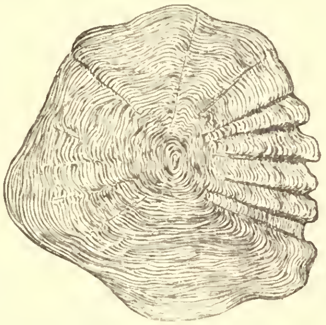


Fig. 14.—Cycloid scale of *Scopelus resplendens* (magn.).

Scales without a covering of enamel, with an entire (not denticulated) posterior margin, and with a concentric striation, are called cycloid scales. Ctenoid scales (figs. 15, 16)

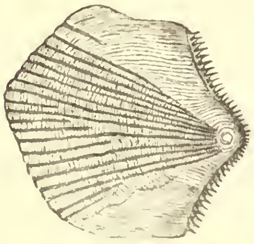


Fig. 15.—Ctenoid scale of *Gobius ommaturus* (magn.).

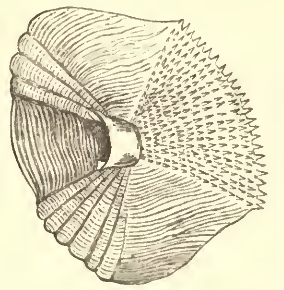


Fig. 16.—Ctenoid scale of *Lethrinus* (magn.).

are generally thicker, and provided with spinous teeth on the posterior edges of the layers of which the scale consists. In some species, only the layer nearest to the margin is provided with denticulations (fig. 15). Scales the free surface of which is spiny, and which have no denticulation on the margin, have been termed sparoid scales; but their distinction from ctenoid scales is by no means sharp, and there are even intermediate forms between the cycloid and ctenoid types. Both kinds of scales may occur, not only in species of the same genus of fishes, but in the same fish.

Ganoid scales are hard and bony, covered with a layer of enamel; they are generally rhombic or quadrangular, rarely rounded and imbricate, and are arranged in oblique rows, those of one row being linked together by an articulary process. This type of scales, common in fossil Ganoid fishes, occurs among recent fishes in *Lepidosteus* and *Polypterus* only.

Finally, in sharks, the *Balistidæ*, and others, true scales are absent, and are replaced by the ossified papillæ of the cutis (fig. 18), which give the surface the appearance of fine-

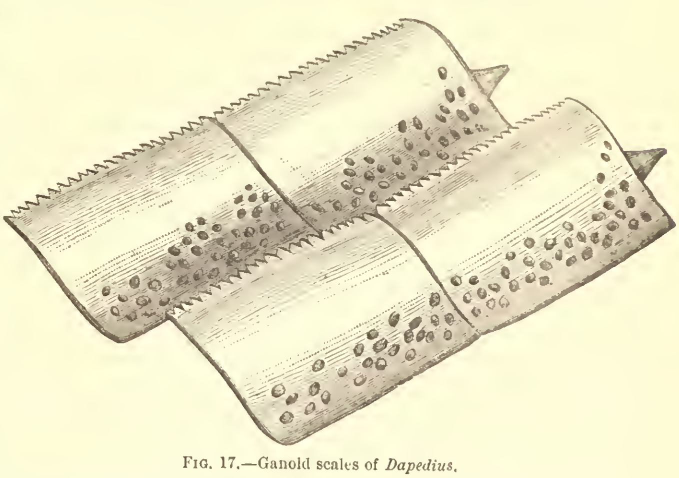


Fig. 17.—Ganoid scales of *Dapedius*.

grained shagreen. These generally small bodies, as well as the large osseous scutes (figs. 6 and 20) of the rays, stur-


Fig. 18.—Dermal papillæ of *Monacanthus trossulus*.

geons, &c., have been comprised under the common name placoid scales, a term which is being deservedly abandoned.

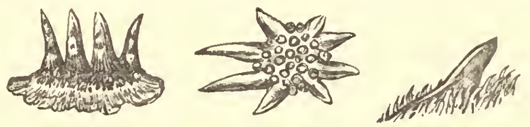


Fig. 19.—Dermal papillæ of *Monacanthus hippocrepis* (magn.).

Along the side of the body of osseous fishes runs a series of perforated scales, which is called the lateral line (fig. 23). The perforating duct is simple at its base, and may be simple also at its outer opening (fig. 21), or (a frequent case) the portion on the free surface of the scale is ramified (fig. 22). The lateral line runs from the head to the tail, sometimes reaching the caudal fin, sometimes stopping short of it, sometimes advancing over its rays. Some species have several lateral lines, an upper one following the dorsal, a lower the abdominal outline, while a third runs along the middle as usual. The scales of the lateral line are sometimes larger than the others, sometimes smaller; sometimes they are modified into scutes; sometimes there are no other scales besides these, the rest of the body being naked. The foramina of the lateral line are the outlets of a muciferous duct which is continued on to the head, running along the infraorbital bones, and sending off a branch into the præopercular margin and mandible. The muciferous system is abundantly provided with nerves, and has therefore been considered to be the seat of a sense peculiar to fishes,

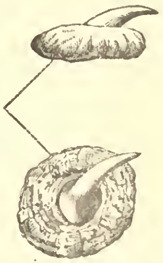


Fig. 20.—Dermal spines of a male Thornback, *Raia clavata*.

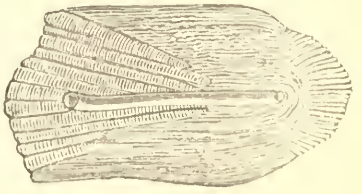


Fig. 21.—Cycloid scale from the lateral line of *Odax lineatus* (magn.).

but there cannot be any doubt that its function is the excretion of mucus, although probably mucus is excreted also from the entire surface of the fish.

The scales, their structure, number, and arrangement, constitute an important character for the determination of

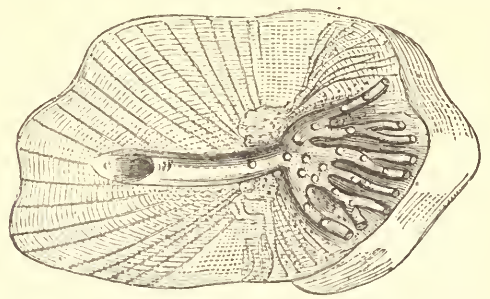


FIG. 22.—Cycloid scale from the lateral line of *Labrichthys laticlavius* (magn.).

fishes. In most scaly fishes they are arranged in oblique transverse series; and, as the number of scales in the lateral line generally corresponds to the number of transverse series, it is usual to count the scales in that line. To ascertain the number of longitudinal series of scales, the

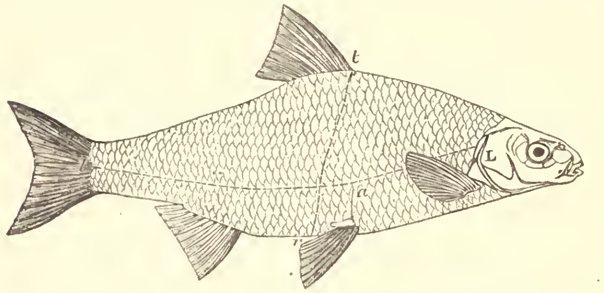


FIG. 23.—Arrangement of scales in the Roach (*Leuciscus rutilus*). *Ll*=Lateral line; *t r* = transverse line; *a*, tranverse line from lateral line to ventral fin.

scales are counted in one of the transverse series, generally in that running from the commencement of the dorsal fin, or the middle of the back, to the lateral line, and from the lateral line down to the vent or ventral fin, or the middle of the abdomen.

Osteology.

In order readily to comprehend the following account of the modifications of the skeleton in the various sub-classes and groups of fishes, the student should acquaint himself with the terms used for the numerous bones of the fish skeleton, as well as with their relative position. For this purpose we commence this section with an account of the skeleton of the *Teleostei*, which is composed of the greatest number of specialized bones, and is most readily accessible. The skeleton of any of the more common kinds of osseous fish may serve for this purpose; that of the perch was chosen by Cuvier, and is employed here (fig. 24), as it was in the last edition of the present work.

In the Teleosteous fishes the spinous column consists of Vert.
completely ossified amphicœlous vertebræ; its termination is homocercal—that is, the caudal fin appears to be more or less symmetrical, the last vertebra occupying a central position in the base of the fin, and being united to a flat fan-like bone, the hypural (70 in fig. 24), on the hind margin of which the fin-rays are fixed. The hypural is but a union of modified hæmapophyses which are directed backwards, and the actual termination of the notochord is bent upwards, and lies along the upper edge of the hypural, hidden below the last rudimentary neural elements. In some Teleosteans, as the *Salmonidæ*, the last vertebræ are conspicuously bent upwards: in fact, strictly speaking, this homocercal condition is but one of the various degrees of heterocercy, different from that of many Ganoids in this respect only, that the caudal fin itself has assumed a higher degree of symmetry.

The neural and hæmal arches generally coalesce with the centrum, but there are many exceptions, inasmuch as some portion of the arches of a species, or all of them, may show the original division.

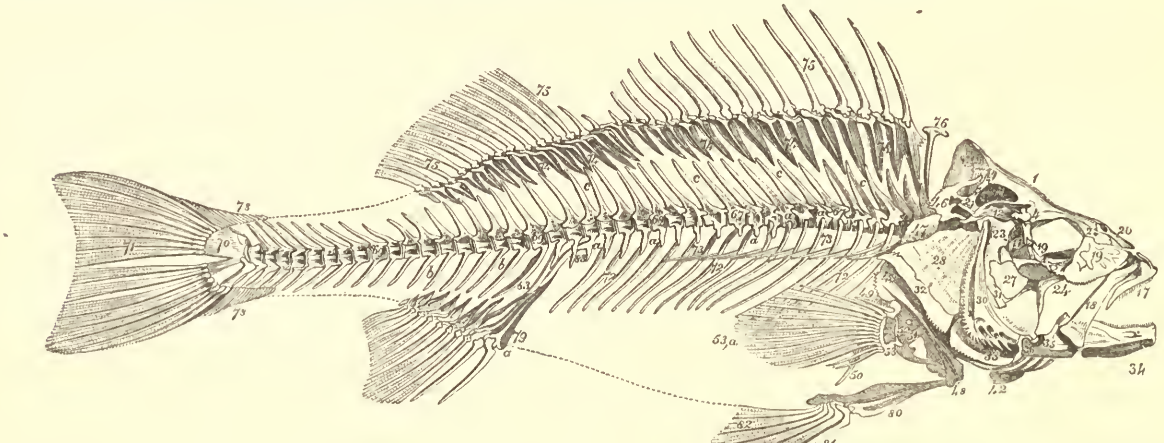


FIG. 24.—Skeleton of the Perch.

The vertebræ are generally united with one another by zygapophyses, and frequently similar additional articulations exist at the lower parts of the centra. Parapophyses and ribs are very general, but the latter are inserted on the centra and the base of the processes, and never on their extremities.

The spinal column consists of abdominal and caudal vertebræ, the coalescence of the parapophyses into a complete hæmal ring and the suspension of the anal fin generally forming a sufficiently well-marked boundary between the abdominal and caudal regions (fig. 24). In the perch there are twenty-one abdominal and as many caudal vertebræ. The centrum of the first vertebra or atlas is very short, with the apophyses scarcely indicated; neither the first nor the second vertebra has ribs. All the other abdominal vertebræ, with the exception of the last or the two last, are provided with ribs, many of which are bifid (72). A series of flat spines (74), called interneurals, to which the spines and rays of the dorsal fins are articulated, are supported by the neural spines, the strength of the neurals and interneurals corresponding to that of the dermal spines (75). The caudal vertebræ differ from the abdominal in having the hæmapophyseal elements converted into spines similar to the neurals, the anterior being likewise destined to support a series of interhæmals (79), to which the anal rays are articulated.

There is a great amount of variation as regards the degree in which the primordial cartilaginous cranium persists; it is always more or less replaced by bone; frequently it disappears entirely, but in some fishes like the *Salmonidæ* or *Esocidæ,* the cartilage persists to the same or even to a greater extent than we shall find in the *Ganoidei holostei.* Besides the bones preformed in cartilage there are a great number of membrane-bones, that is, bones originating in membranous or tegumentary tissue. The different kinds of these membrane-bones occur with greater or less constancy throughout the subclass *Teleostei*; they often coalesce with and are no longer separable from the neighbouring or underlying cartilage-bones.

1. *Cartilage-Bones of the Primordial Skull.*—The basioccipital (5 in figs. 25–27) has retained the form of a vertebral centrum; it is generally concave behind, the

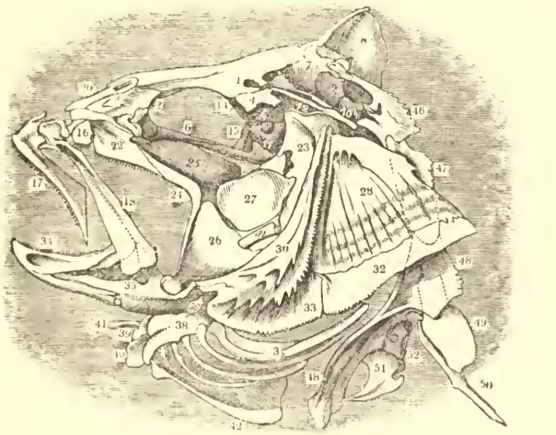


FIG. 25.—Skeleton of Perch's Skull.

concavity containing remains of the notochord. The exoccipitals (10) are situated on the side of the basioccipital, and contribute the greater portion of the periphery of the foramen magnum. The supraoccipital (8) is intercalated between the exoccipitals, and forms a most prominent part by its median crest, which sometimes extends far forward on the upper side of the skull, and offers attachment to the dorsal portion of the large lateral muscle of the trunk. A transverse supraoccipital ridge, coming from each side of the base of this crest, runs outward to the external angles of the bone. When the interior portion of this bone remains cartilaginous, some part of the semicircular canals may be lodged in it.

The region of the skull which succeeds these bones encloses at least the greater portion of the labyrinth, and its component parts have been named with reference to it by some anatomists.[1] The alisphenoids (11) (*prooticum*) form sutures posteriorly with the basi- and ex-occipitals, and meet each other in the median line at the bottom of the cerebral cavity; they contribute to the formation of a hollow in which the hypophysis cerebri and the saccus vasculosus are received; in conjunction with the exoccipital they form another hollow for the reception of the vestibulum; generally they are perforated by the trigeminal and facial nerves. The paroccipitals (9) (*epioticum*) lodge a portion of the posterior vertical semicircular canal, and form a projection of the skull on each side of the occipital crest, to which a terminal branch of the scapular arch is attached. The mastoid (12 + 13) (*opisthoticum*) occupies the postero-external projection of the head; it encloses a part of the external semicircular canal, is generally united to a membrane-bone, the superficial squamosal, which emits a process for the suspension of the scapular arch, and is frequently, as in the perch, divided into two separate bones.

The anterior portion of the skull varies greatly as regards form, which is chiefly dependent on the extent of the cere-

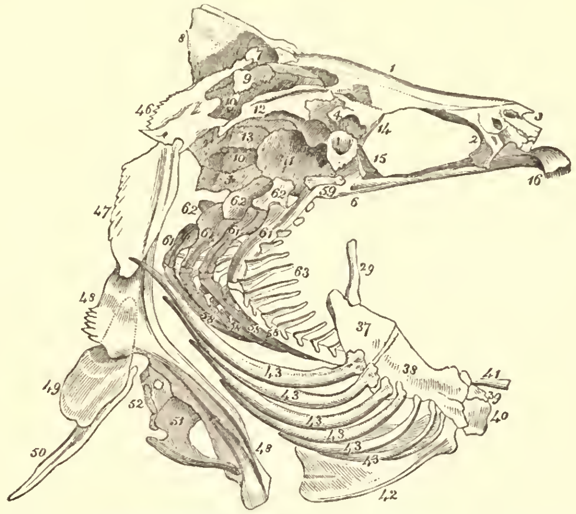


FIG. 26.—Hyoid arch, branchial apparatus, and scapulary arch of the Perch.

bral cavity; if the latter is advanced far forwards, the lateral walls of the primordial cranium are protected by more developed ossifications than is the case if the cerebral cavity is shortened by the presence of a wide and deep orbit. In the latter case parts which normally form the side of the skull are situated in front of the brain-case, between it and the orbit, and, being generally reduced in extent, are often replaced by membranes; the interorbital septum especially may thus be reduced to a membrane. The most constant ossifications of this part of the skull are the orbitosphenoids (14), which join the upper anterior margin of the alisphenoids; superiorly the olfactory and inferiorly the optic nerves pass between them out of the cranium. They vary much with regard to their development: they are small in Gadoids; larger in the perch, pike, Salmonoids, *Macrodon,* and the Clupeoids; and very large in Cyprinoids and Siluroids, in which they contribute to the formation of the side of the brain-case. The single Y-shaped *sphenoideum anterius* (15) (ethmoid of Owen and basisphenoid of Huxley) is as frequently absent as present; each lateral branch is connected with an orbitosphenoid, whilst the lower branch rests upon the long basal bone; it forms the anterior margin of the fossa for the hypophysis. Finally, to this group of cartilage-bones belongs also the postfrontal (4), a small bone from which the infraorbital ring is suspended.

The centre of the foremost part of the skull is occupied by the ethmoid (3), which shows great variations as regards its extent and the degree of ossification; it may extend backwards into the interorbital septum, and reach the orbitosphenoids, or it may be confined to the extremity of the skull; it may remain entirely cartilaginous, or it may ossify into a lamina which separates the two orbits and encloses an anterior prolongation of the brain-case, along which the olfactory nerves pass,—modifications occurring again in higher vertebrates. A paired ossification attached to the forepart of the ethmoid is the prefrontals (2), which form the base of the nasal fossa.

2. *Membrane-Bones attached to the Primordial Skull.*—To this group belong the parietals (7) and frontals (1). The latter form the upper margin of the orbits, and extend from the nasal cavities to the occipital. They are enlarged at the expense of the parietals, which are of much smaller extent

[1] As first proposed by Huxley.

than in higher vertebrates, and are separated from each other by the anterior prolongation of the supraoccipital. The squamosal (12) has been mentioned above in connexion with the mastoid. The prefrontal (2) and supraorbital are always small, and the latter is frequently absent. The lower surface of the skull is protected by the basisphenoid (parasphenoid) (6), a very long and narrow bone extending from the basioccipital beyond the brain-capsule to between the orbits, where it forms the support of the interorbital septum. Anteriorly it is connate with another long hammer-shaped bone (16), the vomer. Both these bones, especially the latter, may be armed with teeth.

3. *Cartilage-Bones of the Alimentary Portion of the Visceral Skeleton of the Skull.*—The suspensorium consists of three cartilage-bones, and affords a base for the opercular apparatus as well as a point of attachment to the hyoid, whilst in front it is connected with the pterygo-palatine arch (fig. 27). These are the hyomandibular (23), sym-

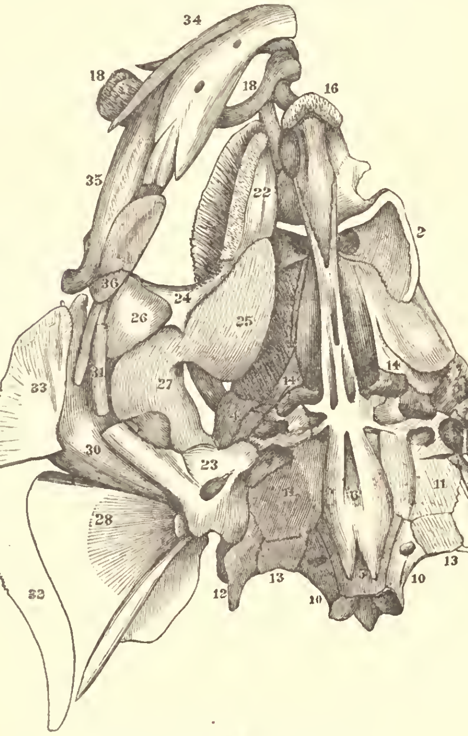


FIG. 27.—Lower view of Skull of Perch.

plectic (31), and quadrate (26); they are connected by means of the metapterygoid (27) with the pterygoid (24) and entopterygoid (25), the foremost bone of the arch being the palatine (22). Of these bones the uppermost, the epitympanic or hyomandibular (23), is articulated by a double articulary head with the mastoid and posterior frontal. Another articulary head is destined for the opercular joint. The mesotympanic or symplectic (31) appears as a styliform prolongation of the lower part of the hyomandibular; it is cartilaginous in the young, but almost completely ossified in the adult. The position of this bone is noteworthy, because, directly inwards from its cartilaginous junction with the hyomandibular, there is situated the uppermost piece of the hyoid arch, the stylohyal. The next bone of the series is the pretympanic or metapterygoid (27), a flat bone forming a bridge towards the pterygoid, and not rarely absent in the subclass. Finally, the large triangular hypotympanic or quadrate (26) has a large condyle for the mandibular joint. The palatine arch proper is formed by three bones: the entopterygoid (25) is an oblong and thin bone attached to the inner border of the palatine and pterygoid, and increasing the surface of the bony roof of the mouth towards the median line; it constitutes also the floor of the orbit; the pterygoid (or *os transversum*) (24) starts from the quadrate, and is joined by suture to the palatine, which is toothed in the perch and many other fishes, and reaches to the vomer and anterior frontal. The piece of the mandible which articulates with the quadrate is the articulary bone (35), distinctly part of Meckel's cartilage; it sends upwards a coronoid process to which the masticatory muscles, as well as a ligament from the maxillary, are attached; it also sends forwards a long-pointed process to be sheathed in a deep notch of the dentary piece. Frequently another portion of cartilage below the articulary remains persistent, or is replaced by a separate membrane-bone, the angular.

4. *Membrane-Bones of the Alimentary Portion of the Visceral Skeleton of the Skull.*—The suspensorium has one tegumentary bone attached to it, viz., the præoperculum (30); it is but rarely absent, as for instance in *Murænophis*; as it is quite a superficial bone, and frequently armed with spines (as in the perch), its form and configuration constitute an important item in the description of many fishes. The premaxillary (17) and maxillary (18) of the *Teleostei* appear to be also membrane-bones, although they are clearly analogous to the upper labial cartilages of the sharks. The premaxillaries sometimes coalesce into a single piece (as in *Diodon*, *Mormyrus*), or they are firmly united with the maxillaries (as in all Gymnodonts, *Serrasalmo*, &c.). The relative position and connexion of these two bones differ much, and form a valuable character in the discrimination of the various families. In some, the front margin of the jaw is formed by the premaxillary only, the two bones having a parallel position, as in the perch, in which case the maxillary is constantly toothless; in others, the premaxillary is shortened, allowing the maxillary to enter, and to complete, the margin of the upper jaw; and finally, in many, no part of the maxillary is situated behind the premaxillary, but the entire bone is attached to the end of the premaxillary, forming its continuation. In the last case the maxillary may be quite abortive. The mobility of the upper jaw is greatest in those fishes in which the premaxillary alone forms its margin. The form of the premaxillary is subject to great variation: the beak of *Belone* and *Xiphias* is formed by the prolonged and coalesced premaxillaries. The maxillary consists sometimes of one piece, sometimes of two or three. The principal membrane-bone of the mandible is the dentary (34), to which is added the angular (36) and rarely a smaller one, the splenial or *os operculare*, which is situated at the inner side of the articulary.

5. *Cartilage-Bones of the Respiratory Portion of the Visceral Skeleton of the Skull.*—With few exceptions all the ossifications of the hyoid and branchial arches belong to this group.

The hyoid arch is suspended by a slender styliform bone, the stylohyal (29), from the hyomandibulars; it consists of three segments, the epihyal (37), the ceratohyal (38), which is the longest and strongest piece, and the basihyal, which is formed by two juxtaposed pieces (39, 40). Between the latter there is a median styliform ossicle (41), extending forwards into the substance of the tongue, called the glossohyal or *os linguale*.

The branchial arches (figs. 26 and 28) are enclosed within the hyoid arch, with which they are closely connected at the base. In the perch and in the majority of Teleosteans they are five in number, of which four bear gills, whilst the fifth (56) remains dwarfed, and is beset with teeth; it is called the lower pharyngeal bone. The arches adhere by their lower extremities to a chain of ossicles (53, 54, 55), the basibranchials, and, curving as they ascend, nearly meet at the base of the cranium, to which they are attached by a layer of ligamentous and cellular tissue. Each of the first three branchial arches consists of four pieces movably connected with one another. The lowest is the hypobranchial (57), the next, a much longer one, the

Fig. 28.—Hyoid bone of the Perch.

ceratobranchial (58), and, above this, a slender and short irregularly-shaped epibranchial. In the fourth arch the hypobranchial is absent. The uppermost of these segments, especially of the fourth arch, are dilated, and more or less confluent; they are beset with fine teeth, and generally distinguished as the upper pharyngeal bones. Only the ceratobranchial is represented in the fifth arch or lower pharyngeal. On their outer convex side the branchial segments are grooved for the reception of large blood-vessels and nerves; on the inner side they support horny processes, called the gill-rakers, which do not form part of the skeleton.

6. *Membrane-Bones of the Respiratory Portion of the Visceral Skeleton of the Skull.*—These include the opercular pieces, viz., the operculum (28), suboperculum (32), and interoperculum (33). The last of these is the least constant; it may be entirely absent, and represented by a ligament extending from the mandible to the hyoid. The operculum is the principal piece, situated behind, and movably united with, the vertical limb of the præoperculum. There is an articulary cavity at its upper anterior angle for its junction with the hyomandibular. The interoperculum is connected by ligament with the angular piece of the mandible, and is also attached to the outer face of the hyoid, so that the gill-covers cannot open or shut without the hyoid apparatus executing a corresponding movement. The remaining membrane-bones are the urohyal (42), a single bone, which is connected by ligament with the anterior extremity of the humeral arch, and separates the musculi sternohyoidei, serving as an increased surface for their insertion; and, finally, the branchiostegals (43), which vary greatly in number, but are always fixed to the ceratohyals and epihyals by ligaments; the branchiostegal membrane is extended between them.

7. *Dermal Bones of the Skull.*—To this category are referred some bones which are ossifications of, and belong to, the cutis. They are the turbinals (20), the suborbitals (19), and the supratemporals. They vary much with regard to the degree in which they are developed, and are seldom entirely absent. Nearly always they are wholly or partly transformed into tubes or hollows, in which the muciferous canals with their numerous nerves are lodged. Those in the temporal and scapulary regions are not always developed; on the other hand, the series of those ossicles may be continued on to the trunk, accompanying the lateral line. The foremost suborbital is termed the præorbital.

The pectoral arch or shoulder-girdle of the Teleosteous fishes exhibits but a remnant of a primordial cartilage, which is replaced by two ossifications,[1] the caracoid (51) and scapula (52); posteriorly they offer attachment to two series of short rods (53), of which the proximal are nearly always ossified, whilst the distal frequently remain small cartilaginous nodules hidden in the base of the pectoral rays; they have been termed carpals and metacarpals. The bones by which this portion is connected with the skull are membrane-bones, viz., the clavicle (48), with the postclavicle (49 + 50), the supraclavicle (47), and the post-temporal (46). By this last bone the shoulder-girdle is suspended from the skull; it is attached, in the perch, by a triple prong to the occipital and mastoid bones. The clavicle completes the arch below by the symphysis or natural connexion of the bones of each side. Many Teleosteous fishes lack pectoral fins, and in them the pectoral arch is frequently more or less reduced or rudimentary, as in many species of *Murænidæ*. In others the membrane-bones are exceedingly strong, contributing to the outer protective armour of the fish, and then the clavicles are generally suturally connected in the median line. The postclavicula and the supraclavicula may be absent. It is only exceptionally that the shoulder-girdle is not suspended from the skull, but from the anterior portion of the spinous column (*Symbranchidæ*, *Murænidæ*, *Notacanthidæ*). The number of elements in each of the two series of basalia never exceeds five, but may be smaller; and the distal series is absent in Siluroids.

Pectoral arch.

The pubic bones (80) of the Teleosteous fishes undergo many modifications of form in the various families, but they are essentially of the same simple type as in the perch, viz., a pair of flat or styliform simple bones, to which the ventral fins are articulated.

Pubic bones.

The bones of the skull of the fish have received so many different interpretations that no two accounts agree in their nomenclature, so that their study is a matter of considerable difficulty. The table of synonyms given on p. 644 will tend to overcome difficulties arising from this cause; it contains the terms used for the different bones of the skeleton by Cuvier, those introduced by Owen, and finally the nomenclature of Stannius, Huxley, and Parker. Those adopted here are printed in italics. The numbers in the table are those used in the preceding pages and in figs. 24–28.

Modifications of the Skeleton.

We now proceed to pass briefly in review the modifications of the skeleton in the principal types of fishes, commencing at the lowest, and pointing out its gradual development in the other three subclasses.

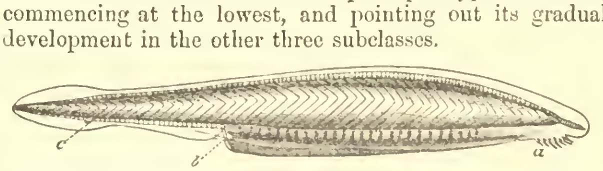


Fig. 29.—*Branchiostoma lanceolatum.* *a*, mouth; *c*, vent; *b*, abdominal porus.

The lowermost subclass of fishes, which comprises one form only, the Lancelet (*Branchiostoma* [s. *Amphioxus*] *lanceolatum*), possesses the skeleton of the most primitive

[1] Parker's nomenclature is adopted here.

TABLE *of Nomenclature used by Cuvier, Owen, Stannius, Huxley, &c., to indicate the Bones in the Skeleton of a Fish.*

CUVIER.	OWEN.	STANNIUS.	HUXLEY, PARKER, &C.
1. Frontal principal	*Frontal*	Os frontale	
2. Frontal antérieur	*Prefrontal*	Os frontale anterius	Lateral ethmoid (Parker)
3. *Ethmoid*	Nasal	Os ethmoideum	
4. Frontal postérieur	*Postfrontal*	Os frontale posterius	Sphenotic (Parker
5. Basilaire	*Basioccipital*	Os basilare	
6. Sphénoide	*Basisphenoid*	Os sphenoideum basilare	Sometimes referred to as "*Basal*"
7. Pariétal	*Parietal*	Os parietale	
8. Interpariétal or occipital supérieur	*Supraoccipital*	Os occipitale superius	
9. Occipital externe	*Paroccipital*	Os occipitale externum	Epioticum (Huxley)
10. Occipital lateral	*Exoccipital*	Os occipitale laterale	
11. Grand aile du sphénoide	*Alisphenoid*	Ala temporalis	Prooticum (Huxley)
12. Mastoidien	*Mastoid*	Os mastoideum + os extrascapulare	Opisthoticum[1] + *Squamosal* (Huxley)
13. Rocher	Petrosal and Otosteal	Oberflächliche Knochen-lamelle	
14. Aile orbitaire	*Orbitosphenoid*	Ala orbitalis	Alisphenoid (Huxley)
15. Sphenoide antérieur	Ethmoid and Ethmo-turbinal	Os sphenoideum anterius	*Basisphenoid* (Huxley)
16. *Vomer*	Vomer	Vomer	
17. Intermaxillaire	*Inter- or Pre-maxillary*	Os intermaxillare	
18. Maxillaire supérieur	*Maxillary*	Os maxillare	
19. Sousorbitaires	*Infraorbital ring*	Ossa infraorbitalia	
20. Nasal	*Turbinal*	Os terminale	
22. Palatine	*Palatin*	Os palatinum	
23. Temporal	Epitympanic	Os temporale	*Hyomandibular* (Huxley)
24. Transverse	*Pterygoid*	Os transversum s. pterygoideum externum	
25. Ptérygoidien interne	*Entopterygoid*	Os pterygoideum	Mesopterygoid (Parker)
26. Jugal	Hypotympanic	Os quadratojugale	*Quadrate* (Huxley)
27. Tympanal	Pretympanic	Os tympanicum	*Metapterygoid* (Huxley)
28. Operculaire	*Operculum*	Operculum	
29. Styloide	*Stylohyal*	Os styloideum	
30. Préopercule	*Præoperculum*	Præoperculum	
31. Symplectique	Mesotympanic	*Os symplecticum*	
32. Sousopercule	*Suboperculum*	Suboperculum	
33. Interopercule	*Interoperculum*	Interoperculum	
34. Dentaire	*Dentary*	Os dentale	
35. Articulaire	*Articulary*	Os articulare	
36. Angulaire	*Angular*	Os angulare	
37, 38. Grandes pièces latérales	*Epihyal, Ceratohyal*	Segmente der Zungenbein-Schenkel	
39, 40. Petites pièces latérales	*Basihyal*		
41. Os lingual	*Glossohyal*	Os linguale s. entoglossum	
42. Queue de l'os hyoide	*Urohyal*		Basibranchiostegal (Parker)
43. Rayon branchiostège	*Branchiostegal*	Radii branchiostegi	
46. Surscapulaire	Suprascapula	Omolita	*Post-temporal* (Parker)
47. Scapulaire	Scapula	Scapula	*Supraclavicula* (Parker)
48. Humeral	Coracoid	Clavicula	*Clavicula* (Parker)
49, 50. Coracoid	Epicoracoid		*Postclavicula* (Parker)
51. Cubital	Radius	Ossa carpi	*Coracoid* (Parker)
52. Radial	Ulna		*Scapula* (Parker)
53. Os du carpe	*Carpals*	Ossa metacarpi	*Basalia* (Huxley) Brachials (Parker)
53 *bis*, 54, 55. Chaine intermédiaire	*Basibranchials*	Copula	
56. Pharyngiens inférieurs	*Lower Pharyngeals*	Ossa pharyngea inferiora	
57. Pièce interne de partie inférieure de l'arceau branchiale	*Hypobranchial*	Segmente der Kiemenbogen-Schenkel	
58. Pièce externe do. do.	*Ceratobranchial*		
59. Stylet de prémière arceau branchiale	*Upper epibranchial of first branchial arch*		
61. Partie supérieure de l'arceau branchiale	*Epibranchials*		
62. Os pharyngien supérieur	Pharyngobranchial	Os pharyngeum superius	*Upper pharyngeals*
63.	*Gill-rakers*		
65. Rayons de la pectorale	*Pectoral rays*	Brustflossen-Strahlen	
67, 68. Vertèbres abdominales	*Abdominal vertebræ*	Bauchwirbel	
69. Vertèbres caudales	*Caudal vertebræ*	Schwanzwirbel	
70. Plaque triangulaire et verticale	[Aggregated interhæmals]	Verticale Platte	*Hypural* (Huxley)
71.	*Caudal rays*	Schwanzflossen-Strahlen	
72. Côte	*Rib*	Rippen	
73. Appendices or stylets	*Epipleural spines*	Muskel-Gräthen	
74. Interépineux	*Interneural spines*	Ossa interspinalia s. obere Flossenträger	
75. Épines et rayons dorsales	*Dorsal rays and spines*	Rückenflossen-Strahlen u. Stacheln	
76.	*First interneural*		
78	*Rudimentary caudal rays*		
79. Apophyses épineuses inférieures	*Interhæmal spines*	Untere Flossenträger	
80.	*Pubic*	Becken	
81.	*Ventral spine*	Bauchflossen-Stachel	

[1] Pterotic of Parker.

type. The vertebral column is represented by a simple chorda dorsalis or notochord only, which extends from one extremity of the fish to the other, and, so far from being expanded into a cranial cavity, is pointed at its anterior end as well as at its posterior. It is enveloped in a simple membrane like the spinal cord and the abdominal organs,

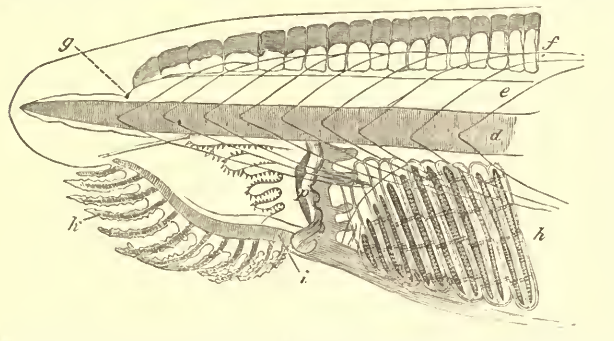


FIG. 30.—Anterior end of body of *Branchiostoma* (magn.). *d*, chorda dorsalis; *e*, spinal cord; *f*, cartilaginous rods; *g*, eye; *h*, branchial rods; *i*, labial cartilage; *k*, oral cirrhi.

and there is no trace of vertebral segments or ribs; a series of short cartilaginous rods, however, above the spine evidently represent apophyses. A maxillary or hyoid apparatus, or elements representing limbs, are entirely absent.

The skeleton of the *Cyclostomata* (or *Marsipobranchii*) (lampreys and sea-hags) shows a considerable advance of development. It consists of a notochord, the anterior pointed end of which is wedged into the base of a cranial capsule, partly membranous, partly cartilaginous. This skull, therefore, is not movable upon the spinal column. No vertebral segmentation can be

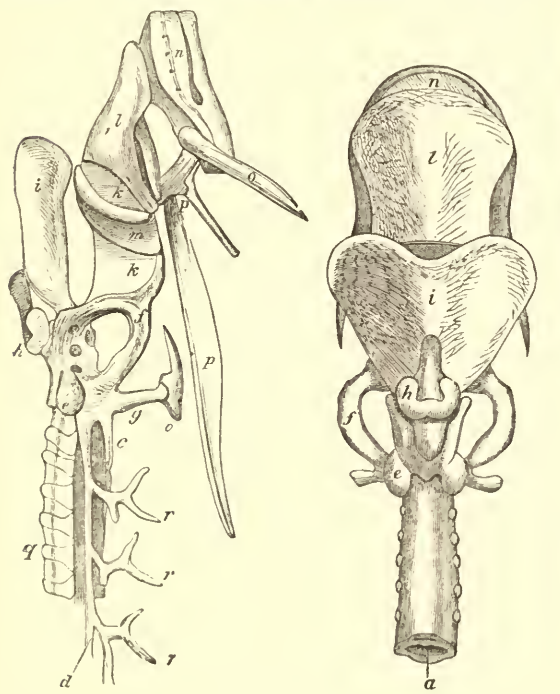
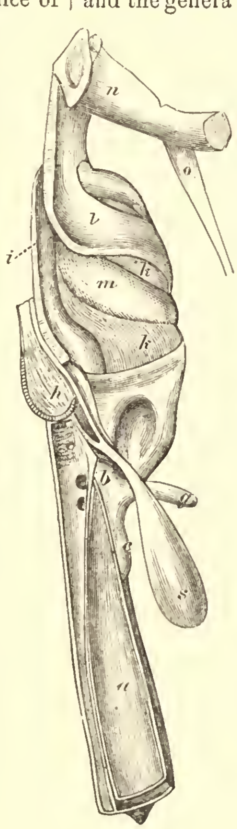



FIG. 31.—Upper (*A*) and side (*B*) views, and vertical section (*C*), of the skull of *Petromyzon marinus*. *a*, notochord; *b*, basis cranii; *c*, inferior, and *d*, lateral process of basis; *e*, auditory capsule; *f*, subocular arch; *g*, stylohyal process; *h*, olfactory capsule; *i*, ethmo-vomerine plate; *k*, palato-pterygoid portion of subocular arch; *l*, *m*, *n*, accessory labial or rostral cartilages, with *o*, appendage; *p*, lingual cartilage; *q*, neural arches; *r*, branchial skeleton; *s*, blind termination of the nasal duct between the notochord and œsophagus.

observed in the notochord, but neural arches are represented by a series of cartilages on each side of the spinal chord. In *Petromyzon* (fig. 31) the basis cranii emits two prolongations on each side, an inferior, extending for some distance along the lower side of the spinal column, and a lateral, which is ramified into a skeleton supporting the branchial apparatus. A stylohyal process and a subocular arch with a palato-pterygoid portion may be distinguished. The roof of the cranial capsule is membranous in *Myxine* and in the larvæ of *Petromyzon*, but more or less cartilaginous in the adult *Petromyzon* and in *Bdellostoma*. A cartilaginous capsule on each side of the hinder part of the skull contains the auditory organ, whilst the olfactory capsule occupies the anterior upper part of the roof. A broad cartilaginous lamina, starting from the cranium and overlying part of the snout, has been determined as representing the ethmo-vomerine elements, whilst the oral organs are supported by large, very peculiar cartilages (labials), greatly differing in general configuration and arrangement in the various Cyclostomes. There are three in the sea-lamprey, of which the middle one is joined to the palate by an intermediate smaller one; the foremost is ring-like, tooth-bearing, emitting on each side a styliform process. The lingual cartilage is large in all Cyclostomes. There is no trace of ribs or limbs.

The Chondropterygians exhibit a most extraordinary diversity in the development of their vertebral column; almost every degree of ossification, from a notochord without a trace of annular structure to a series of completely ossified vertebræ, being found in this order. The sharks in which the notochord is persistent are the *Holocephali* (if they be reckoned as belonging to this order) and the genera *Notidanus* and *Echinorhinus*. In the other sharks the segmentation is complete, each vertebra having a deep conical excavation in front and behind, with a central canal through which the notochord is continued; but the degree in which the primitive cartilage is replaced by concentric or radiating lamellæ of bone varies greatly in the various genera, and according to the age of the individuals. In the rays all the vertebræ are completely ossified, and the anterior ones confluent into one continuous mass. In the majority of Chondropterygians the extremity of the vertebral column shows a decidedly heterocercal condition, and only a few, like *Squatina* and some rays, possess a diphycercal tail.

The advance in the development of the skeleton in Chondropterygians beyond the primitive condition of the previous subclasses manifests itself further by the presence of neural and hæmal elements, extending to the foremost part of the axial column; but of these the hæmal form a closed arch in the caudal region only, whilst on the trunk they appear simply as a lateral longitudinal ridge. The neural and hæmal apophyses are either merely attached to the axis, as in Chondropterygians with persistent notochord (the rays and some sharks); or their basal portions penetrate like wedges into the substance of the centrum, so that, in a transverse section, in consequence of the difference in their texture, they appear in the form of an X (figs. 32–34). The interspaces between the neurapophyses of the vertebræ are not filled by fibrous membrane, as in other fishes, but by separate cartilages (laminæ or cartilagines intercrurales), to which frequently a series of terminal pieces is superadded, which must be regarded as the first appearance of the interneural spines of the *Teleostei* and many Ganoids. Similar terminal pieces are sometimes observed on the hæmal arches. Ribs are either absent or but imperfectly represented (*Carcharias*).

The substance of the skull of the Chondropterygians is cartilage, interrupted especially on its upper surface by more or less extensive fibro-membranous fontanelles. Superficially it is covered by a more or less thick shagreen-

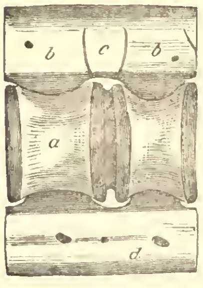


Fig. 32.

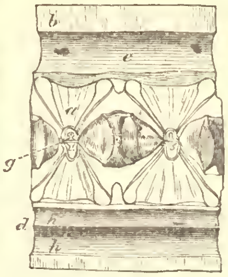


Fig. 33.

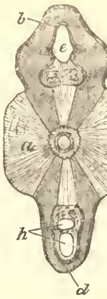


Fig. 34.

FIGS. 32, 33, 34.—Lateral view, longitudinal section, and transverse section of caudal vertebra of Basking Shark (*Selache maxima*). (After Hasse.) *a*, centrum; *b*, neurapophysis; *c*, intercrural cartilage; *d*, hæmapophysis; *e*, spinal canal; *f*, intervertebral cavity; *g*, central canal for persistent portion of notochord; *h*, hæmal canals for blood-vessels.

like osseous deposit. The articulation with the vertebral column is effected by a pair of lateral condyles. In the sharks, besides, a central conical excavation corresponds to that of the centrum of the foremost vertebral segment, whilst in the rays this central excavation of the skull receives a condyle of the axis of the spinous column. The cranium itself is a continuous undivided cartilage, in which the limits of the orbit are well marked by an anterior and posterior protuberance. The ethmoidal region sends horizontal plates over the nasal sacs, the apertures of which retain their embryonic situation upon the under surface of the skull. In the majority of Chondropterygians these plates are produced conically, forming the base of the soft projecting snout; and in some forms, especially in the long-snouted rays and the saw-fishes (*Pristis*), this prolongation appears in the form of three or more tubiform rods. As separate cartilages there are appended to the skull a suspensorium, a palatine, a mandible, a hyoid, and rudimentary maxillary elements. The suspensorium is movably attached to the side of the skull. It generally consists of one piece only, but in some rays of two. In the rays it is articulated to the mandible only, their hyoid possessing a distinct point of attachment to the skull. In the sharks the hyoid is suspended from the lower end of the suspensorium together with the mandible. What is generally called the upper jaw of a shark is, as Cuvier has already stated, not the maxillary, but the palatine. It consists of two simple lateral halves, each of which articulates with the corresponding half of the lower jaw, which is formed by the simple representative of Meckel's cartilage. Some cartilages of various sizes are generally developed on each side of the palatine, and one on each side of the mandible. They are called labial cartilages, and seem to represent maxillary elements. The hyoid consists generally of a pair of long and strong lateral pieces, and a single mesial piece. From the former, cartilaginous filaments (representing branchiostegals) pass directly outwards. Branchial arches, varying in number, and similar to the hyoid, succeed it. They are suspended from the side of the foremost part of the spinous column, and, like the hyoid, bear a number of filaments.

The vertical fins are supported by interneural and interhæmal cartilages, each of which consists of two or more pieces; to these fins the fin-rays are attached without articulation. The scapular arch of the sharks is formed by a single coracoid cartilage bent from the dorsal region downwards and forwards. In some genera (*Scyllium*, *Squatina*) a small separate scapular cartilage is attached to the dorsal extremities of the coracoid; but in none of the Elasmobranchs is the scapular arch suspended from the skull or vertebral column; it is merely sunk and fixed in the substance of the muscles. Behind, at the point of its greatest curvature, three carpal cartilages are joined to the coracoid, which Gegenbaur has distinguished as propterygium, mesopterygium, and metapterygium, the first occupying the front, the last the hind margin of the fin. Several more or less regular transverse series of styliform cartilages follow. They represent the phalanges, to which the horny filaments which are imbedded in the skin of the fin are attached. In the rays, with the exception of torpedo, the scapular arch is intimately connected with the confluent anterior portion of the vertebral column. The anterior and posterior carpal cartilages are followed by a series of similar pieces, which extend like an arch forwards to the rostral portion of the skull, and backwards to the pubic region. Extremely numerous phalangeal elements, longest in the middle, are supported by the carpals, and form the skeleton of the lateral expansion of the so-called disk of the ray's body, which thus, in fact, is nothing but the enormously enlarged pectoral fin.

The pubic is represented by a single median transverse cartilage, with which a tarsal cartilage articulates. The latter supports the fin-rays. To the end of this cartilage is also attached, in the male Chondropterygians, a peculiar accessory generative organ or clasper.

The *Holocephali* differ from the other Chondropterygians in several important points of the structure of their skeleton, and unmistakably approach certain Ganoids. That their spinal column is persistently notochordal has been mentioned already. Their palatal apparatus, with the suspensorium, coalesces with the skull, the mandible articulating with a short apophysis of the cranial cartilage (autostylic skull). The mandible is simple, without anterior symphysis. The spine with which the dorsal fin is armed articulates with a neural apophysis, and is not immovably attached to it, as in the sharks. The pubic consists of two lateral halves, with a short, rounded tarsal cartilage.

The skeleton of the Ganoid fishes presents extreme variations with regard to the degree in which ossifications replace the primordial cartilage. Whilst some exhibit scarcely any advance beyond the Plagiostomes with persistent cartilage, others, as regards the development and specialization of the several parts of their osseous framework, approach the Teleosteans so closely that their Ganoid nature can be demonstrated by, or inferred from, other considerations only. All Ganoids possess a separate gill-cover.

The diversity in the development of the Ganoid skeleton is well exemplified by the few representatives of the order in the existing fish fauna. Lowest in the scale in this respect are those with a persistent notochord, and an autostylic skull, that is, a skull without separate suspensorium—the fishes constituting the suborder *Dipnoi*, of which the existing representatives are *Lepidosiren*, *Protopterus*, and *Ceratodus*, and the extinct (so far as demonstrated at present) *Dipterus*, *Chirodus* (and *Phaneropleuron*?). In these fishes the notochord is persistent, passing uninterruptedly into the cartilaginous base of the skull. Some *Dipnoi* are diphy-, others hetero-cercal. Neural and hæmal elements and ribs are well developed.

The primordial cranium of the *Dipnoi* is cartilaginous, but with more or less extensive ossifications in its occipital, basal, or lateral portions, and with large tegumentary bones, which, from this suborder upwards in the series, will be found to exist throughout the remaining forms of fishes. A strong process descends from the cranial cartilage, and offers by means of a double condyle (fig. 35, *s*) attachment to corresponding articulary surfaces of the lower jaw. Maxillary and intermaxillary elements are not developed, but are perhaps represented in *Ceratodus* by some inconstant rudimentary labial cartilages situated behind the posterior nasal opening. Facial cartilages and an infraorbital ring are developed, at least in *Ceratodus*. The presence of a pair of small teeth in front indicates the vomerine portion (*v*) which remains cartilage, whilst the posterior pair of teeth are implanted in a pterygo-palatine ossification (*l*), which sometimes is paired, sometimes continuous. The base of the skull is constantly covered by a large basal ossification (*o*). The hyoid is well developed, sometimes reduced to a pair of ceratohyals, sometimes with a basihyal and glossohyal. The skeleton of the branchial apparatus approaches the Teleosteous type, less so in *Lepidosiren* than in *Ceratodus*, in which five branchial arches are developed, but with the lateral and mesial pieces reduced in number. A large operculum, and a smaller sub- or inter-operculum are present.

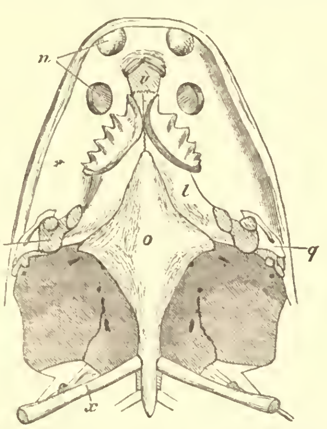


Fig. 35.—Palatal view of skull of *Ceratodus*.

The scapular arch consists of a single median transverse cartilage, and a pair of lateral cartilages which bear the articular condyle for the pectoral limb. The latter cartilages form the base of a large membrane-bone, and the whole arch is suspended from the skull by means of an osseous supraclavicle. The fore-limb of the *Dipnoi* (fig. 36) greatly differs externally from the pectoral fin of other Ganoid fishes. It is covered with small scales along the middle, from the root to its extremity, and surrounded by a rayed fringe similar to the vertical fin (crossopterygian type of fin). A muscle split into numerous fascicles extends all the length of the fin, which is flexible in every part and in every direction. The cartilaginous framework supporting it is joined to the scapular arch by an oblong cartilage, followed by a broad basal cartilage (*a*), generally single, but sometimes showing traces of a triple division. Along the middle of the fin runs a jointed axis (*b*), the joints gradually becoming smaller and thinner towards the extremity; each joint bears on each side a three-, two-, or one-jointed branch (*c*, *d*). This axial arrangement of the pectoral skeleton, which evidently represents one of its first and lowest conditions, has been termed the *archipterygium* by Gegenbaur. It is found in *Ceratodus* and other genera, but in *Lepidosiren* the jointed axis only has been preserved, while rudimentary rays are added in *Protopterus*.

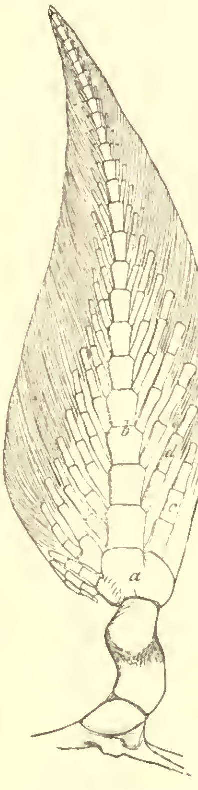


Fig. 36.—Fore-limb of *Ceratodus*.

The pubic consists of a single flattened subquadrangular cartilage, produced into a long single anterior process. Posteriorly it terminates on each side in a condyle, to which the basal cartilage of the ventral paddle is joined. The endoskeleton of the paddle is almost identical with that of the pectoral.

The Ganoid fishes with persistent notochord, but with a hyostylic skull (that is, a skull with a separate suspensorium), consist of the suborder *Chondrostei*, of which the existing representatives are the sturgeons (*Acipenser*, *Scaphirhynchus*, *Polyodon*), and the extinct the *Chondrosteidæ*, *Palæoniscidæ*, and (according to Traquair) *Platysomidæ*.

Their spinal column does not differ essentially from that of the *Dipnoi*. Segmentation is represented only so far as the neural and hæmal elements are concerned. All are eminently heterocercal. Ribs are present in most, but are replaced by ligaments in *Polyodon*.

The primordial cranium of the sturgeons consists of persistent cartilage without ossifications in its substance, but superficial bones are still more developed and specialized than in the *Dipnoi*; so it is, at least, in the true sturgeons, but less so in *Polyodon* (fig. 37). The upper and lateral parts of the skull are covered by well-developed membrane-bones. The lower surface of the skull is covered by an extremely large basal bone, which extends from the vomerine region on to the anterior part of the spinal column. The nasal excavation in the skull is rather lateral than inferior. The ethmoidal region is generally much produced, forming the base of the long projecting snout. The suspensorium is movably attached to the side of the skull, and consists of two pieces, a hyomandibular and a symplectic, which now appears for the first time as a separate piece, and to which the hyoid is attached. The palato maxillary apparatus is more complex than in the sharks and *Dipnoi*; a palato-pterygoid consists of two mesially-connected rami in *Polyodon*, and of a complex cartilaginous disk in *Acipenser*, being articulated in both to the Meckelian cartilage. In addition, the sturgeons possess one or two pairs of osseous rods, which, in *Polyodon* at least, represent the maxillary, and therefore must be the representatives of the labial cartilages of the sharks. The Meckelian cartilage is more or less covered by tegumentary bones. In the gill-cover, besides the operculum, a sub- and inter-operculum may be distinguished in *Acipenser*. The hyoid consists of three pieces, of which the posterior bears a broad branchiostegal in *Polyodon*.

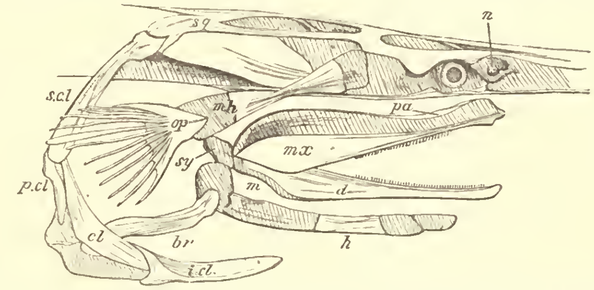


Fig. 37.—Skull of *Polyodon*. (After Traquair.) *n*, nasal cavity; *sq*, squamosal; *mh*, hyomandibular; *sy*, symplectic; *pa*, palato-pterygoid; *m*, Meckelian cartilage; *mx*, maxillary; *d*, dentary; *h*, hyoid; *op*, operculum; *br*, branchiostegal; *s.cl*, supraclavicular; *p.cl*, postclavicular; *cl*, clavicle; *i.cl*, infraclavicular.

In the scapulary arch the primordial cartilaginous elements scarcely differ from those of the *Dipnoi*. The membrane-bones are much expanded, and show a continuous series suspended from the skull. Their division in the median ventral line is complete. The pectoral is supported by a cartilaginous framework (fig. 38) similar to that of *Ceratodus*, but much more shortened and reduced in its periphery, the branches being absent altogether on one side of the axis. This modification of the fin is analogous to the heterocercal condition of the end of the spinous column. To the inner corner of a basal cartilage (*a*) a short axis (*b*) is joined, which on its outer side bears a few branches (*d*) only, the remaining branches (*c*) being fixed to the basal cartilage. The dermal fin-rays are opposed to the extremities of the branches, as in the *Dipnoi.*

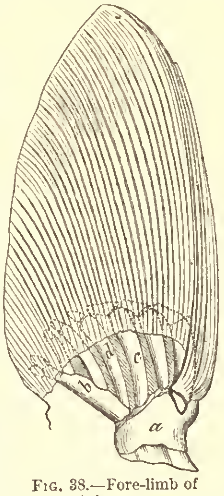


Fig. 38.—Fore-limb of *Acipenser.*

The pubic consists of a paired cartilage, to which tarsal pieces supporting the fin-rays are attached.

The other existing Ganoid fishes have the spinous column entirely or almost entirely ossified; these have been comprised under the common name *Holostei.* They form, however, three very distinct types; several attempts have been made to co-ordinate with them the fossil forms, but this task is beset with extreme difficulties, of which no satisfactory solution has as yet been advanced.

The *Polypteroidei* have their spinous column formed by distinct osseous amphicœlous vertebræ, that is, vertebræ with concave anterior and posterior surfaces. It is nearly diphycercal. The neural arches, though ossified, do not coalesce with the

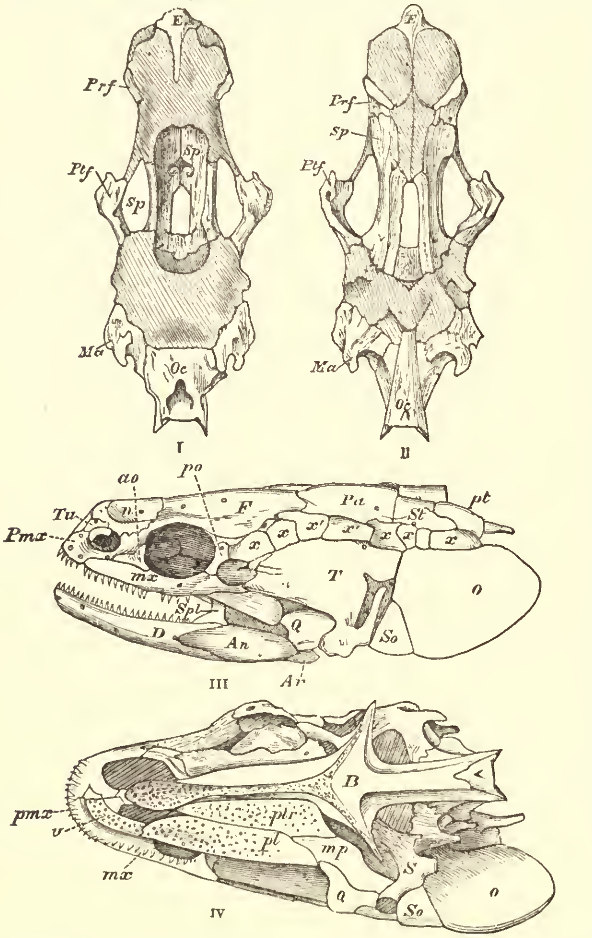


Fig. 39.—Skull of *Polypterus.* (After Traquair.) I. Upper aspect of the primordial cranium, with the membrane-bones removed. II. Lower aspect of the same. III. Side view, with the membrane-bones. IV. Lower aspect of the skull, part of the bones being removed on one side. The parts shaded with oblique lines are cartilage of the primordial skull. *An*, angular; *ao*, anteorbital; *Ar*, articulary; *B*, basal; *D*, dentary; *E*, ethmoid; *F*, frontal; *Ma*, mastoid; *Mp*, metapterygoid; *Mx*, maxillary; *N*, nasal; *O*, operculum; *Oc*, occipital; *Pa*, parietal; *Pl*, palatine; *Pmx*, præmaxillary; *po*, postorbital; *Prf*, prefrontal; *Pt*, post-temporals; *Ptf*, postfrontal; *Ptr*. pterygoid; *Q*, quadrate; *S*, suspensorium; *So*, suboperculum; *Sp*, sphenoid; *Spl*, splenial; *St*, supratemporals; *T*, tympanic lamina; *Tu*, turbinal; *v*, vomer; *x x*, small ossicles; *x′ x′*, spiraculars.

centrum, and form one canal only for the myelon. There are no intermediate elements between the neural spines. Interneurals are developed, but are simple, articulating with the dermoneurals. The abdominal vertebræ have parapophyses developed with epipleural spines. Only the caudal vertebræ have hæmal spines, which, like the interhæmals, agree in every essential respect with the opposite neurals. Ribs are inserted, not on the parapophyses, but on the centra, immediately below the parapophyses.

The skull of *Polypterus* (fig. 39) shows a great advance towards the Teleosteous type, the number of separable bones being greatly increased. They are arranged much in the same fashion as in *Teleostei*, but a great portion of the primordial cranium remains cartilaginous. The membrane-bones which cover the upper and lower surfaces of the brain-case are so much developed as to cause the underlying cartilage to disappear, so that a large vacuity or fontanelle exists in the substance of the upper as well as of the lower cartilaginous wall. Of ossifications belonging to the primordial skull must be noticed the single occipital with a mastoid on each side. They are separated by persistent cartilage from the sphenoids and postfrontals; the former, which are the largest ossification of the primordial cranium, enclose the anterior half of the brain cavity. Finally, the nasal portion contains a median ethmoid and a pair of præfrontal bones. Only a very small portion of the bones described are visible externally, nearly the whole of the primordial cranium being covered by the membrane-bones. Of these are seen on the upper surface a pair of parietals, frontals, "nasals," and turbinals; on the lower surface a large cross-shaped basal, anteriorly bordered on each side by a pterygoid, parallel to a palatine which forms a suture with the double vomer. The suspensorium has in front a metapterygoid and quadrate bone, and an operculum and suboperculum are attached to it behind. Præmaxillaries and maxillaries are now fully developed, but immovably attached to the skull. The lower jaw is ossified, and consists of an articulary, angular, dentary, and splenial. Of labial cartilages a rudiment at the angle of the mouth has remained persistent. The side of the skull, in front of the operculum, is covered by a large irregularly-shaped bone (*T*) (corresponding to the "tympanic lamina" of *Ceratodus*, fig. 35, *q*), held by some to be the præoperculum; along its upper circumference lies a series of small ossicles, of which two may be distinguished as spiraculars, as they form a valve for the protection of the spiracular orifice of these fishes. An infraorbital ring is represented by a præorbital and postorbital only.

Each hyoid consists of three pieces, none of which bear branchiostegals, the single median piece being osseous in front and cartilaginous behind. Four branchial arches are developed, the foremost consisting of three, the second and third of two, and the last of a single piece. There is no lower pharyngeal. Between the rami of the lower jaw the throat is protected by a pair of large osseous laminæ (gular plates), which have been considered to represent the urohyal of osseous fishes. The scapulary arch is almost entirely formed by the well-developed membrane-bones, which in the ventral line are suturally united. The pectoral fin is supported by three bones, pro-, meso-, and meta-pterygium, of which the dilated middle one alone bears rays, and is excluded from the articulation with the shoulder-girdle.

The pubic consists of a paired bone, to which tarsal bones supporting the fin-rays are attached.

In the *Lepidosteoidei* the vertebræ are completely ossified and opisthocœlous, having a convexity in front and a concavity behind, as in some amphibians. Though the end of the body externally appears nearly diphycercal, the termination of the vertebral column is, in fact, distinctly heterocercal. The caudal fin is suspended from hæmapophyses only, and does not extend to the neural side of the vertebral column. The neural arches coalesce with the centrum; the interneurals are simple. The abdominal vertebræ have parapophyses, to which the ribs are attached. Only the caudal vertebræ have hæmal spines.

In the skull of *Lepidosteus* the cartilage of the endocranium is still more replaced by ossifications than in *Polypterus*, those ossifications, moreover, being represented by a greater number of discrete bones. The membrane-bones in particular are greatly multiplied: the occipital, for instance, consists of three pieces; the vomer is double, as in *Polypterus*; the maxillary consists of a series of pieces firmly united by suture. The symplectic reaches the lower jaw, so that the articulary is provided with a double joint, viz., for the symplectic and quadrate; the component parts of the lower jaw are as numerous as in reptiles, a dentary, splenial, articulary, angular, supra-angular, and coronary being distinct. The sides of the head are covered with numerous bones, and a præoperculum is developed in front of the gill-cover, which, again, consists of an operculum and suboperculum.

Each hyoid consists of three pieces, of which the middle is the longest, the upper bearing the largest of the three branchiostegals which *Lepidosteus* possesses; a long and large glossohyal is intercalated between the lower ends of the hyoids. There are five branchial arches, the hindmost of which is modified into a lower pharyngeal; upper pharyngeals are likewise present as in the majority of Teleosteous fishes, but there is no gular plate.

Of the scapulary arch the two halves are separated by a suture in the median line; the membrane-bones are well developed, only a remnant of the primordial cartilage remaining; the supraclavicle is very similar to that of Teleosteous fishes, and in a less degree the post-temporal. The base to which the limb is attached is a single osseous plate, supporting on its posterior margin semi-ossified rods in small number, which bear the pectoral rays. The pubic consists of a paired bone. The elements representing a tarsus are quite rudimentary, and reduced in number (two or three).

The vertebral column of the *Amioidei* shows unmistakable characters of the Palæichthyic type. The arrangement of its component parts is extremely simple. The centra of the amphicœlous vertebræ are well ossified, but the neural and hæmal arches do not coalesce with the centra, from which they are separated by a thin layer of cartilage. All the vertebræ do not possess apophyses: in the caudal portion of *Amia* only every alternate vertebra is provided with them. The heterocercal condition of the spinous column is well marked; as in the other *Holostei*, the hindmost vertebræ are turned upwards, become gradually smaller in size, and lose their neural arches, the hæmals remaining developed to the end. Finally, the column terminates in a thin cartilaginous band, which is received between the lateral halves of the fifth or sixth upper caudal ray. The interneurals and interhæmals are simple. Only the abdominal vertebræ have parapophyses, with which the ribs are articulated.

The configuration of the skull, and the development and arrangement of its component parts, approach so much the Teleostean type, that perhaps there are greater differences in skulls of truly Teleostean fishes than between the skulls of *Amia* and of many *Physostomi*. Externally the cranium is entirely ossified; the remains of the cartilaginous primordial cranium can only be seen in a section, and are of much less extent than in many Physostomous fishes. The immovable intermaxillary, the double vomer, the double articulary cavity of the mandible for junction with the quadrate and symplectic bones, remind us still of similar conditions in the skull of *Lepidosteus*; but the mobility and formation of the maxillary, the arrangement of the gill-covers, the development of a præoperculum, the suspensorium, the palate, the insertion of a number of branchiostegals on the long middle hyoid piece, the composition of the branchial framework (with upper and lower pharyngeals), are as in the Teleosteous type. A gular plate replaces the urohyal.

The scapular arch is composed entirely of the membrane-bones found in the *Teleostei*, and the two sides are loosely united by ligament. The base to which the limb is attached is cartilaginous; short semi-ossified rods are arranged along its hinder margin, and bear the pectoral rays.

Myology.

In the lowest vertebrate, *Branchiostoma*, the whole of the muscular mass is arranged in a longitudinal band running along each side of the body; it is vertically divided into a number of flakes or segments (myocommas) by aponeurotic septa, which serve as the surfaces of insertion to the muscular fibres. But this muscular band has no connexion with the notochord except in its foremost portion, where some relation has been formed to the visceral skeleton. A very thin muscular layer covers the abdomen. In the Cyclostomes also the greater portion of the muscular system is without direct relation to the skeleton, and, again, it is only on the skull and visceral skeleton that distinct muscles have been differentiated for special functions.

To the development of the skeleton in the more highly organized fishes corresponds a similar development of the muscles: the maxillary and branchial apparatus, the pectoral and ventral fins, the vertical fins and especially the caudal, possess a separate system of muscles. But the most noteworthy is the muscle covering the sides of the trunk and tail (already noticed in *Branchiostoma*), which Cuvier described as the "great lateral muscle," and which, in the higher fishes, is a compound of many smaller segments (myocommas), corresponding in number with the vertebræ. Each lateral muscle is divided by a median longitudinal groove into a dorsal and ventral half; the depression in its middle is filled by an embryonal muscular substance which contains a large quantity of fat and numerous blood-vessels, and therefore differs from ordinary muscle by its softer consistency, and by its colour, which is reddish or greyish. Superficially the lateral muscle appears crossed by a number of white parallel tendinous zigzag stripes, forming generally three angles, of which the upper and lower point backwards, the middle one forwards. These are the outer edges of the aponeurotic septa between the myocommas. Each septum is attached to the middle and to the apophyses of a vertebra, and, in the abdominal region, to its rib; frequently the septa receive additional support by the existence of epipleural spines.

In connexion with the muscles reference has to be made to the electric organs with which certain fishes are provided. That these have been developed out of muscular substance is more than probable, not only from the examination of peculiar muscular organs (the function of which is still conjectural) occurring in the rays, and in *Mormyrus* and *Gymnarchus*, but especially from the researches into the development of the electric organ of *Torpedo*. The fishes possessing fully developed electric organs, with the power of accumulating electric force and communicating it in the form of shocks to other animals, are the electric rays (*Torpedinidæ*), the electric sheath-fish of tropical Africa (*Malapterurus*), and the electric eel of tropical America (*Gymnotus*). The structure and arrangement of the electric organ are very different in these fishes.

In *Torpedo* the electric organs are large, flat, uniform bodies, lying one on each side of the head, bounded behind by the scapular arch, and laterally by the anterior crescent-shaped tips of the pectoral fins. They consist of an assemblage of vertical hexagonal prisms, whose ends are in contact with the integuments above and below; and each prism is subdivided by delicate transverse septa, forming cells filled with a clear, trembling, jelly-like fluid, and lined within by an epithelium of nucleated corpuscles. Between this epithelium and the transverse septa and walls of the prism there is a layer of tissue on which the terminations of the nerves and vessels ramify. Hunter counted four hundred and seventy prisms in each battery of *Torpedo marmorata*, and demonstrated the enormous supply of nervous matter which they receive. Each organ receives one branch of the trigeminal nerve and four branches of the vagus, the former, and the three anterior branches of the latter, being each as thick as the spinal chord (electric lobes).

In *Malapterurus* the electric organ extends over the whole body, but is thickest on the abdomen; it lies between two aponeurotic membranes below the skin, and consists of rhomboidal cells which contain a rather firm gelatinous substance. The electric nerve takes its origin from the spinal chord, does not enter into connexion with ganglia, and consists of a single enormously-strong primitive fibre, which distributes its branches in the electric organ.

The electric eel is the most powerful of electric fishes. Its electric organ consists of two pairs of longitudinal bodies, situated immediately below the skin, above the muscles,—one pair on the back of the tail, and the other pair along the anal fin. Each fasciculus is composed of flat partitions or septa, with transverse divisions between them. The outer edges of the septa appear in nearly parallel lines in the direction of the longitudinal axis of the body, and consist of thin membranes, which are easily torn; they serve the same purpose as the columns in the analogous organ of the torpedo, making the walls or abutments for the perpendicular and transverse dissepiments, which are exceedingly numerous, and so closely aggregated as to seem almost in contact. The minute prismatic cells, intercepted between these two sorts of plates, contain a gelatinous matter; the septa are about $\frac{1}{30}$th of an inch from each other, and a length of one inch contains a series of two hundred and forty cells, giving an enormous surface to the electric organs. The whole apparatus is supplied with more than two hundred nerves, which are the continuations of the rami anteriores of the spinal nerves. In their course they give out branches to the muscles of the back, and to the skin of the animal. In the Gymnotes, as in the torpedo, the nerves supplying the electric organs are much larger than those bestowed on any part for the purposes of sensation or movement.

The phenomena attending the exercise of this extraordinary faculty closely resemble muscular action. The time and strength of the discharge are entirely under the control of the fish. The power is exhausted after some time, and needs repose and nourishment to restore it. If the electric nerves are cut and divided from the brain, the cerebral action is interrupted, and no irritant to the body has any effect in exciting electric discharge; but if their ends be irritated the discharge takes place, just as a muscle is excited to contraction under similar circumstances. Singularly enough, also, the application of strychnine causes simultaneously a tetanic state of the muscles and a rapid succession of involuntary electric discharges. The strength of the discharges depends entirely on the size, health, and energy of the fish, an observation completely agreeing with that made on the efficacy of snake-poison. Like this latter, the property of the electric force serves two ends in the economy of the animals which are endowed with it: it is necessary to them for overpowering, stunning, or killing the creatures on which they feed, whilst incidentally they use it as the means of defending themselves from their enemies.

Neurology.

The most simple condition of the nervous central organ known in vertebrates is found in *Branchiostoma*. In this fish the spinal cord tapers at both ends, no anterior cerebral swelling, or anything approaching a brain, being present. It is band-like along its middle third, and groups of darker cells mark the origins of the fifty or sixty pairs of nerves which accompany the intermuscular septa, and divide into a dorsal and a ventral branch, as in other fishes. The two anterior pairs pass to the membranous parts above the mouth, and supply with nerve filaments a ciliated depression near the extremity of the fish, which is considered to be an olfactory organ, and two pigment spots, the rudiments of eyes. An auditory organ is absent. The spinal cord of the Cyclostomes is flattened in its whole extent, band-like, and elastic; also in *Chimæra* it is elastic, but flattened in its posterior portion only. In all other fishes it is cylindrical, non-ductile, and generally extending along the whole length of the spinal canal. The Plectognaths offer a singular exception in this respect, that the spinal cord is much shortened, the posterior portion of the canal being occupied by a long cauda equina; this shortening of the spinal cord has become extreme in the sun-fish (*Orthagoriscus*), in which it has shrunk into a short and conical appendage of the brain. In the devil-fish (*Lophius*) also a long cauda equina partly conceals the cord which terminates on the level of about the twelfth vertebra.

The brain of fishes is relatively small; in the burbot (*Lota*) it has been estimated to be the $\frac{1}{720}$th part of the weight of the entire fish, in the pike the $\frac{1}{1305}$th part, and in the large sharks it is relatively still smaller.

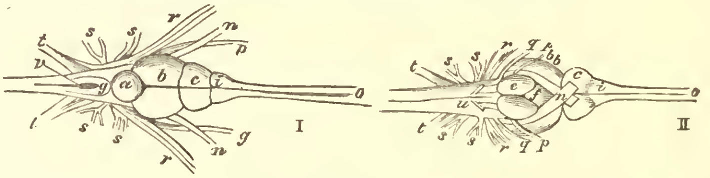


Fig. 40.—Brain of Perch. I. Upper aspect. II. Lower aspect. *a*, cerebellum; *b*, optic lobes; *c*, hemispheres; *e*, lobi inferiores; *f*, hypophysis; *g*, lobi posteriores; *i*, olfactory lobes; *n*, nervus opticus; *o*, nervus olfactorius; *p*, nervus oculo-motorius; *q*, nervus trochlearis; *r*, nervus trigeminus; *s*, nervus acousticus; *t*, nervus vagus; *u*, nervus abducens; *v*, fourth ventricle.

The brain of osseous fishes (fig. 40) viewed from above shows three protuberances, respectively termed the prosencephalon, mesencephalon, and metencephalon, the two anterior of which are paired, the hindmost being single. The foremost pair are the hemispheres, which are solid in their interior, and provided with two swellings in front, the olfactory lobes. The second pair are the optic lobes, which generally are larger than the hemispheres, and succeeded by the third single portion, the cerebellum. The optic lobes possess a cavity (ventriculus lobi optici), at the bottom of which some protuberances of variable development represent the corpora quadrigemina of higher animals. On the lower surface of the base of the optic lobes, behind the crura cerebri, two swellings are observed, the lobi inferiores, which slightly diverge in front for the passage of the infundibulum, from which a generally large hypophysis or pituitary gland is suspended. The relative size of the cerebellum varies greatly in the different osseous fishes: in the tunny and silurus it is so large as nearly to cover the optic lobes; sometimes distinct transverse grooves and a median longitudinal groove are visible. The cerebellum possesses in its interior a cavity which communicates with the anterior part of the fourth ventricle. The medulla oblongata is broader than the spinal cord, and contains the fourth ventricle. In most fishes a perfect roof is formed over the fourth ventricle by two longitudinal pads, which meet each other in the median line (lobi posteriores).

The brain of Ganoid fishes shows great similarity to that of the *Teleostei*; there is, however, considerable diversity in the arrangement of its various portions in the different types. In the sturgeons and *Polypterus* (fig. 41) the hemispheres are more or less remote from the mesencephalon, so that in an upper view the crura cerebri, with the intermediate entrance into the third ventricle (fissura cerebri magna), may be seen. A vascular membranous sac, epiphysis, containing lymphatic fluid, takes its origin from the third ventricle, its base being expanded over the anterior interspace of the optic lobes, and the apex being

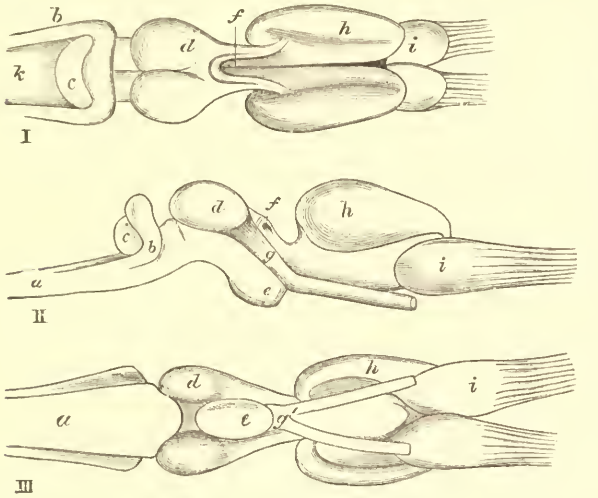


Fig. 41.—Brain of *Polypterus*. (After Müller.) I. Upper, II., Lateral, III. Lower aspect. *a*, medulla; *b*, corpora restiformia; *c*, cerebellum; *d*, lobi optici; *e*, hypophysis; *f*, fissura cerebri magna; *g*, nervus opticus; *g'*, chiasma; *h*, hemispheres; *i*, lobus olfactorius; *k*, sinus rhomboidalis (fourth ventricle).

fixed to the cartilaginous roof of the cranium. This structure is not peculiar to the Ganoids, but is found in various stages of development in Teleosteans, marking, when present, the boundary between the prosencephalon and mesencephalon. The lobi optici are essentially as in Teleosteans. The cerebellum penetrates into the ventriculus lobi optici, and extends thence into the open sinus rhomboidalis. At its upper surface it is crossed by a commissure formed by the corpora restiformia of the medulla.

As regards external configuration, the brain of *Lepidosteus* and *Amia* approach still more the Teleosteous type. The prosencephalon, mesencephalon, and metencephalon are contiguous, and the cerebellum lacks the prominent transverse commissure at its upper surface. The sinus rhomboidalis is open.

The brain of Chondropterygians (fig. 42) is more developed than that of other fishes, and is distinguished by well-marked characters. These are—first, the prolongation of the olfactory lobes into pedicles of greater or less length, which dilate into great ganglionic masses, where they come into contact with the olfactory sacs; secondly, the space which generally intervenes between the prosencephalon and mesencephalon, as in some Ganoids; thirdly, the large development of the metencephalon.

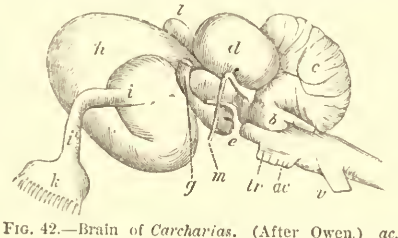


Fig. 42.—Brain of *Carcharias*. (After Owen.) *ac*, nervus acousticus; *b*, corpus restiforme; *c*, cerebellum; *d*, lobus opticus; *e*, hypophysis; *g*, nervus opticus; *h*, hemisphere; *i*, lobus olfactorius; *i'*, olfactory pedicle; *k*, nervus olfactorius; *l*, epiphysis; *m*, nervus oculo-motorius; *tr*, nervus trigeminus; *v*, nervus vagus.

The cerebellum is very large, overlying a portion of the optic lobes and of the sinus rhomboidalis, and is often transversely grooved. The side-walls of the fourth ventricle, which are formed by the corpora restiformia, are singularly folded, and appear as two pads, one on each side of the cerebellum (lobi posteriores or lobi nervi trigemini).

The brain of the Cyclostomes represents a type different from that of other fishes, showing at its upper surface three pairs of protuberances in front of the cerebellum; they are all solid. The foremost pair are the large olfactory tubercles, which are extremely large in *Petromyzon*. They are followed by the hemispheres, with a single body wedged in between their posterior half; in *Petromyzon*, at least, the vascular tissue leading to an epiphysis seems to be connected with this body. Then follows the lobus ventriculi tertii, distinctly paired in Myxinoids, but less distinctly in *Petromyzon*. The last pair are the corpora quadrigemina. According to this interpretation, the cerebellum would be absent in Myxinoids, and represented in *Petromyzon* by a narrow commissure only, stretching over the foremost part of the sinus rhomboidalis. In the Myxinoids the medulla oblongata ends in two divergent swellings, free and obtuse at their extremity, from which most of the cerebral nerves take their origin.[1]

Two very important conditions require mention. The first relates to the optic nerves, viz., to their mutual relation immediately after their origin, which is very characteristic of the subclasses of fishes. In the Cyclostomes they have no further connexion with each other, each going to the eye of its own side. In the *Teleostei* (fig. 40, *n*) they simply cross each other (decussate), so that the one starting from the right half of the brain goes to the left eye and *vice versa*. Finally, in the *Palæichthyes* (fig. 41, *g'*) the two nerves are fused together, immediately after their origin, into a chiasma.

The second noteworthy peculiarity occurs in the distribution of the nervus vagus; it emits a strong branch, called nervus lateralis, which accompanies the lateral mucous system of the trunk and tail. This is either a single longitudinal stem, gradually becoming thinner behind, and running superficially below the skin (*Salmonidæ*, *Cyclopterus*) or deeply between the muscles (sharks, *Chimæra*), or is divided into two parallel branches (most *Teleostei*); thus in the perch there are two branches on each side, the superficial one supplying the lateral line, whilst the deep-seated branch communicates with the spinal nerves and supplies the septa between the myocommas and the skin. In fishes which lack the lateral muciferous system and possess hard integuments, as the Ostracions, the lateral nerve is more or less rudimentary. It is entirely absent in Myxinoids, but the gastric branches of the vagus are continued, united as a single nerve, along the intestine to the anus.

Fishes possess all the spino-cerebral nerves of the higher Vertebrata, with the exception of the nervus accessorius. A separate nervus hypoglossus is also absent, but elements from the first spinal nerve are distributed over the area normally supplied by this nerve in higher vertebrates. The number of spinal nerves corresponds to that of the vertebræ, through or between which they pass out.

A sympathic nervous system appears to be absent in *Branchiostoma*, and has not yet been clearly made out in the Cyclostomes. It is well developed in the *Palæichthyes*, but without the cephalic portion. This latter is present in all osseous fishes, in which the communication of sympathy has been found to exist between all the cerebral nerves, except the olfactory, optic, and acoustic. The sympathic trunks run along each side of the aorta and the back of the abdomen into the hæmal canal, communicate in their course with the ventral branches of each of the spinal nerves, and, finally, often blend together into a common trunk beneath the tail. At the points of communication with the cerebral and spinal nerves ganglia are frequently developed, from which nerves emerge which are distributed to the various viscera.

[1] For a more detailed account of the spino-cerebral nerves, see *Introduction to the Study of Fishes*, by A. Günther.

ORGANS OF SENSE.

Organ of Smell.—It is characteristic of the organ of smell in fishes that it has no relation whatever to the respiratory function, with the exception of the *Dipnoi*, in which possibly part of the water received for respiration passes through the nasal sac.

The olfactory organ is single in *Branchiostoma* and the Cyclostomes. In the former a small depression on the front end of the body, clothed with a ciliated epithelium, is regarded as a rudimentary organ of smell. In the adult *Petromyzon* a membranous tube leads from the single opening on the top of the head into the cartilaginous olfactory capsule, the inside of which is clothed by membranes prolonged into a posterior blind tube (fig. 31, *s*), which penetrates the cartilaginous roof of the palate, but not the mucous membrane of the buccal cavity. In the Myxinoids the outer tube is strengthened by cartilaginous rings like a trachea; the capsule is lined by a longitudinally folded pituitary membrane, and the posterior tube opens backwards on the roof of the mouth, the opening being provided with a valve. In all other fishes the organ of smell is double, there being one on each side; it consists of a sac lined with a pituitary membrane, and may be provided with one or with two openings, or may have none. The position of these openings is very different in the various orders and suborders of fishes.

It is certain that fishes possess the faculty of perceiving odours, and that various scents attract or repel them. A mangled carcase or fresh blood attracts sharks, as well as the voracious Serrasalmonoids of the South American rivers. There is no reason to doubt that the seat of that perception is in the olfactory sac; and it may be reasonably conjectured that its strength depends mainly on the degree of development indicated by the number and extent of the interior folds of the pituitary membrane.

Organ of Sight.—The position, direction, and dimensions of the eyes of fishes vary greatly. In some they have an upward aspect, and are often very close together; in others they are lateral, and in a few they are even directed downwards. In a very few this organ appears to be entirely absent. In some Gobioids and Trachinoids (*Periophthalmus, Boleophthalmus, Uranoscopus*, &c.) the eyes, which are on the upper side of the head, can be elevated and depressed at the will of the fish. In the range of their vision and in their acuteness of sight, fishes are very inferior to the higher classes of vertebrates, yet at the same time it is evident that they perceive their prey, or approaching danger, from a considerable distance; and it would appear that the visual powers of a *Periophthalmus* (fig. 12), when hunting insects on the mud-flats of the tropical coasts, are quite equal to those of a frog.

The eye of *Branchiostoma* (fig. 30, *g*) is of the most rudimentary kind. It is simply a minute speck coated with a dark pigment, and receiving the end of a short nerve. In Myxinoids the minute rudiment of the eye is covered by skin and muscles. This is also the case in many of the blind Teleosteous fishes; whilst in the former fishes, however, the organ of sight has not attained to any degree of development, the rudimentary eye of blind *Teleostei* is a retrogressive formation, in which a lens and other portions of the eye can often be recognized. In fishes with a well-developed eye it is imbedded in a layer of gelatinous and adipose substance, which covers the cavity of the orbit. A lachrymal gland is absent. In the Chondropterygians the eyeball is supported by and moves on a cartilaginous peduncle of the orbital wall. In the majority of Teleosteans, and in *Acipenser*, a fibrous ligament attaches the sclerotic to the wall of the orbit. The proper muscles of the eyeball are always present. In all fishes the general integument of the head passes over the eye, and becomes transparent where it enters the orbit; sometimes it simply passes over the orbit, sometimes it forms a circular fold. The anterior and posterior portions may be specially broad, becoming the seat of an adipose deposit (adipose eyelids), as in *Scomber, Caranx, Mugil*, &c. In many of these fishes the extent of the eyelids varies with the seasons; during the spawning season they are so much loaded with fat as nearly to hide the whole eye. Many sharks possess a nictitating membrane, developed from the lower part of the palpebral fold, and moved by a proper set of muscles.

The form of the bulbus (fig. 43) is subhemispherical, the cornea (*co*) being flat. If it were convex, as in higher vertebrates, it would be more liable to injury; but, as it is level with the side of the head, the chances of injury by friction are diminished. The sclerotica (*sc*) is cartilaginous in Chondropterygians and Acipensers, fibrous and of varying thickness in Teleosteans, in the majority of which it is supported by a pair of cartilaginous or ossified hemispheroid cups (*c*). In a few fishes, as in *Ceratodus, Xiphias*, the cups are confluent into one cup, which possesses a foramen behind to allow the passage of the optic nerve (*o*).

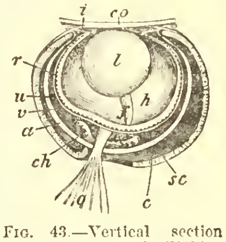


FIG. 43.—Vertical section through eye of *Xiphias*. (After Owen.) *co*, cornea; *sc*, sclerotica; *o*, nervus opticus; *c*, sclerotic capsule; *a*, membrana argentea; *v*, membrana vasculosa; *u*, membrana uvea; *ch*, choroid gland; *r*, retina; *f*, processus falciformis; *h*, humor vitreus; *l*, lens; *i*, iris.

The membranes situated between the sclerotica and retina are collectively called choroidea, and are three in number. The one in immediate contact with the sclerotic, and continued upon the iris, is by no means constantly present; it is the membrana argentea (*a*), and is composed of microscopical crystals reflecting a silvery or sometimes golden lustre. The middle layer is the membrana vasculosa or Halleri (*v*), the chief seat of the ramifications of the choroid vessels; the innermost layer is the membrana Ruyscheana or uvea (*u*), which is composed of hexagonal pigment-cells, usually of a deep-brown or black colour.

In many *Teleostei* a rete mirabile surrounds the entry of the optic nerve; it is situated between the membrana argentea and vasculosa, and called the choroid gland (*ch*). It receives its arterial blood from the artery issuing from the pseudobranchia, the presence of a choroid gland being always combined with that of a pseudobranchia. Teleosteans without pseudobranchia have no choroid gland. In the *Palæichthyes*, on the other hand, the pseudobranchia is present and a choroid gland absent.

The iris (*i*) is merely the continuation of the choroid membrane; its capability of contracting and expanding is much more limited than in higher vertebrates. The pupil is generally round, sometimes horizontally or vertically elliptical, sometimes fringed. In the rays and *Pleuronectidæ* a lobe descends from the upper margin of the pupil, and the outer integument overlying this lobe is coloured and non-transparent,—a structure evidently preventing light from entering the eye from above.

In most *Teleostei* a fold of the choroidea, called the processus falciformis (*f*), extends from the vicinity of the entrance of the optic nerve to the lens. It seems to be constantly absent in Ganoids.

The vitreous humour (*h*), which fills the posterior cavity of the eye-ball, is of a firmer consistency than in the higher vertebrates. The lens is spherical, or nearly so, firm, denser towards the centre, and lies in a hollow of the vitreous humour. When a falciform process is present, it has one end attached to the lens, which is thus steadied in its position. It is composed of concentric layers consisting of fibres, which in the nucleus of the body have marginal teeth, by which they are interlocked together. In *Petromyzon* this serrature is absent, or but faintly indicated.

The anterior cavity of the eye is very small in fishes, in consequence of the small degree of convexity in the cornea; the quantity of the aqueous humour, therefore, is very small, just sufficient to float the free border of the iris; and the lessened refractive power of the aqueous humour is compensated by the greater convexity of the lens.

Organ of Hearing.—No trace of an organ of hearing has been found in *Branchiostoma*. In the Cyclostomes the labyrinth is enclosed in externally visible cartilaginous capsules laterally attached to the skull; it consists of a single semicircular canal in the Myxinoids, whilst the *Petromyzontes* possess two semicircular canals with a vestibulum.

In all other fishes the labyrinth consists of a vestibule and three semicircular canals, the vestibule dilating into one or more sacs, which contain the otoliths. A tympanum, tympanic cavity, and external parts are entirely absent in the class of fishes.

In the Chondropterygians and *Dipnoi*, the labyrinth is enclosed in the cartilaginous substance of the skull. In the former the excavation in the cartilage is larger than the membranous labyrinth, but nearly corresponds to it in form; the part which receives the membranous vestibulum is called vestibulum cartilagineum, from which a canal issues and penetrates to the surface of the skull, where it is closed by the skin in sharks, but opens by a minute foramen in rays. The otolithic contents are soft and chalklike.

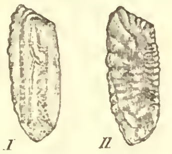


Fig. 44.—Otolith of Haddock (*Gadus æglefinus*). I. Outer, II. Inner aspect.

In the Teleosteans the sac which contains the otoliths lies on each side of the base of the cranial cavity, and is often divided by a septum into two compartments of unequal size, each containing a firm and solid otolith (fig. 44); these bodies possess indented margins, frequently other impressions and grooves, in which nerves from the N. acousticus are lodged; they vary much in size and form, but in both respects show a remarkable constancy in the same kind of fishes. Outwards the vestibule is in contact with the osseous side wall of the skull, inwards with the metencephalon and medulla oblongata; it contains another firm concretion, and opens by five foramina into the three semicircular canals. The terminations of the acoustic nerve are distributed over the vestibular concretion and the ampulliform ends (fig. 45) of the semicircular canals, without being continued into the latter, which are filled with fluid. The semicircular canals (fig. 45) are sometimes lodged in the cranial bones, sometimes partly free in the cranial cavity. Many *Teleostei* have fontanelles in the roof of the skull, closed only by skin or very thin bone at the place where the auditory organ approaches the surface, by which means sonorous undulations must be conducted with greater ease to the ear.

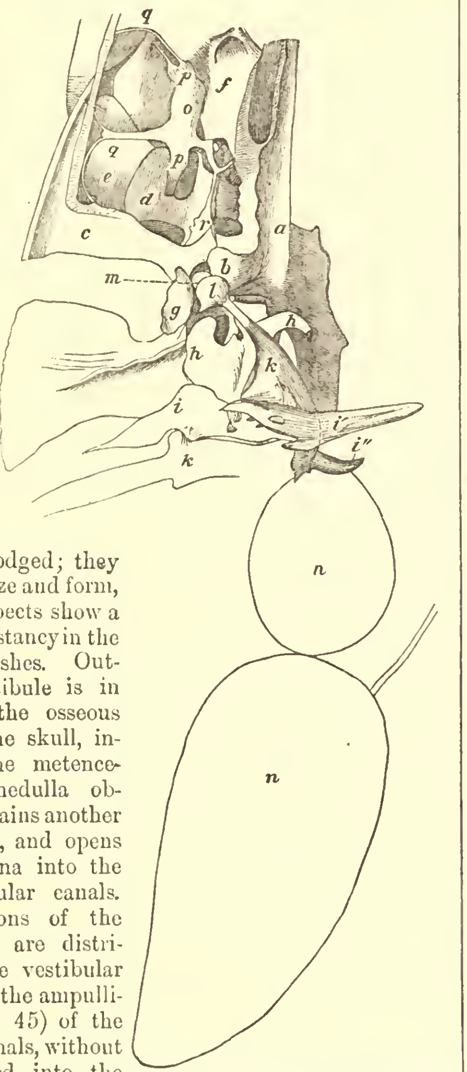


Fig. 45.—Communication between auditory organ and air-bladder in the Carp. (After E. H. Weber.) *a*, basisphenoid; *b*, occipital; *c*, supraoccipital; *d*, exoccipital; *e*, paroccipital; *f*, alisphenoid; *g*, neural arch of first vertebra; *h*, *i*, *k*, second, third, and fourth vertebræ; *h′*, *i′*, parapophyses of second and third vertebræ; *i″*, process of the third vertebra for the attachment of the air-bladder; *k*, *l*, *m*, chain of ossicles; *n*, air-bladder; *o*, vestibulum; *p*, *p*, ampullæ; *q*, *q*, canales semicirculares; *r*, sinus impar.

In many *Teleostei* a most remarkable relation obtains between the organ of hearing and the air-bladder. In the most simple form this connexion is established in Percoids and the allied families, in which the two anterior horns of the air-bladder are attached to fontanelles of the occipital region of the skull, the vestibulum occupying the opposite side of the membrane by which the fontanelle is closed. The condition is similar, but more complicated, in many Clupeoids. The anterior narrow end of the air-bladder is produced into a canal at the base of the skull, and divided into two very narrow branches, which again bifurcate and terminate in a globular swelling. An appendage of the vestibulum meets the anterior of these swellings, and comes into close contact with it. In addition, the two vestibules communicate with each other by a transverse canal, crossing the cranial cavity below the brain.

The connexion is effected by means of a chain of ossicles in *Siluridæ*, *Characinidæ*, *Cyprinidæ*, and *Gymnotidæ*. A canal issues from the communication between the vestibule and its sac, and meeting that from the other side forms with it a common sinus impar (fig. 45, *r*), lodged in the substance of the basioccipital; this communicates on each side by a small orifice with two subspherical atria, on the body of the atlas, close to the foramen magnum. Each atrium is supported externally by a small bone (*m*); a a third and larger bone (*k*) completes the communication with the anterior part of the air-bladder. From the sinus impar a bifid canal penetrates into the alisphenoids, in which it terminates. In *Cobitis* and several loach-like Siluroids the small air-bladder consists of two globular portions placed side by side, and wholly included within two bullæ formed by the modified parapophyses of the second and third vertebræ. The three ossicles on each side are present, but concealed by the fore part of the osseous bulla.

Organ of Taste.—Some fishes, especially vegetable feeders, or those provided with broad molar-like teeth, masticate their food; and it may be observed in carps and other Cyprinoid fish that this process of mastication frequently takes some time. But the majority of fishes swallow their food rapidly, and without mastication, and therefore we may conclude that the sense of taste cannot be keen. The tongue is often entirely absent, and, even when it exists in its most distinct state, it consists merely of ligamentous or cellular substance, and is never furnished with muscles capable of producing the movements of extension or retraction as in most of the higher vertebrates. A peculiar organ on the roof of the palate of Cyprinoids is perhaps adapted for the perception of this sense; in these fishes the palate between and below the upper pharyngeal bones is cushioned with a thick, soft, contractile substance, richly supplied with nerves from the nervus vagus and nervus glosso-pharyngeus.

Organs of Touch.—The faculty of touch is more developed than that of taste, and there are numerous fishes which possess special organs of touch. Most fishes are very sensitive to external touch, although their body may be protected by hard horny scales. They perceive impressions even on those parts which are covered by osseous scutes, in the same manner as a tortoise perceives the slightest touch of its carapace. The seat of the greatest sensitiveness however, appears to be the snout and the labial folds surrounding the mouth. Many species possess soft and delicate appendages, called barbels, which are almost constantly in action, and clearly used as organs of touch. Among the *Triglidæ* and allied families, there are many species which have one or more rays of the pectoral fin detached from the membrane, and supplied with strong nerves. Such detached rays (also found in the *Polynemidæ* and in *Bathypterois*) are used partly for locomotion, partly for exploring the ground over which the fish moves.

Some fishes appear to be much less sensitive than others, or at least lose their sensitiveness under peculiar circumstances. It is well known that a pike whose mouth has been lacerated and torn by the hook continues to yield to the temptation of a bait immediately afterwards. The Greenland shark, when feeding on the carcase of a whale, allows itself to be repeatedly stabbed in the head without abandoning its prey. A pair of congers are so dead to external impression at the time of copulation, and, as it were, so automatically engaged, that they have been taken by the hand together out of the water.

Organs of Nutrition and Digestion.

Fishes are for the most part either exclusively carnivorous or herbivorous, but not a few feed on vegetable as well as animal substances, or on mud containing alimentary matter in a living or decomposing state. Generally they are very voracious, especially the carnivorous kinds, and the rule of "eat or be eaten" applies to them with unusual force. They are almost constantly engaged in the pursuit and capture of their prey, the degree of their power in these respects depending on the dimensions of the mouth and gullet and the strength of the teeth and jaws. If the teeth are sharp and hooked, they are capable of securing the most slender and agile animals; if with teeth of this kind are combined a wide gullet and distensible stomach, the fish is able to overpower and swallow others larger than itself; if the teeth are broad, strong molars, they are able to crush the hardest alimentary substances; if they are feeble, they are only serviceable in procuring some small or inert and unresisting prey. Teeth may be wanting altogether. Whatever the prey, in the majority of cases it is swallowed whole; but some of the most voracious fishes, like some sharks and *Characinidæ*, are provided with cutting teeth, which enable them to tear their prey to pieces if too large to be swallowed whole. Auxiliary organs, similar to the claws of some carnivorous mammals and birds, for the purpose of seizing and overpowering their prey before it is torn by the teeth, are not found in this class; but in a few fishes the jaws themselves are modified for that purpose. In the sword-fishes the bones of the upper jaw form a long dagger-shaped weapon, with which they not only attack large animals, but also frequently kill fishes on which they feed. The saw-fishes are armed with a similar but still more complex weapon, the saw, which is armed on each side with large teeth implanted in deep sockets, specially adapted for killing and tearing the prey before it is seized and masticated by the small teeth within the mouth. Fishes show but little choice in the selection of their food, and some devour their own offspring indiscriminately with other fishes. Their digestive powers are strong and rapid, but are affected in some degree by the temperature, which, when it sinks below a certain point, lowers the vital powers of these cold-blooded animals. On the whole, marine fishes are more voracious than those inhabiting fresh waters; and, whilst the latter may survive total abstinence from food for weeks or months, the marine species succumb to hunger within a few days.

The organs of nutrition, manducation, and deglutition are lodged in two large cavities—an anterior (the mouth or buccal cavity), and a posterior (the abdominal cavity). In the former the alimentary organs are associated with those fulfilling the respiratory functions, the transmission of food to the stomach and of water to the gills being performed by similar acts of deglutition. The abdominal cavity commences immediately behind the head, so, however, that an extremely short thoracic cavity for the heart is partitioned off in front. Besides the alimentary organs it contains also those of the urogenital system and the air-bladder. The abdominal cavity is generally situated in the trunk only, but in numerous fishes it extends into the tail, being continued for some distance along each side of the hæmal apophyses. In numerous fishes the abdominal cavity opens outwards by one or two openings. A single porus abdominalis in front of the vent is found in *Lepidosiren* and some sturgeons; a paired one, opening on each side of the vent, in *Ceratodus*, some species of sturgeon, *Lepidosteus*, *Polypterus*, *Amia*, and all Chondropterygians. As in these fishes semen and ova are discharged by their proper ducts, the abdominal openings may serve for the expulsion of semen, and of those ova only which, having lost their way to the abdominal aperture of the oviduct, would be retained in the abdominal cavity. In those Teleosteans which lack an oviduct a single porus genitalis opens behind the vent.

Mouth.—The mouth of fishes shows extreme variation with regard to form, size, and position. Generally opening in front, it may be turned upwards, or it may lie at the lower side of the snout, as in most Chondropterygians, sturgeons, and some Teleosteans. In most fishes the jaws are covered by the skin, which, before passing over the jaws, is often folded, forming more or less fleshy lips. In the sharks the skin retains its external character even within the teeth, but in other fishes it changes into a mucous membrane. A tongue may exist as a more or less free and short projection, formed by the glossohyal and a soft covering, or may be entirely absent. Salivary glands and a velum palati are absent in fishes.

Teeth.—With regard to the dentition, the class of fishes offers an amount of variation such as is not found in any of the other classes of vertebrates. As the teeth form one of the most important elements in the classification of fishes, their special arrangement and form will be referred to in the account of the various families and genera. Whilst not a few fishes are entirely edentulous, in others most of the bones of the buccal cavity, or some of them, may be toothed, as the bones of the jaws, the palatines, pterygoids, vomers, basi-sphenoid, glossohyal, branchial arches, upper and lower pharyngeals. In others teeth may be found fixed in some portion of the buccal membrane without being supported by underlying bone or cartilage; or the teeth have been developed in membrane overlying one of the dentigerous bones mentioned, without having become anchylosed to the bone. When the tooth is fixed to the bone the attachment has generally been effected by the ossification of the bone of the tooth, but in some fishes a process of the bone projects into the cavity of the tooth; in others the teeth are implanted in alveoli. In these, again, frequently a process of bone rises from the bottom, on which the tooth rests.

Many of the class, especially predatory fishes, with long, lancet-shaped teeth, have all or some of these capable of being bent towards the interior of the mouth. Such "hinged" teeth resume at once the upright position when pressure is removed from them. They are, however, depressible in one direction only, thus offering no obstacle to the ingress, while they oppose the egress of prey. Mr C. S. Tomes has shown that the means by which this mechanism is worked are different in different fishes; for, whilst in the *Pediculati* and Gadoids (hake) the elasticity resides solely in the tissue of the hinge (the tooth being as resilient as ever after everything else is severed), in the pike the hinge is not in the least endowed with elasticity, but the bundles of fibres proceeding from the interior of the dentine cap are exceedingly elastic.

The teeth may be, and generally are, very different as regards size or form in the different parts of the mouth; they may be also different according to the age or sex of the fish (*Raia*). The teeth may be few in number and isolated, or placed in a single, double, or triple series, distant from one another or closely set; they may form narrow or broad bands, or patches of various forms. As regards form, they may be cylindrical or conical, pointed, straight, or curved, with or without an angular bend near their base; some are compressed laterally or from the front backwards (the latter may be triangular in shape, or truncated at the top like the incisors of mammals); they may have one apex (cusp) only, or be bi- or tri-lobate (bi- or tri-cuspid), or may have the margins denticulated or serrated. Compressed teeth may be confluent, and form a cutting edge in both jaws, which assume the shape of a parrot's beak. In some the apex is hooked or provided with barbs. Again, some teeth are broad, with flat or convex surface, like molar teeth. With regard to size, the finest teeth are like fine flexible bristles, ciliiform or setiform; or, if very short and anchylosed to the bone, they appear only as inconspicuous asperities of the bone. Very fine conical teeth arranged in a band are termed villiform teeth; when they are coarser, or mixed with coarser teeth, they are cardlike (dents en râpe or en cardes); molar-like teeth of very small size are termed granular.

In all fishes the teeth are shed and renewed during the whole course of their life. In fishes which have compound teeth, as the *Dipnoi*, Chimæroids, *Scari*, Gymnodonts, as well as in those which have apparently permanent teeth, as in the saw of *Pristis*, the detrition of the surface is made up by a constant growth of the tooth from its base. When the teeth are implanted in alveoli, they are generally succeeded by others in the vertical direction; but in other forms they succeed one another side by side. In the majority of fishes the new tooth is not developed (as in reptiles and mammals) in a diverticulum of the sac of its predecessor, but, like it, from the free surface of the buccal membrane. Generally there are more than one tooth growing which are in various stages of development, destined each to replace the others in function. This is very conspicuous in sharks, in which the whole phalanx of their numerous teeth is ever marching slowly forwards (or in some backwards), in rotatory progress, over the alveolar border of the jaw, the teeth being successively cast off after having reached the outer margin and fulfilled for a longer or shorter period their special function.[1]

Intestines.—The intestinal tract is divided into four portions,—the œsophagus, the stomach, the small and the large intestine; two or more of these divisions may coalesce in fishes and become indistinguishable. But it is characteristic of the class that the urinary apertures are constantly situated behind the termination of the intestinal tract.

In *Branchiostoma* the whole intestinal tract is straight, and coated with a ciliated mucous membrane. The liver is represented by a green-coloured cœcal diverticulum of the stomachic dilatation. In the *Cyclostomi* the intestinal tract is likewise straight, and without clearly defined divisions.

The *Palæichthyes* show differences in the structure of their intestinal tract as considerable as are found among the *Teleostei*, but they have this in common that the absorbent surface of their intestine is enlarged by the development of a spiral valve, evidence of the presence of which in extinct *Palæichthyes* is still preserved in the fossilized fæces or coprolites, so abundant in some of the older strata.

In Chondropterygians (fig. 46) the stomach is divided into a cardiac and a pyloric portion, the former frequently terminating in a blind sac, and the latter varying in length. The pyloric portion is bent both at its origin and its end, and is separated from the short duodenum (called *Bursa entiana* in these fishes) by a valve; the ductus hepaticus and ductus pancreaticus enter the duodenum. This is succeeded by the straight intestine, provided with the spiral valve, the coils of which may either be longitudinal and wound vertically about the axis of the intestine, as in *Carcharias*, *Galeocerdo*, *Thalassorhinus*, and *Zygæna*, or they may be transverse to that axis, as in the other genera. The number of gyrations in the latter case varies; there may be as many as forty. The short rectum passes into a cloaca, which contains also the orifices of the urogenital ducts. Only the beginning and end of the intestinal tract are fixed by mesenterial folds.

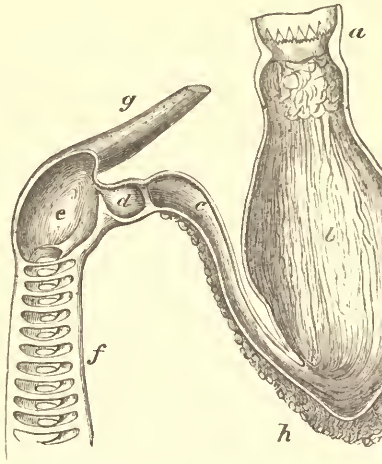


Fig. 46.—Siphonal stomach and spiral valve of Basking-Shark (*Selache*). (After Home and Owen.) *a*, œsophagus; *b*, cardiac portion of stomach; *c*, pyloric portion; *d*, pouch intermediate between stomach and duodenum, with circular valves at both ends; *e*, duodenum; *f*, valve of intestine; *g*, ductus hepaticus; *h*, spleen.

The structure of the intestinal tract of Teleosteous fishes is subject to so numerous modifications that we should go beyond the limits of the present article were we to attempt to enter into details. Great differences in this respect may be found even in groups of the same natural families. Frequently the intestinal tract remains of nearly the same width throughout its course, and only the entrance of the various ducts serves as a guide for the distinction of its divisions. An intestine of such uniform width may be straight and short, as in *Scombresocidæ*, *Symbranchidæ*, or it may be more or less convoluted and long, as in many *Cyprinidæ*, *Doradina*, &c. On the whole, carnivorous fishes have a much shorter and simpler intestinal tract than the herbivorous.

In the majority of Teleosteans, however, the œsophagus, stomach, duodenum, small intestine, and rectum can be more or less clearly distinguished, even externally.

There are two predominant forms of the stomach, intermediate forms, however, being numerous. In the first, the siphonal, it presents the form of a bent tube or canal, one-half of the horse-shoe being the cardiac, the other the pyloric portion. In the second, the cæcal, the cardiac division is prolonged into a long descending blind sac, the cardiac and pyloric openings of the stomach lying close together (*Clupea*, *Scomber*, *Thynnus*, &c.).

The duodenum always receives the hepatic and pancreatic secretions, and also those of the appendices pyloricæ, which, in varying numbers (from 1 to 200), are of very common occurrence in Teleosteans. They vary also in length and width, and whilst the narrowest serve only as secretory organs, the widest are frequently found filled with the same contents as the intestine.

Glands.—The liver of fishes is distinguished by the great quantity of fluid fat (oil) which it contains. The gall-bladder is but rarely absent; it is attached to the right lobe, or towards the centre; in some fishes, however, it is detached from the liver and connected with it by the cystic duct only. The bile may be conveyed by one or more hepatic ducts into a common duct which is continued towards the gall-bladder as ductus cysticus, and towards the duodenum as ductus choledochus; or some of the hepatic ducts enter the gall-bladder directly, or the duodenum directly, without communicating with the common duct. Individual variations in this respect are of common occurrence.

[1] The richest materials for our knowledge of the teeth of fishes are contained in Owen's *Odontography*, Lond., 1840, 8vo.

A pancreas has been found hitherto in all Chondropterygians, in *Acipenser*, and in many Teleosteans.

The spleen, which is substantially a lymphatic gland, may be mentioned here, as it is constantly situated in the immediate vicinity of the stomach, generally near its cardiac portion. With the exception of *Branchiostoma*, it is found in all fishes, and appears as a rounded or oblong organ of dark red colour.

Organs of Respiration.

Fishes breathe the air dissolved in water by means of gills or branchiæ. The oxygen consumed by them is not that which forms the chemical constituent of the water, but that contained in the air which is dissolved in the water. Hence fishes transferred to water from which the air has been driven out by a high temperature, or in which the air absorbed by them is not replaced, are speedily suffocated. The absorption of oxygen by fishes is comparatively small; it has been calculated that a man consumes fifty thousand times more than is required by a tench. Some fishes, however, evidently require a much larger supply of oxygen than others: eels and carps, and other fishes of similar low vitality, can survive removal from their element for days, the small quantity of moisture retained in their gill-cavity being sufficient to sustain life, whilst other fishes, especially such as have very wide gill-openings, are immediately suffocated after being taken out of the water. In some fishes noted for their muscular activity, like the *Scombridæ*, the respiratory process is so energetic as to raise the temperature of their blood far beyond that of the medium in which they live. A few fishes, especially such as are periodically compelled to live in water thickened into mud by desiccation and vitiated by decomposing substances, breathe atmospheric air, and generally have special contrivances for this purpose. These are so much habituated to breathing air that many of them, even when brought into pure water of normal condition, are obliged to rise to the surface at frequent intervals to take in a quantity of air, and, if they are kept beneath the surface by means of a gauze net, they perish from suffocation. The special contrivances consist of additional respiratory organs, lodged in cavities either adjoining the gill-cavity or communicating with the ventral side of the œsophagus, or of the air-bladder which enters upon respiratory functions (*Dipnoi*, *Lepidosteus*, *Amia*).

The water used by fishes for respiration is received by the mouth, driven to the gills by an action similar to that of swallowing, and expelled by the gill-openings, of which there may be one or several on each side behind the head, or rarely one only in the median line of the ventral surface.

The gills or branchiæ consist essentially of folds of the mucous membrane of the gill-cavity (laminæ branchiales), in which the capillary vessels are distributed. In all fishes the gills are lodged in a cavity, but during the embryonic stage the Chondropterygians have the gill-laminæ extended into long filaments projecting beyond the gill-cavity, and in a few young Ganoids external gills are superadded to the internal.

In *Branchiostoma* the dilated pharynx is perforated by numerous clefts, supported by cartilaginous rods (fig. 30, *h*). The water passes between these clefts into the peritoneal cavity, and makes its exit by the porus abdominalis, situated considerably in advance of the vent. The water is propelled by cilia.

In the Cyclostomes the gills of each side are lodged in a series of six or more antero-posteriorly compressed sacs, separated from each other by intervening septa. Each sac communicates by an inner duct with the œsophagus, the water being expelled by an outer duct. In *Bdellostoma* each outer duct has a separate opening, but in *Myxine* all the outer ducts pass outwards by one common gill-opening on each side. In the lampreys the ducts are short, the outer ones having separate openings (fig. 1). The inner ducts lead into a single diverticulum or bronchus, situated below the œsophagus, blind behind, and communicating in front with the pharynx, where it is provided with two valves by which the regurgitation of the water into the buccal cavity is prevented.

The same type of branchial organs persists in Chondropterygians, which possess five, rarely six or seven, flattened pouches with transversely plaited walls. The septa between them are supported by cartilaginous filaments rising from the hyoidean and branchial arches. Each pouch opens by a cleft outwards, and by an aperture into the pharynx, without intervening ducts. The anterior wall of the first pouch is supported by the hyoidean arch. Between the posterior wall of the first and the anterior of the second sac, and between the adjacent walls of the succeeding, a branchial arch with its two series of radiating cartilaginous filaments is interposed. Consequently the first and last pouches have one set of gill-laminæ only, viz., the first on its posterior and the last on its anterior wall. The so-called spiracles on the upper surface of the head of Chondropterygians must be referred to in connexion with the respiratory organs. They are the external openings of a canal leading on each side into the pharynx, and situated generally close to and behind the orbit. They frequently possess valves or an irregularly indented margin, and are found in all species during the embryonic stage, but it is only in some that they remain persistent. The spiracles are the remains of the first visceral cleft of the embryo, and in the fœtal state long branchial filaments have been observed to protrude as from the other branchial clefts.

The *Holocephali* and *Ganoidei* show numerous deviations from the Chondropterygian type, all leading towards the Teleosteans. As a whole they take an intermediate position between the preceding types and the Teleosteans, but they show a great variation among themselves, and have in common only the imperfect separation of the branchial sacs and the presence of a single outer branchial aperture.

In the *Teleostei* the gills with their supporting branchial arches lie in one undivided cavity; more or less wide clefts between the arches lead from the pharynx to the gills, and a more or less wide opening gives exit to the water after it has washed the gills. The interbranchial clefts have sometimes nearly the same extent as the branchial arches; sometimes they are reduced to small openings, the integuments stretching from one arch to the other. Sometimes there is no cleft behind the fourth arch, in which case this arch has only a uniserial gill developed. The gill-opening likewise varies much in its extent, and when reduced to a foramen may be situated at any part of the posterior boundary of the head. In the *Symbranchidæ* the gill-openings coalesce into a single narrow slit in the median line of the isthmus. In the majority of Teleosteans the integument of the concave side of the branchial arches develops a series of horny protuberances of various form, the so-called gill-rakers. These serve to catch any solid corpuscles or substances which would be carried into the gill-cavity with the water. In some fishes they are setiform, and make a complete sieve, whilst in others they are merely rough tubercles, the action of which must be very incomplete if they have any function at all.

The majority of Teleosteans possess four complete gills.

The gills of the Teleosteans, as well as of the Ganoids, are supported by a series of solid cartilaginous or horny pointed rods, arranged along the convex edges of the branchial arches. Arches bearing a complete gill have two series of those rods, one along each edge; those with uniserial gills bear one row of rods only. The rods are not part of the arch, but fixed in its integument, the several rods of the one row corresponding to those of the other, forming pairs (feuillet, Cuvier) (fig. 47). Each rod is covered by a loose mucous membrane passing from one rod to its fellow opposite, which again is finely plaited transversely, the extent of surface being greatly increased by these plaits. In most *Teleostei* the branchial lamellæ are compressed, and taper towards their free end, but in the Lophobranchs their base is attenuated and the end enlarged. The mucous membrane contains the finest terminations of the vessels, which, being very superficial, impart a blood-red colour to living gills. The arteria branchialis, the course of which lies in the open canal in the convexity of the branchial arch, emits a branch (*a*) for every pair of lamellæ, which ascends (*b*) along the inner edge of the lamella, and supplies every one of the transverse plaits with a branchlet. The latter break up into a fine network of capillaries, from which the oxygenized blood is collected into venous branchlets, returning by the venous branch (*d*), which occupies the outer edge of the lamella.

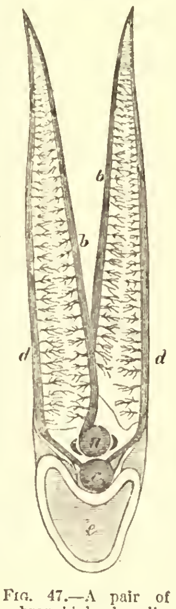


Fig. 47.—A pair of branchial lamellæ (magnified) of the Perch. *a*, branch of arteria branchialis; *b*, ascending branch of the same; *c*, branch of vena branchialis; *d*, descending branch of the same; *e*, transverse section through the branchial arch.

The so-called pseudobranchiæ (fig. 48) are the remains of an anterior gill which had respiratory functions during the embryonic life of the individuals. By a change in the circulatory system these organs have lost those functions, and appear in the adult fish as retia mirabilia, as they receive oxygenized blood, which, after having passed through their capillary system, is carried to other parts of the head. In *Palæichthyes* the pseudobranchia is a rete mirabile caroticum for the brain and eye; in Teleosteans a rete mirabile ophthalmicum only. Pseudobranchiæ are as frequently absent as present in Chondropterygians as well as Teleosteans. Among the Ganoids, the organs occur in *Ceratodus*, *Acipenser*, *Polyodon*, and *Lepidosteus*, and are absent in *Lepidosiren*, *Protopterus*, *Scaphirhynchus*, *Polypterus*, and *Amia*.

In Chondropterygians and sturgeons the pseudobranchiæ are situated within the spiracles; in those in which spiracles have become obliterated, the pseudobranchiæ lie on the suspensorium, hidden below cellular tissue; but pseudobranchiæ are not necessarily coexistent with spiracles. In the other Ganoids and Teleosteans the pseudobranchiæ (fig. 48, *h*) are within the gill-cavity, near the base of the gill-cover; in *Ceratodus* even rudiments of the gill-rakers (*x'*, *x''*) belonging to this embryonic gill are preserved, part of them (*x''*) being attached to the hyoid arch. Pseudobranchiæ are frequently hidden below the integuments of the gill-cavity, and have the appearance of a glandular body rather than of a gill.

Fig. 48.—Gills of *Ceratodus*. *x*, arcus aortæ; *gl*, glossohyal; *ch*, ceratohyal; *u*, attachment of the first gill to the walls of the gill-cavity; *h*, pseudobranchia; *x'*, *x''*, two series of gill-rakers belonging to the pseudobranchia

Accessory respiratory organs for retaining water or breathing air are found in the *Labyrinthici*, *Ophiocephalidæ*, certain *Siluridæ*, and *Lutodira*.

Air-bladder.—The air-bladder, one of the most characteristic organs of fishes, is a hollow sac, formed of several tunics, containing gas, situated in the abdominal cavity, but outside the peritoneal sac, entirely closed or communicating by a duct with the intestinal tract. Being compressible, its special functions consist in altering the specific gravity of the fish or in changing the centre of gravity. In a few fishes it assumes the function of the organ of higher vertebrates of which it is the homologue—viz., of a lung. The gas contained in the air-bladder is secreted from its inner surface. In most freshwater fishes it consists of nitrogen, with a very small quantity of oxygen and a trace of carbonic acid; in sea-fishes, especially those living at some depth, oxygen predominates, as much as 87 per cent. having been found. Davy found in the air-bladder of a fresh-run salmon a trace of carbonic acid and 10 per cent. of oxygen, the remainder of the gas being nitrogen.

An air-bladder is absent in *Leptocardii*, *Cyclostomi*, *Chondropterygii*, and *Holocephali*, but occurs in all Ganoids, in which, besides, its respiratory functions more or less clearly manifest themselves. Its occurrence in Teleosteans is very irregular, closely allied species sometimes differing from each other in this respect; it shows in this subclass the most extraordinary modifications, but has no respiratory function whatever.

Constantly situated within the abdominal cavity, below the vertebral column, but outside the sac of the peritoneum which covers only its ventral portion, the air-bladder is frequently prolonged into the tail, the prolongation being either single and lodged between the non-united parapophyses, or double and penetrating between the muscles and hæmapophyses of each side. In the opposite direction processes of the air-bladder may penetrate into the skull, as has been mentioned above (p. 653). In some fishes the air-bladder is almost loose in the abdominal cavity, whilst in others it adheres most intimately by firm and short tissue to the vertebral column, the walls of the abdomen, and the intestines. In the *Cobitina* and many Siluroids it is more or less completely enclosed in osseous capsules formed by the vertebræ.

There are two tunics in the greater number of air-bladders,—an extremely thin internal one, frequently shining with a silvery lustre, containing crystalline corpuscles, sometimes covered with a pavement-epithelium, and a thicker outer one of a fibrous texture, which sometimes attains to considerable thickness and yields isinglass. The outer wall is strengthened in many fishes by muscular layers for the compression of the whole organ or of some portion of it.

A distinction has been made between air-bladders which communicate by a duct with the intestinal tract and those which are entirely closed. It is to be remembered, however, that at an early stage of development all air-bladders are provided with such a duct, which in some fishes is more or less completely obliterated, being then represented by a fine ligament only. Air-bladders without duct are found in Acanthopterygians, Pharyngognaths, Anacanths, and Lophobranchs. They may consist of a single cavity, or may be divided by constrictions into two or three chambers situated behind one another; they may consist of two lateral divisions, assuming a horseshoe-like form, or of a single sac with a pair of simple or bifid processes in front or behind. The families of *Sciænidæ* and *Polynemidæ* possess air-bladders with a most extraordinary development of appendages rising from each side. Air-bladders with a pneumatic duct are found in Ganoids and Physostomes, the duct entering the dorsal side of the intestinal tract, with the exception of *Polypterus* and the *Dipnoi*, in which it enters on the ventral side of the œsophagus. In most cases the orifice is in the œsophagus, but in some it is in the cardiac portion of the stomach, as in *Acipenser*, or in its blind sac, as in many Clupeoids. The air-bladder may be single, or may consist of two divisions situated one behind the other (fig. 45); its inner surface may be perfectly smooth, or it may form manifold pouches and cells. If two divisions are present the anterior possesses a middle elastic membrane which is absent in the posterior; each division has a muscular layer, by which it can be separately compressed, so that part of the contents of the posterior may be driven into the elastic anterior division, and *vice versa*. The posterior division being provided with the ductus pneumaticus does not require the elasticity of the anterior.

Some Siluroids possess a peculiar apparatus for voluntarily exercising a pressure upon the air-bladder. From the first vertebra a process takes its origin on each side, expanding at its end into a large round plate; this is applied to the side of the air-bladder, and by pressing upon it expels the air through the duct; the small muscle moving the plate rises from the skull. The connexion of the air-bladder with the organ of hearing in some Physostomes has been described above, p. 653.

In the modifications of the air-bladder hitherto mentioned, the chief and most general function is a mechanical one: this organ serves to regulate the specific gravity of the fish, to aid it in maintaining a particular level in the water, in rising or sinking, in raising the front part of its body or depressing it, as occasion may require. Yet a secretion of gas from the blood into its cavity must take place; and if this be so, it is not at all impossible that an exchange of gases between the two kinds of blood is also effected by means of the extraordinary development of retia mirabilia in many air-bladders.

In all fishes the arteries of the air-bladder take their origin from the aorta or the system of the aorta, and its veins return either to the portal, the vertebral, or the hepatic veins; like the other organs of the abdominal cavity, it receives arterial blood and returns venous blood.

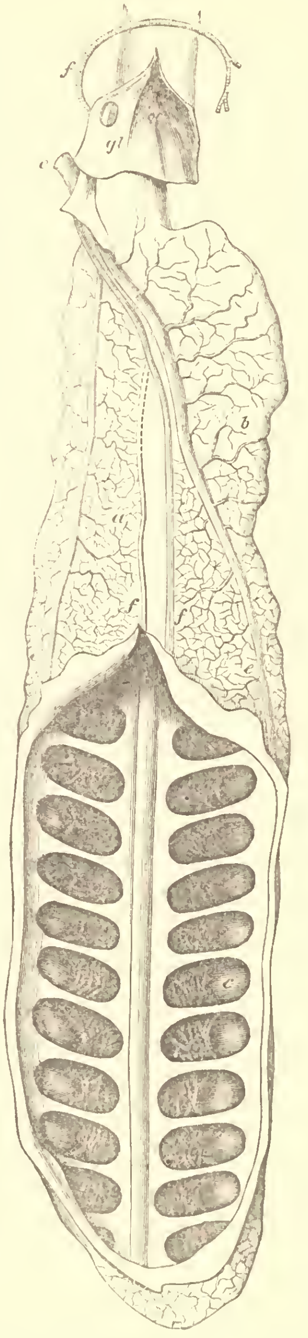


FIG. 49.—Lung of *Ceratodus*, opened in its lower half to show its cellular pouches. *a*, right half; *b*, left half; *c*, cellular pouches; *e*, vena pulmonalis; *f*, arterial blood-vessel; *oe*, œsophagus, opened to show glottis (*gl.*).

Whilst the air-bladders of some Ganoids, anatomically as well as functionally, closely adhere to the Teleosteous type, that of *Amia* is more cellular and lung-like in its interior than the Teleosteous air-bladder, and *Polypterus* approaches the *Dipnoi*, not only in having a laterally divided air-bladder, but also in its pneumatic duct entering the ventral side of the œsophagus. The air-bladder of the *Dipnoi* possesses still further the anatomical characteristics of a lung and assumes its functions, though, as it coexists with gills, only periodically or in an auxiliary manner. The ductus pneumaticus is a membranous bronchus, entering the ventral side of the œsophagus, and provided at its entrance with a glottis. In *Ceratodus* (fig. 49) the lung is still a single cavity, but with a symmetrical arrangement of its internal pouches; it has no pulmonary artery, but receives branches from the arteria cœliaca. Finally, in *Lepidosiren* and *Protopterus* the lung is completely divided into lateral halves, and by its cellular structure approaches most nearly that of a reptile; it is supplied with venous blood by a true pulmonary artery.

ORGANS OF CIRCULATION.

The blood-corpuscles of fishes, with one exception, are of an elliptic shape; this exception is *Petromyzon*, which possesses circular, flat, or slightly biconvex blood-corpuscles. They vary much in size; they are smallest in Teleosteans and Cyclostomes, those of *Acerina cernua* measuring $\frac{1}{2481}$ of an inch in their longitudinal, and $\frac{1}{3000}$ in their transverse diameter. So far as it is known at present the *Salmonidæ* have the largest blood corpuscles among Teleosteans, those of the salmon measuring $\frac{1}{1524}$ by $\frac{1}{2460}$ in., approaching those of the sturgeon. Those of the Chondropterygians are still larger; and finally, *Lepidosiren* has blood-corpuscles not much smaller than those of Perennibranchiates, viz., $\frac{1}{570}$ by $\frac{1}{941}$ in. *Branchiostoma* is the only fish which does not possess red blood-corpuscles.

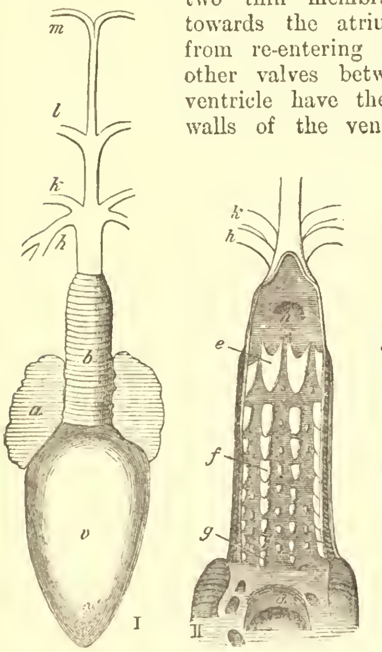
Fishes, in common with the other vertebrates, are provided with a complete circulation for the body, with another equally complete for the organs of respiration, and with a particular abdominal circulation, terminating at the liver by means of the vena portæ; but the peculiar characteristic consists in this, that the branchial circulation alone is provided at its base with a muscular apparatus or heart, corresponding to the right half of the heart of mammalia and birds.

The heart is situated between the branchial and abdominal cavities, between the two halves of the scapulary arch,—rarely farther behind, as in *Symbranchidæ*. It is enclosed in a pericardium, generally separated entirely from the abdominal cavity by a diaphragma, which is, in fact, the anterior portion of the peritoneum, strengthened by aponeurotic fibres. In some fishes, however, there is a communication between the pericardial and peritoneal sacs, viz., in the Chondropterygians and *Acipenser*, whilst in the Myxinoids the pericardial sac is merely a continuation of the peritoneum.

Relatively to the size of the body, the heart is very small. It consists of three divisions:—the atrium, with a large sinus venosus into which the veins enter; the ventricle; and a conical hollow swelling at the beginning of the arterial system, the structure of which forms one of the most important characters used in the classification of fishes. In all *Palæichthyes* (figs. 50 and 51) this swelling is still a division of the pulsating heart, being provided with a thick muscular stratum; it is not separated from the ventricle by two valves opposite to each other, but its interior is fitted with a plurality of valves, arranged in transverse series more or less numerous in the various groups of the subclass. *Lepidosiren* and *Protopterus* offer an example of a modification of this valvular arrangement, their valves being longitudinal, each valve in fact being formed by the confluence of several smaller ones situated behind one another. This Palæichthyan type is called conus arteriosus.

In Cyclostomes and Teleosteans (fig. 52) the enlargement is a swelling of the artery, without muscular stratum and without contractility; with the exception of the Myxinoids, its walls are thick and fibrous with many trabeculæ and pouches, but it has no valves in its interior, and is separated from the ventricle by two valves opposite to each other. This Teleostean type is called bulbus aortæ.

The sinus venosus sends the whole of the venous blood by a single orifice of its anterior convexity into the atrium; two thin membranous valvules turned towards the atrium prevent the blood from re-entering the sinus. A pair of other valves between the atrium and ventricle have the same function. The walls of the ventricle are strong, and, internally, it is furnished with powerful fleshy trabeculæ.



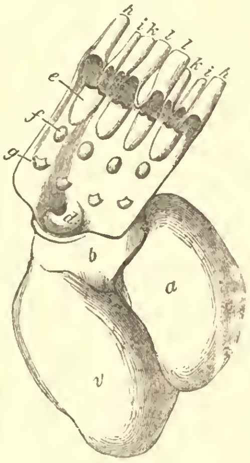


Fig. 50. Fig. 51.

FIG. 50—Heart of *Lepidosteus osseus*. I. External aspect. II. Conus arteriosus opened. *a*, atrium; *b*, conus arteriosus; *v*, ventricle; *h*, branchial artery for third and fourth gill; *k*, for the second; *l*, for the first; *m*, branch for the opercular gill; *d*, single valve at the base of the conus; *e*,*f*,*g*, transverse rows of Ganoid valves.

FIG. 51.—Heart of *Ceratodus*. *a*, atrium; *b*, conus arteriosus; *d*, papillary valve within the conus; *e*,*f*,*g*, transverse rows of Ganoid valves; *h*, *i*, anterior arcus aortæ; *k*, *l*, posterior arcus aortæ; *v*, ventricle.

The bulbus or conus arteriosus is prolonged into the branchial artery, which soon divides, sending off a branch to each branchial arch. On returning from the respiratory organ the branchial veins assume the structure and functions of arteries. Several branches are sent off to different portions of the head and to the heart, but the main trunks unite to form the great artery which carries the blood to the viscera and to all the parts of the trunk and tail, and which, therefore, represents the aorta of higher animals.

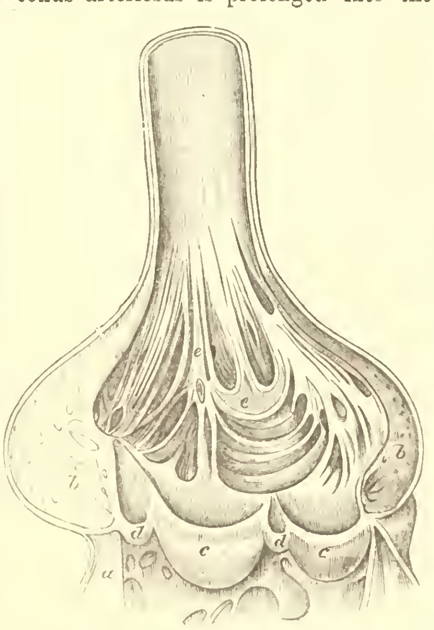


FIG. 52.—Bulbus aortæ of *Xiphias gladius*, opened. *a*, section through part of the wall of ventricle; *b*, section through the bulbus; *c*, Teleosteous valves of the ostium arteriosum; *d*, accessory valves, of rudimentary nature and inconstant; *e*, trabeculæ carneæ of the bulbus.

The circulatory system of *Branchiostoma* and of the *Dipnoi* shows essential differences from that of other fishes. *Branchiostoma* is the only fish which does not possess a muscular heart, several cardinal portions of its vascular system being contractile. A great vein extends forwards along the caudal region below the notochord, and exhibits contractility in a forward direction; it is bent anteriorly, passing into another tube-like pulsatory trunk, the branchial heart, which runs along the middle of the base of the pharynx, sending off branches on each side to the branchiæ; each of these branches has a small contractile dilatation (bulbillus) at its base. The two anterior branches pass directly into the aorta; the others are branchial arteries, the blood of which returns by branchial veins emptying into the aorta. The blood of the intestinal veins is collected in a contractile tube, the portal vein, below the intestine, and distributed over the rudimentary liver. Of all other fishes, the portal vein is contractile in Myxinoids only.

In *Dipnoi* a rudimentary partition of the heart into a right and a left division has been observed; this is limited to the ventricle in *Ceratodus*, but in *Lepidosiren* and *Protopterus* an incomplete septum has been observed in the atrium also. All *Dipnoi* have a pulmonal vein, which enters the atrium by a separate opening, provided with a valve. The pulmonal artery rises in *Lepidosiren* and *Protopterus* from an arch of the aorta, but in *Ceratodus* it is merely a subordinate branch, rising from the arteria cœliaca.

URINARY ORGANS.

In *Branchiostoma* no urinary organs have been found.

In Myxinoids these organs are of very primitive structure; they consist of a pair of ducts, extending from the urogenital porus through the abdominal cavity. Each duct sends off at regular intervals from its outer side a short wide branch (the uriniferous tube), which communicates by a narrow opening with a blind sac. At the bottom of this sac there is a small vaso-ganglion (Malpighian corpuscle), by which the urine is secreted.

In the lampreys the kidneys form a continuous gland-like body, with irregular detached small portions. The ureters coalesce before they terminate in the urogenital papilla.

In Chondropterygians the kidneys occupy the posterior half or two-thirds of the back of the abdominal cavity, outside the sac of the peritoneum (as in all fishes), which forms a firm tendinous horizontal septum. The kidneys of the two sides are never confluent, and generally show a convoluted or lobulated surface. The ureters are short; each is dilated into a pouch, and communicating with its fellow terminates by a single urethra (which also receives the vasa deferentia) behind the end of the rectum in the large common cloaca.

In Ganoids the kidneys occupy a similar position as in Chondropterygians, but these fishes differ considerably with regard to the termination and the arrangement of the ends of the urogenital ducts.

The kidneys of Teleosteans are likewise situated outside the peritoneal cavity, immediately below some part of the vertebral column, and vary exceedingly with regard to form and extent. Sometimes they reach from the skull to between the muscles of the tail, sometimes they are limited to the foremost part of the abdominal cavity (in advance of the diaphragm), but generally their extent corresponds to that of the abdominal portion of the vertebral column. The ureters terminate, either separate or united, in a urinary bladder, varying in shape, which opens by a short urethra behind the vent. The urinary opening may be separate from or confluent with that of the genital ducts, and is frequently placed on a more or less prominent papilla (papilla urogenitalis). If separate, the urinary opening is behind the genital; and if a papilla is developed, its extremity is perforated by the urethra, the genital opening being situated nearer the base. A few Teleosteans show an arrangement similar to that of Chondropterygians and *Dipnoi*, the urogenital openings being in the posterior wall of the rectum (*Symbranchidæ*, *Pediculati*, and some *Plectognathi*).

ORGANS OF REPRODUCTION.

All fishes are diœcious, or of distinct sex. Instances of so-called hermaphroditism are, with the exception of *Serranus*, abnormal individual peculiarities; such have been observed in the cod-fish, in some *Pleuronectidæ*, and in the herring. Either the generative organ of one side was found to be male and that of the other female, or the organ of one or both sides was observed to have been developed partly into an ovary, partly into a testicle. In the European species of *Serranus* a testicle-like body is attached to the lower part of the ovary; but many specimens of this genus are undoubtedly males, having normally developed testicles only.

The majority of fishes are oviparous (comparatively few viviparous), the embryos being developed either in the ovarium or in some dilated portion of the oviduct. In viviparous fishes actual copulation takes place, and the males of most of them are provided with copulatory or intromittent organs. In oviparous fishes the generative products are, during sexual excitement, discharged into the water, a very small quantity of semen being sufficient for effectual impregnation of a number of ova dispersed in a considerable quantity of water,—circumstances which render artificial impregnation more practicable than in any other class of animals.

In *Branchiostoma* the generative organs occupy the ventral side of the abdominal cavity, into which they discharge their contents. No ducts are developed in either sex.

In the Cyclostomes the generative organ is single, and fixed to or suspended from the median line of the back of the visceral cavity by a duplicature of the peritoneum (mesoarium), the testicle and ovary being distinguishable by their contents only. These escape by dehiscence of the cells or capsules and rupture of the peritoneal covering into the abdominal cavity, and are expelled, by reciprocal pressure of the intertwined sexes, through the porus genitalis.

The ova of the lampreys are small and globular, like those of Teleosteans. Those of *Myxine* have a very peculiar shape when mature; they are of an oval form, about 15 millimetres long and 8 millimetres broad, enveloped in a horny case, which at each end is provided with a bundle of short threads, each thread ending in a triple hook. Whilst in the mesoarial fold, the eggs are attached to one another by means of these hooks, and after being expelled they probably fix themselves by the same means to other objects. As in all fishes producing ova of large size, the number of ova matured in one season is but small.

In Teleosteans the generative organs are comparatively large. In some families the ovaries are without a closed covering and without oviducts, as in *Salmonidæ*, *Galaxiidæ*, *Notopteridæ*, *Murænidæ*, and others. The surface of such an open ovary—as, for instance, that of the salmon—is transversely plaited, the ova being developed in capsules in the stroma of the laminæ; after rupture of the capsules the mature ova drop into the abdominal cavity, and are expelled by the porus genitalis. The ovaries of the other Teleosteans are closed sacs, continued into oviducts. Frequently such ovaries coalesce into a single body, or one in which the division is effected internally only by a more or less complete septum. In the viviparous Teleosteans the embryos are developed within the ovary, notably in the *Embiotocidæ*, many *Blenniidæ*, and *Cyprinodontidæ*, *Sebastes viviparus*, &c.

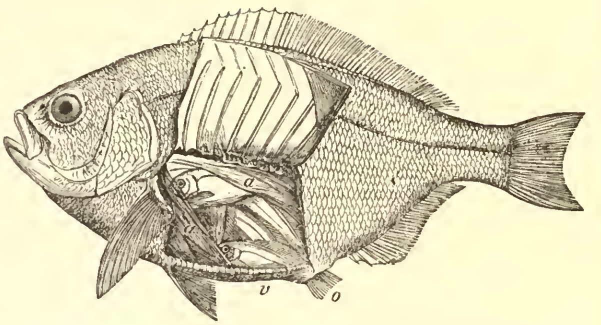


FIG. 53.—*Ditrema argenteum*, with fully developed young, ready for expulsion by the genital orifice, *o*; *a*, folds of the ovarian sac; *v*, vent.

The ova of Teleosteous fishes are extremely variable in size, quite independently of the size of the parent species. The ova of large and small individuals of the same species, of course, do not differ in size; but, on the whole, larger individuals produce a greater number of ova than smaller ones of the same species. The larger the size of the ova is in a species, the smaller is the number produced during one season. The ova of the eel are almost microscopic. The numbers of ova in the small-sized roe of the herring, lump-fish, halibut, and cod-fish have been estimated respectively at 25,000, 155,000, 3,500,000, and 9,344,000. Larger in size and fewer in number are those of *Antennarius*, *Salmo*, *Aspredo*, Lophobranchs, &c. Those of *Gastrosteus* are comparatively the largest; and the Siluroid genus *Arius*, the males of which take care of their progeny, produces ova from 5 to 10 millimetres in diameter. The ova of all Teleosteans are perfectly globular and soft-shelled. Teleosteans without oviduct deposit them separated from one another; whilst in many Teleosteans with an oviduct, the ova are enveloped in a glutinous substance, secreted by its glands, swelling in the water and forming lumps or chords, in which the ova are aggregated.

FIG. 54.—Ovum of *Arius boakii* (Ceylon), showing embryo. Nat. size.

Instances of the female taking care of her progeny are extremely rare in fishes. At present only two examples are known, that of the Siluroid genus *Aspredo*, and the *Solenostoma*. In the former (fig. 55), during the time of propagation, the integuments of the lower side of the flat trunk of the female assume a soft and spongy texture. After having deposited the eggs, the female attaches them to and presses them into the spongy integument, by merely lying over them. She carries them on her belly, as the Surinam toad (*Pipa*) carries her ova on her back. When the eggs are hatched the excrescence on the skin disappears, and the abdomen becomes as smooth as before. In *Solenostoma* the inner side of the long and broad ventral fins coalesces with the integuments of the body, a large pouch being formed for the reception of the eggs. There is a peculiar provision for the retention of the eggs in the sac, and probably for the attachment of the embryo. The inner walls of the sac are lined with long filaments, arranged in series along the ventral rays, and more numerous and longer at the base of the rays than in the middle of their length, behind which they disappear entirely.

The testicles of the Teleosteans are always paired, and occupy the same position as the ovaries. Their size varies extraordinarily at the different seasons of the year. Vasa deferentia are constant. In the males of viviparous Teleosteans the urogenital papilla is frequently enlarged, and clearly serves as an intromittent organ.

Many *Teleostei* take care of their progeny, but with the exception of *Aspredo* and *Solenostoma*, as mentioned above, it is the male on which this duty devolves. In some, as in *Cottus*, *Gastrosteus*, *Cyclopterus*, *Antennarius*, *Ophiocephalus*, *Callichthys*, the male constructs with more or less skill a nest, and jealously guards the ova deposited in it by the female. The male of some species of *Arius* carries the ova (fig. 54) about with him in his capacious pharynx. The species of *Chromis* inhabiting the sea of Galilee are said to take care of their ova in the same manner. And, finally, in the Lophobranchs, nature has aided this instinct by the development of a pouch or the abdomen or lower side of the tail. In the *Syngnathidæ* this pouch is formed by a fold of the skin developed from each side of the trunk and tail, the free margins of the fold being firmly united in the median line, whilst the eggs are being hatched in the inside of the pouch. In *Hippocampus* the pouch is completely closed, with a narrow anterior opening.

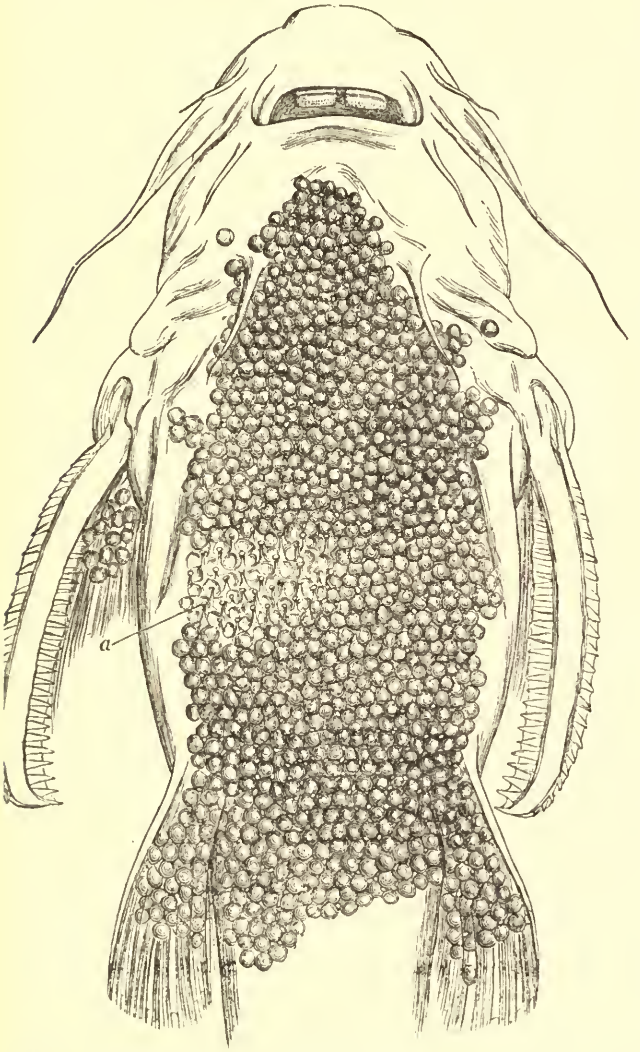


FIG. 55.—Abdomen of *Aspredo batrachus*, with the ova attached; at *a* the ova are removed, to show the spongy structure of the skin, and the processes filling the interspaces between the ova. (Natural size.)

The genital organs of Ganoids show diversity of structure similar to that found in Teleosteans, but on the whole they approach the Batrachian type. The ovaries are not closed, except in *Lepidosiren*; all Ganoids possess oviducts. In the sturgeons the oviduct as well as the vas deferens is represented by a funnel-shaped prolongation of the peritoneum, which communicates with the wide ureter. The inner aperture of the funnel is on a level with the middle of the testicle or ovary, while the outer is within the ureter; and it is a noteworthy fact that only at certain periods of the life of the fish is this outer aperture found to be open,—at other times the peritoneal funnel appears as a closed blind sac within the ureter. The mode of passage of the semen into the funnel is not known.

In *Polypterus* and *Amia* proper oviducts, with abdominal apertures in about the middle of the abdominal cavity, are developed; they coalesce with the ureters close to the common urogenital aperture.

In *Ceratodus* a long convoluted oviduct extends to the foremost limit of the abdominal cavity, where it opens by a slit at a considerable distance from the front end of the long ovary; this aperture is closed in sexually immature specimens. The oviducts unite close to their common opening in the cloaca. During their passage through the oviduct the ova receive a gelatinous covering secreted by its mucous membrane. This is probably also the case in *Lepidosiren*, which possesses a convoluted oviduct with secretory glands in the middle of its length.

The ova of Ganoids, so far as they are known at present, are small, and enveloped in a gelatinous substance. In the sturgeon as many as 7,635,200 have been counted. Those of *Lepidosteus* seem to be the largest, measuring 5 millimetres in diameter with their envelope, and 3 millimetres without it. They are deposited singly, like those of newts.

In Chondropterygians (and *Holocephali*) the organs of reproduction assume a more compact form, and are more free owing to a lengthened attachment to the back of the abdominal cavity. The ovaries of the majority are paired (single in the *Carchariidæ* and *Scylliidæ*, one remaining undeveloped). But the oviducts are always paired, with a common aperture beginning immediately behind the diaphragma. They consist of two divisions, separated by a circular valve; the upper is narrow, and is provided within its coats with a gland which secretes the leathery envelope in which

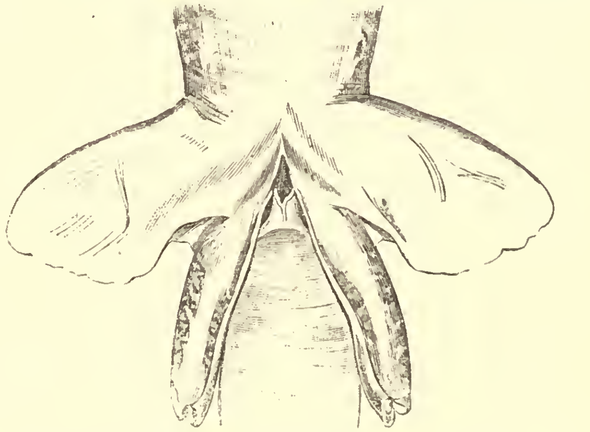


FIG. 56.—Ventral fins and claspers of *Chiloscyllium trispeculare*.

most of the Chondropterygian ova are enclosed; the lower forms the uterine dilatation in which the embryos of the viviparous species are developed. Generally the vitelline sac of the embryos is free, and has no connexion with the uterus, which in these cases has merely the function of a protecting pouch; but in *Carcharias* and *Mustelus lævis* a placenta uterina is formed, the vascular walls of the vitelline sac forming plaits fitting into those of the membrane of the uterus. The ends of the uteri open into the cloaca by a common aperture behind the ureter.

The testicles are always paired, rounded, and situated in the anterior part of the abdominal cavity, covered by the liver. The vas deferens opens with the urethra in a papilla within the cloaca.

The so-called claspers of Chondropterygians (fig. 56) are characteristic of all male individuals. They are semi-ossified appendages of the pubic, with which they are movably joined, and special muscles serve to regulate their movements. Sometimes they are armed with hook-like osseous excrescences (*Selache*). They are irregularly convoluted longitudinally, and, when closely pressed to each other, form a canal open at their extremity. A gland, which discharges a secretion abundantly during the season of propagation, is situated at the base of the canal, and opens into it. It is still doubtful whether the generally adopted opinion that their function consists in holding the female during copulation is correct, or whether they are not rather an intromittent organ, the canal of which conducts, not only the secretion of their proper gland, but also the impregnating fluid.

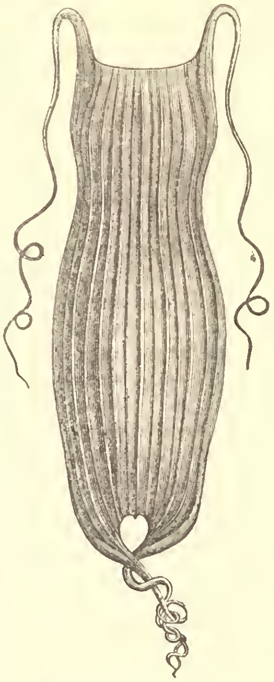


Fig. 57.—Egg of a *Scyllium* from Magellan's Straits (? *Sc. chilense*), natural size.

The ova of the oviparous Chondropterygians are large, and few in number; they are successively impregnated, and the impregnation must take place before they are invested with a tough leathery envelope, which would be impenetrable to the semen, that is, before they enter the uterus; therefore, copulation must take place in all these fishes. The form of the egg-shell differs in the various genera; usually (fig. 57) they are flattened and quadrangular, with each of the four corners produced, and frequently prolonged into, lengthy filaments which serve for the attachment of the ova to other fixed objects. In *Notidanus* the surfaces are crossed by numerous ridges. In *Cestracion* the egg is pyriform, with two broad ridges or plates wound edgewise round it, the two ridges forming five spires. The eggs of *Callorhynchus* have received a protective resemblance to a broad-leaved fucus, forming a long depressed ellipse, with a plicated and fringed margin.

Growth and Variation of Fishes.

Changes of form normally accompanying growth (after absorption of the vitelline sac) are observed in all fishes, but in the majority these affect only the proportional size of the various parts of the body. Relatively to the size of the head, the eyes in young fishes are always larger than in the adult; and again, the head is relatively larger than the body. Changes amounting to metamorphosis have been hitherto observed in *Petromyzon* only. In the larval condition (*Ammocœtes*) the head is very small, and the toothless buccal cavity is surrounded by a semicircular upper lip. The eyes are extremely small, hidden in a shallow groove; and the vertical fins form a continuous fringe. In the course of three or four years the teeth are developed, and the mouth changes into a perfect suctorial organ; the eyes grow; and the dorsal fin is separated into two divisions. In Malacopterygians and Anacanths the embryonal fringe from which the vertical fins are developed is much longer persistent than in Acanthopterygians. A metamorphosis relating to the respiratory organs, as in Batrachians, is indicated in the class of fishes by the external gills with which fœtal Plagiostomes and the young of some Ganoids, viz., the *Protopterus* and *Polypterus*, are provided.

One of the most extraordinary changes by which, during growth, the form and position of several important organs are affected, occurs in flat-fishes (*Pleuronectidæ*); their young are symmetrically formed, with a symmetrical mouth, and with one eye on each side, and therefore keep their body in a vertical position when swimming. As they grow they live more on the bottom, and their body, during rest, assumes a horizontal position; in consequence, the eye of the lower side moves towards the upper, which alone is coloured; and in many genera the mouth is twisted in the opposite direction, so that the bones, muscles, and teeth are much more developed on the blind side than on the coloured. In a great number of other *Teleostei* certain bones of the head show a very different form in the young state. Ossification proceeds in those bones in the direction of lines or radii which project in the form of spines or processes; as the interspaces between these processes are filled with bone, the processes disappear entirely, or at least project much less in the older than in the younger individuals. The young of some fishes may be armed with a long powerful præopercular or scapular spine, or may show a serrature of which nothing remains in the adult fish except some ridges or radiating lines. These processes seem to serve as weapons of defence during a period in the life of the fish in which it needs them most. In not a few instances a portion of this armature is so much developed that the disappearance of its most projecting parts with the growth of the fish is not only due to its being surrounded by other bone, but partially, at least, caused by absorption. The *Carangidæ*, *Cyttidæ*, *Squamipinnes*, *Xiphiidæ*, offer instances of such remarkable changes. A fish described as *Tholichthys osseus* (fig. 58) is probably the young of a Cyttoid, the suprascapula, humerus, and præoperculum forming enormously enlarged plates. In another fish (fig. 59) these bones appear still enlarged, and the frontals develop a remarkably long and curved horn above the orbit. In the *Tholichthys*-stage of *Pomacanthus* (specimens 10 millimetres long), the frontal bone is prolonged into a straight lancet-shaped process, nearly half as long as the body; the suprascapular and præopercular processes cover and hide the dorsal and ventral fins. The plates attached to the shoulder-girdle remain persistent until the young fish has assumed the form of the adult; thus they are still visible in young *Chætodon citrinellus*, 30 millimetres long, in which the specific characters are already fully developed (fig. 60). The sword-fishes with ventral fins (*Histiophorus*) belong to the Teleosteans of the largest size; in young individuals, 9 millimetres long (fig. 61), both jaws are produced, and armed

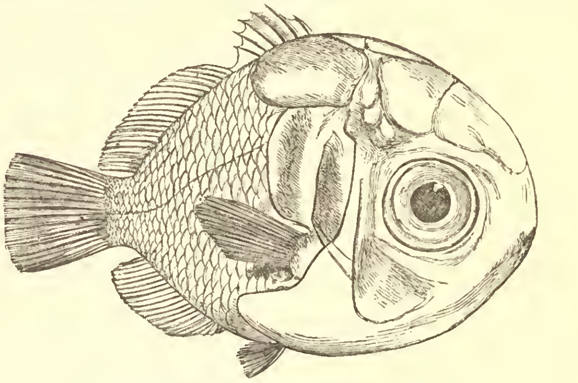


Fig. 58.—*Tholichthys osseus* (six times the natural size).

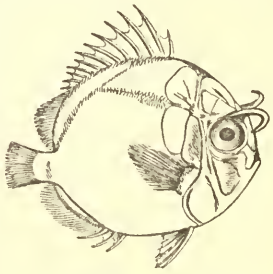


Fig. 59.—Tholichthys-stage of *Heniochus* (?).

with pointed teeth; the supraorbital margin is ciliated; the parietal and præoperculum are prolonged into long spines; the dorsal and anal fins are a low fringe; and the ventrals make their appearance as a pair of short buds. When 14 millimetres long the young fish has still the same armature on the head, but the dorsal fin has become much higher, and the ventral filaments have grown to a great length. At a third stage, when the fish has attained to a length of 60 millimetres, the upper jaw is considerably prolonged beyond the lower, losing its teeth; the spines of the head are shortened, and the fins assume nearly the shape which they retain in mature individuals. Young sword-fishes without ventral fins (*Xiphias*) undergo similar changes; and, besides, their skin is covered with small rough excrescences longitudinally arranged, which continue to be visible after the young fish has in other respects assumed the form of the mature (fig. 63).

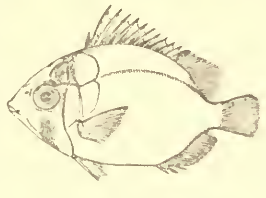


Fig. 60.—Young *Chætodon citrinellus* (30 mill. long).

Fig. 61.—Young Sword-fish (*Histiophorus*), 9 mill. long. Atlantic. (Magn.)

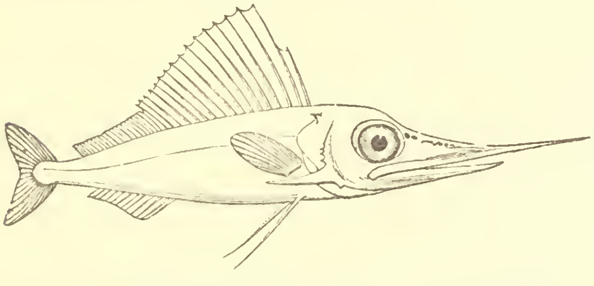


Fig. 62.—Young Sword-fish (*Histiophorus*), 60 mill. long. Mid-Atlantic.

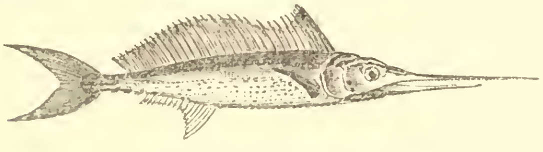


Fig. 63.—*Xiphias gladius*, young, about 8 inches long.

The Plectognaths show changes no less extraordinary: a remarkable form caught in the South Atlantic, and named *Ostracion boops*, is considered by Lütken to be the young of a sun-fish (*Orthagoriscus*). In still very young but more advanced sun-fishes (18 to 32 millimetres) the vertical diameter of the body is not much less than the longitudinal, and may even exceed it; and small conical spines are scattered over its various parts. The caudal fin is developed long after the other vertical fins.

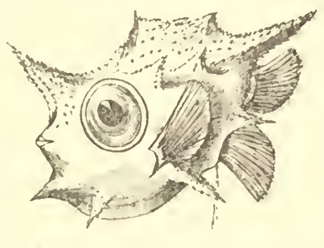


Fig. 64.—*Ostracion boops* (much magnified).

Similar changes take place in a number of other fishes, and in many cases the young are so different that they have been described as belonging to distinct genera: thus *Priacantichthys* has proved to be the young of *Serranus*, *Rhynchichthys* that of *Holocentrum*, *Cephalacanthus* of *Dactylopterus*, *Dicrotus* of *Thyrsites*, *Naucleras* of *Naucrates*, *Porthmeus* of *Chorinemus*, *Lampugus* of *Coryphæna*, *Acronurus* of *Acanthurus*, *Keris* of *Naseus*, *Porobronchus* of *Fierasfer*, *Couchia* of *Motella*, *Stomiasunculus* of *Stomias*, &c.

The fins are most frequently subject to changes during growth; but, whilst in some fishes parts of them are prolonged into filaments with age, in others the filaments exist during the early life-periods only; whilst in some a part of the dorsal or of the ventral fins is normally developed in the young only, in others those very parts are peculiar to the mature age. The integuments are similarly altered: in some species the young only have asperities on the skin, in others the young are smooth and the old have a tubercular skin; in some the young only have a hard bony head, in others (some Siluroids) the osseous carapace of the head and neck, as it appears in the adult, is more or less covered with soft skin whilst the fish is young.

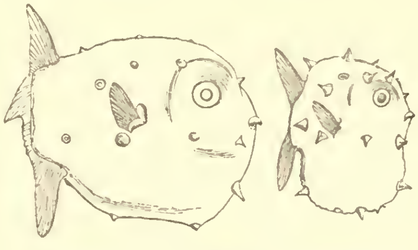


Fig. 65.—Young of *Orthagoriscus*, 18 and 32 mill. long (natural size).

In not a few fishes the external changes bear a relation to the sexual development (*Callionymus*, many *Labyrinthici* Cyprinodonts). These secondary sexual differences do not show themselves in the male individual till it commences to enter upon its sexual functions, and it may require two or more seasons before its external characteristics are fully developed. Immature males do not differ externally from the old female. The secondary sexual characters of the male consist principally in the prolongation of some of the fin-rays, or of entire fins, and in *Salmonidæ* in the greater development of the jaw-bones. The coloration of the male is in many fishes much brighter and more variegated than that of the female, but is permanent in comparatively few (as in some *Callionymus*, *Labrus mixtus*); generally it is acquired immediately before and during the season of propagation only, and lost afterwards. Another periodical change in the integuments, also due to sexual influence and peculiar to the male, is the excrescence of wart-like tubercles on the skin of many Cyprinoids; they are developed chiefly on the head, but sometimes extend over the whole body and all the fins.

With regard to size, it appears that in all Teleosteous fishes the female is larger than the male; in many Cyprinodonts the male may be only one-sixth of the bulk of the female or even less. In *Palæichthyes* we possess few observations on the relative size of the sexes, but such as have been made tend to show that, if a difference exists at all, the male is generally the larger (*Lepidosteus*). In the rays (*Raia*) the sexes, after they have attained maturity, differ in the development of dermal spines and the form of the teeth, the female being frequently much rougher than the male. There is much variation in this respect in the different species; but the males are constantly distinguished by an oblong patch of erectile clawlike spines on each pectoral fin, and by having the teeth (all, or only a portion) pointed, and not obtuse, like those of the females. In sharks no secondary sexual differences have been observed; the male *Chimæridæ* possess a singular comb-like cartilaginous appendage on the top of the head, which can be erected or depressed into a groove, both the appendage and the anterior part of the groove being armed with hooklets. The use of this singular organ is not known.

The majority of *Teleostei* are mixogamous—that is, the males and females congregate on the spawning-beds, and, the number of the former being in excess, several males attend to the same female, frequently changing from one to another. The same habit has been observed in *Lepidosteus*. *Gastrosteus* is truly polygamous, several females depositing their ova in the same nest, guarded by one male only. Some *Teleostei* (*Ophiocephalus*), and probably all Chondropterygians, are monogamous; and it is asserted that the connexion between the pair is not merely temporary, but lasts until they are separated by accident. All those Teleosteans also are probably monogamous which bring forth living young.

Hybridism is another source of changes and variations within the limits of a species, and is by no means so rare as has been hitherto believed; it is apparently of exceptional occurrence, merely because the life of fishes is more withdrawn from our direct observation than that of terrestrial animals. It has been observed among species of *Serranus*, *Pleuronectidæ*, *Cyprinidæ*, *Clupeidæ*, and especially *Salmonidæ*. As with other animals, the more certain kinds of fishes are brought under domestication, the more readily do they interbreed with other allied species. It is characteristic of hybrids that their characters are very variable, the degrees of affinity to the one or the other of the parents being inconstant; and, as these hybrids are known readily to breed with either of the parent race, the variations of form, structure, and colour are infinite. Of internal organs the teeth, the gill-rakers, and the pyloric appendages are those particularly affected by such mixture of species.

Some fishes are known to grow rapidly (in the course of from one to three years) and regularly to a certain size, growth being definitely arrested after the standard has been attained. Such fishes may be called "full-grown," in the sense in which the term is applied to warm-blooded vertebrates; the sticklebacks, most Cyprinodonts, and many Clupeoids (herring, sprat, pilchard) are examples of this regular kind of growth.[1] But in the majority of fishes the rate of growth is extremely irregular, and it is hardly possible to know when growth is actually and definitely arrested. All seems to depend on the amount of food and the more or less favourable circumstances under which the individual grows up. Fishes which rapidly grow to a definite size are short-lived, whilst those, Teleosteans as well as Chondropterygians, which steadily and slowly increase in size attain to a great age. Carp and pike have been ascertained to live beyond a hundred years.

Abundance or scarcity of food, and other circumstances connected with the localities inhabited by fishes, affect considerably the colour of their muscles and integuments; the periodical changes of colour in connexion with their sexual functions have been referred to above. The flesh of many *Teleostei* is colourless, or but slightly tinged by the blood; that of *Scombridæ*, and most Ganoids and Chondropterygians, is more or less red; but in badly-fed fishes, as well as in very young ones, the flesh is invariably white (anæmic). Many fishes, like the *Salmonidæ*, feed at times exclusively on crustaceans, and the colouring substance of these invertebrates, which by boiling and by the stomachic secretion turns red, seems to pass into their flesh, imparting to it the well-known "salmon" colour. The coloration of the integuments of many marine fishes, again, is dependent on the nature of their surroundings. In those which habitually hide themselves on the bottom, in sand, between stones, or among seaweed, the colours of the body readily assimilate to those of the vicinity, and are thus an important element in the economy of their life. The changes from one set or tinge of colours to another may be rapid and temporary, or more or less permanent; in some fishes—as in the *Pediculati*, of which the sea-devil, or *Lophius*, and *Antennarius* are members—scarcely two individuals are found exactly alike in coloration, and such differences are only too frequently mistaken for specific characters. The changes of colour are produced in two ways,—either by an increase or decrease of the pigment-cells, or chromatophors (black, red, yellow, &c.), in the skin of the fish, or by the rapid contraction or expansion of the chromatophors which happen to be developed. The former change is gradual, like every kind of growth or development; the latter, owing to the great sensitiveness of the cells, is rapid, but certainly involuntary. In many bright-shining fishes—as mackerels, mullets—the colours appear to be brightest in the time intervening between the capture of the fish and its death, a phenomenon clearly due to the pressure of the convulsively-contracted muscles on the chromatophors. External irritation readily excites the chromatophors to expand—a fact unconsciously utilized by fishermen, who, by scaling the red mullet immediately before its death, produce the desired intensity of the red colour of the skin, without which the fish would not be saleable. It does not, however, require such strong measures to prove the sensitiveness of the chromatophors to external irritation, the mere change from darkness into light is sufficient to induce them to contract, the fish appearing paler, and *vice versa*. In trout which are kept or live in dark places, the black chromatophors are expanded, and, consequently, such specimens are very dark-coloured; when removed to the light, they become paler almost instantaneously.

Total absence of chromatophors in the skin, or albinism, is very rare among fishes; much more common is incipient albinism, in which the dark chromatophors are changed into cells with a more or less intense yellow pigment. Fishes in a state of domestication, like the crucian carp of China, the carp, the tench, and the ide, are particularly subject to this abnormal coloration, and are known as the common gold-fish, the gold-tench, and the gold-orfe. But it occurs also not rarely in fishes living in a wild state, and has been observed in the haddock, flounder, plaice, carp, roach, and eel.

It will be evident from the foregoing remarks that the amount of variation within the limits of the same species—due either to natural growth and development, or to external physical conditions, or to abnormal accidental circumstances—is greater in fishes than in any of the higher classes of vertebrates. The amount of variation is greater in certain genera or families than in others, and it is much greater in Teleosteans and Ganoids than in Chondropterygians. Naturally, it is greatest in the few species that have been domesticated, which we shall mention in the following section.

Domestication, Tenacity of Life, Hibernation, &c.

Only a few fishes are thoroughly domesticated—that is, bred in captivity, and capable of transportation within certain climatic limits—viz., the carp, crucian carp (European and Chinese varieties), tench, orfe or ide, and goramy. The first two have accompanied civilized man almost to every part of the globe where he has effected a permanent settlement. Dom catic

[1] This applies only to individuals growing up under normal conditions. Dr H. A. Meyer has made observations on young herrings. Individuals living in the sea had attained at the end of the third month a length of 45 to 50 millimetres, whilst those reared from artificially impregnated ova were only from 30 to 35 millimetres long. When the latter had been supplied with more abundant food, they grew proportionally more rapidly in the following months, so that at the end of the fifth month they had reached the same length as their brethren in the sea, viz., 65 to 70 millimetres.

clima- ition. Attempts to acclimatize particularly useful species in countries in which they are not indigenous have been made from time to time, but have been permanently successful in a few instances only, the failures being due partly to the choice of a species which did not yield the profitable return expected, partly to utter disregard of the difference of climatic and other physical conditions between the original and the new homes of the fish. The first successful attempts at acclimatization were made with domestic species, viz., the carp and goldfish, which were transferred from Eastern Asia to Europe. Then, in the early part of the present century, the Javanese goramy was acclimatized in Mauritius and Guiana, but no care seems to have been taken to insure permanent advantages from the successful execution of the experiment. In these cases fully developed individuals were transported to the country in which they were to be acclimatized. The most successful attempt of recent years is the acclimatization of the trout and sea-trout, and probably also of the salmon, in Tasmania and New Zealand, and of the Californian salmon (*Salmo quinnat ?*), in Victoria, by means of artificially-impregnated ova. In transporting these ice was employed, in order to retard their development generally, and thus to preserve them from destruction during the passage across the tropical zone.

ificial preg- ion of Artificial impregnation of fish-ova was first practised by J. L. Jacobi, a native of Westphalia, in the years 1757–63, who employed exactly the same method which is followed now; and there is no doubt that this able observer of nature conceived and carried out his idea with the distinct object of advantageously restocking water-courses that had become unproductive, and increasing production by fecundating and preserving all ova which, in the ordinary course of propagation, would be left unfecundated or might accidentally perish. Physiology soon turned to account Jacobi's discovery, and artificial impregnation has proved to be one of the greatest helps to the student of embryology.

acity ife. Fishes differ in an extraordinary degree with regard to tenacity of life. Some will bear suspension of respiration —caused by removal from water, or by exposure to cold or heat—for a long time, whilst others succumb at once. Nearly all marine fishes are very sensitive to changes in the temperature of the water, and will not bear transportation from one climate to another. This seems to be much less the case with some freshwater fishes of the temperate zones; the carp may survive after being frozen in a solid block of ice, and will thrive in the warmest parts of the temperate zones. On the other hand, some freshwater fishes are so sensitive to a change in the water that they perish when transplanted from their native river into another apparently offering the same physical conditions (grayling, *Salmo hucho*). Some marine fishes may be transferred at once from salt into fresh water, like sticklebacks, some blennies, and *Cottus*, &c.; others survive the change when gradually effected, as many migratory fishes; whilst others, again, cannot bear the least alteration in the composition of the salt water (all pelagic fishes). On the whole, instances of marine fishes voluntarily entering brackish or fresh water are very numerous, whilst freshwater fishes proper but rarely descend into salt water.

Abstinence from food affects different fishes in a similarly different degree. Marine fishes are less able to endure hunger than freshwater fishes,—at least in the temperate zones, no observations having been made in this respect on tropical fishes. Goldfishes, carps, and eels are known to be able to subsist without food for months, without showing a visible decrease in bulk; whilst the Trigloids, Sparoids, and other marine fishes survive abstinence from food for a few days only. In freshwater fishes the temperature of the water has great influence on their vital functions generally, and consequently on their appetite. Many cease to feed altogether in the course of the winter; a few, like the pike, are less inclined to feed during the heat of the summer than when the temperature is lowered.

Captivity. Captivity is easily borne by most fishes, and the appliances introduced in modern aquaria have rendered it possible to keep in confinement fishes which formerly were considered to be intolerant of captivity, and even to induce them to propagate.

Injury from wounds. Wounds affect fishes generally much less than higher vertebrates. A Greenland shark continues to feed though its head is pierced by a harpoon or by the knife, so long as the nervous centre is not touched; a pike will survive the loss of its tail, or a sea-perch that of a portion of it, and a carp that of half its snout. Some fishes, however, are much more sensitive, and perish even from the superficial abrasion caused by the meshes of the net during capture (*Mullus*).

Reproduction of lost parts. The power of reproduction of lost parts in Teleosteous fishes is limited to the delicate terminations of their fin-rays and the various tegumentary filaments with which some are provided. These filaments are sometimes developed in an extraordinary degree, imitating the waving fronds of the seaweed in which the fish hides. The ends of the fin-rays and also the filaments are frequently lost, not only by accident, but also merely by wear and tear; and, as these organs are essential for the preservation of the fish, their reproduction is necessary. In *Dipnoi*, *Ceratodus*, and *Protopterus*, the terminal portion of the tail has been found to have been reproduced, but without the notochord.

Hibernation. Hibernation has been observed in many Cyprinoids and Murænoids of the temperate zones. They do not fall into a condition of complete torpidity, as reptiles and mammals do, but their vital functions are simply lowered, and they hide in sheltered holes, and cease to go abroad in search of their food. Between the tropics a great number of fishes (especially Siluroids, *Labyrinthici*, Ophiocephaloids, the *Dipnoi*) are known to survive long-continued droughts by passing the dry season in a perfectly torpid state, imbedded in the hardened mud. *Protopterus*, and probably many of the other fishes mentioned, prepare for themselves a cavity large enough to hold them, and coated on the inside with a layer of hardened mucus, which preserves them from complete desiccation. It has been stated that in India fishes may survive in this condition for more than one season, and that ponds, known to have been dry for several years and to a depth of many feet, have swarmed with fishes as soon as the accumulation of water released them from their hardened bed.

Economic uses. The principal benefit derived by man from the class of fishes consists in the abundance of wholesome and nourishing food which they yield. In the polar regions especially, whole tribes are entirely dependent on this class for subsistence; and in almost all nations fishes form a more or less essential part of food, many, in a preserved condition, being most important articles of trade. Their use in other respects is of but secondary importance. Cod-liver oil is prepared from the liver of some of the Gadoids of the northern hemisphere and of sharks, isinglass from the swim-bladder of sturgeons, Sciænoids, and Polynemoids, and shagreen from the skin of sharks and rays.

Poisonous fishes. The flesh of some fishes is constantly or occasionally poisonous. When eaten, it causes symptoms of more or less intense irritation in the stomach and intestines, inflammation of the mucous membranes, and not rarely death. The fishes which appear always to have poisonous properties are—*Clupea thrissa*, *Clupea venenosa*, and some species of *Scarus*, *Tetrodon*, and *Diodon*. There are many others which have occasionally or frequently caused symptoms of poisoning. Poey enumerates no less than seventy-two different kinds from Cuba; and various species of *Sphyræna*, *Balistes*, *Ostracion*, *Caranx*, *Lachnolæmus*, *Tetragonurus*, *Thynnus*, have been found to be poisonous in all seas between the tropics. All or nearly all these fishes acquire their poisonous properties from their food, which consists of poisonous *Medusæ* and corals, or of decomposing substances. Frequently the fishes are found to be eatable if the head and intestines are removed immediately after capture. In the West Indies it has been ascertained that all the fishes living and feeding on certain coral banks are poisonous. In other fishes the poisonous properties are developed at certain seasons of the year only, especially the season of propagation; as the barbel, pike, and burbot, whose roe causes violent diarrhœa when eaten during the season of spawning.

Poison-organs are more common in the class of fishes than was formerly believed, but they seem to have exclusively the function of defence, and are not auxiliary in procuring food, as in venomous snakes. Such organs are found in the sting-rays, the tail of which is armed with one or more powerful barbed spines. Although they have no special

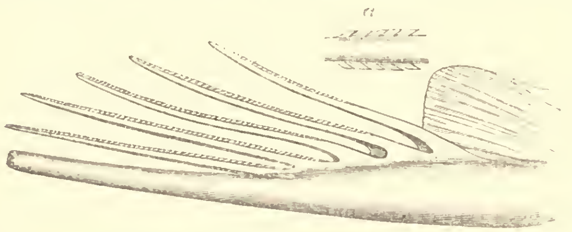


FIG. 66.—Portion of tail, with spines, of *Aetobatis narinari*, a Sting-ray from the Indian Ocean. *a*, natural size of spine.

organ secreting poison, or canal in or on the spine by which the venomous fluid is conducted, the symptoms caused by a wound from the spine of a sting-ray are such as cannot be accounted for merely by the mechanical laceration, the pain being intense, and the subsequent inflammation and swelling of the wounded part terminating not rarely in gangrene. The mucus secreted from the surface of the fish and inoculated by the jagged spine evidently possesses venomous properties. This is also the case in many Scorpænoids, and in the weever (*Trachinus*), in which the dorsal and opercular spines have the same function as the caudal spines of the sting-rays; in the weevers, however, the spines are deeply grooved, the groove being charged with a fluid mucus. In *Synanceia* the poison-organ (fig. 67) is still more developed: each dorsal spine is in its terminal half provided with a deep groove on each side, at the lower end of which lies a pear-shaped bag containing the milky poison; it is prolonged into a membranous duct, lying in the groove of the spine, and open at its point. The native fishermen, well acquainted

FIG. 67.—A dorsal spine, with poison-bags, of *Synanceia verrucosa* (Indian Ocean).

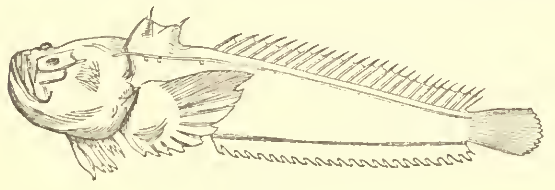


FIG. 68.—*Thalassophryne reticulata.*

with the dangerous nature of these fishes carefully avoid handling them; but it often happens that persons wading with naked feet in the sea step upon the fish, which generally lies hidden in the sand. One or more of the erected spines penetrate the skin, and the poison is injected into the wound by the pressure of the foot on the poison-bags. Death has frequently been the result.

The most perfect poison-organs hitherto discovered in fishes are those of *Thalassophryne*, a Batrachoid genus of fishes from the coasts of Central America. In these fishes again the operculum and the two dorsal spines are the weapons. The former (fig. 69) is very narrow, vertically styliform, and very mobile; it is armed behind with a spine, eight lines long, and of the same form as the hollow venom-fang of a snake, being perforated at its base and at its extremity. A sac covering the base of the spine discharges its contents through the apertures and the canal in the interior of the spine. The structure of the dorsal spines is similar. There are no secretory glands imbedded in the membranes of the sacs, and the fluid must be secreted by their mucous membrane. The sacs have no external muscular layer, and are situated immediately below the thick loose skin which envelops the spines to their extremity; the ejection of the poison into a living animal, therefore, can only be effected, as in *Synanceia*, by the pressure to which the sac is subjected the moment the spine enters another body

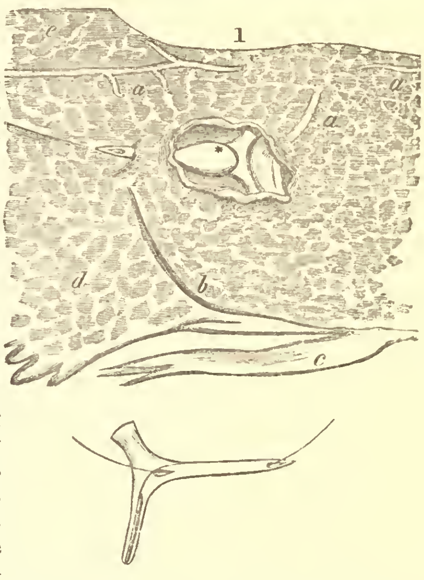


FIG. 69.—Opercular part of the poison-apparatus of *Thalassophryne* (Panama). 1. Hinder half of the head, with the venom-sac * *in situ*. *a*, lateral line and its branches; *b*, gill-opening; *c*, ventral fin; *d*, base of pectoral fin; *e*, base of dorsal. 2. Operculum with the perforated spine.

GEOLOGICAL DISTRIBUTION.

Of what kind the fishes were which were the first to make their appearance on the globe, whether or not they were identical with or similar to any of the principal types existing at present, are questions which probably will for ever remain hidden in mystery and uncertainty. The supposition that the Pharyngobranchs and Cyclostomes, the lowest of the vertebrate series, must have preceded the other subclasses, is an idea which has been held by many zoologists, and, as the horny teeth of the Cyclostomes are the only parts which under favourable circumstances could have been preserved, palæontologists have ever been searching for this evidence.

Indeed, in deposits belonging to the Lower Silurian and Devonian, in Russia, England, and North America, minute, slender, pointed horny bodies, bent like a hook, with sharp opposite margins, have been found and described under the name of "conodonts." More frequently they possess an elongated basal portion, in which there is generally a larger tooth with rows of similar but smaller denticles on one or both sides of the larger tooth, according as this is central or at one end of the base. In other examples there is no prominent central tooth, but a series of more or less similar teeth is implanted

FIG. 70.—Right dental plate of *Myxine affinis.*

on a straight or curved base. Modifications of these arrangements are very numerous, and many palæontologists still entertain doubts whether the origin of these remains is not rather from annelids and mollusks than from fishes.

The first undeniable evidence of a fish, or, indeed, of a vertebrate animal, occurs in the Upper Silurian rocks, in a bone-bed of the Downton Sandstone, near Ludlow. It consists of compressed, slightly curved, ribbed spines, of less than 2 inches in length (*Onchus*); small shagreen-scales (*Thelodus*); the fragment of a jaw-like bar with pluricuspid teeth (*Plectrodus*); the cephalic bucklers of what seems to be a species of *Pteraspis*; and, finally, coprolitic bodies of phosphate and carbonate of lime, including recognizable remains of the mollusks and crinoids inhabiting the same waters. But no vertebra or other part of the skeleton has been found. The spines and scales seem to have belonged to the same kind of fish, which probably was a Plagiostome. It is quite uncertain whether or not the jaw (if it be the jaw of a fish) belonged to the buckler-bearing *Pteraspis*, the position of which among Ganoids, with which it is generally associated, is open to doubt.

No detached undoubted tooth of a Plagiostome or Ganoid scale has been discovered in the Ludlow deposits; but this much is certain, that those earliest remains in Palæozoic rocks belonged to fishes closely allied to forms occurring in greater abundance in the succeeding formation, the Devonian, where they are associated with undoubted *Palæichthyes*, Plagiostomes as well as Ganoids.

These fish-remains of the Devonian or Old Red Sandstone can be determined with greater certainty. They consist of spines, the so-called "ichthyodorulites," which show sufficiently distinctive characters to be referred to several genera, one of them, *Onchus*, still surviving from the Silurian epoch. All these spines are believed to be those of Chondropterygians, to which order some pluricuspid teeth (*Cladodus*) from the Old Red Sandstone in the vicinity of St Petersburg have been likewise referred.

The remains of the Ganoid fishes are in a much more perfect state of preservation, so that it is even possible to obtain a tolerably certain idea of the general appearance and habits of some of them, especially of such as were provided with hard carapaces, solid scales, and ordinary or bony fin-rays. A certain proportion of them, as might have been expected, remind us, as regards their external form, of Teleosteous fishes rather than of any of the few still existing Ganoid types; but it is contrary to all analogy and to all palæontological evidence to suppose that those fishes were, in their internal structure, more nearly allied to Teleosteans than to Ganoids. If they were not true Ganoids, they may justly be supposed to have had the essential characters of *Palæichthyes*. Other forms even at that remote geological epoch exhibit so unmistakably the characteristics of existing Ganoids that no one can entertain any doubt with regard to their place in the system. In none of these fishes is there any trace of vertebral segmentation.

The *Palæichthyes* of the Old Red Sandstone, the systematic position of which is still obscure, are the *Cephalaspidæ* from the Lower Old Red Sandstone of Great Britain and Eastern Canada; *Pterichthys, Coccosteus, Dinichthys*, and *Asterolepis* (genera which have been combined in one group, *Placodermæ*); and *Acanthodes* and allied genera, which combined numerous branchiostegals with Chondropterygian spines and a shagreen-like dermal covering.

Among the other Devonian fishes (and they form the majority) two types may be recognized, both of which are unmistakably Ganoids. The first approaches the still living *Polypterus*, with which some of the genera like *Diplopterus* singularly agree in the form and armature of the head, the lepidosis of the body, the lobate pectoral fins, and the termination of the vertebral column. Other genera, as *Holoptychius*, have cycloid scales; many have two dorsal fins (*Holoptychius*), and, instead of branchiostegals, jugular scutes; others have one long dorsal confluent with the caudal (*Phaneropleuron*). In the second type the principal characters of the *Dipnoi* are manifest; and some of them—for example, *Dipterus, Palædaphus, Holodus*—approach so closely the *Dipnoi* which still survive that the differences existing between them warrant a separation into families only.

Devonian fishes are frequently found under peculiar circumstances, enclosed in the so-called nodules. These bodies are elliptical flattened pebbles, which have resisted the action of water in consequence of their greater hardness, whilst the surrounding rock has been reduced to detritus by that agency. Their greater density is due to the dispersion in their substance of the fat of the animal which decomposed in them. Frequently, on cleaving one of these nodules with the stroke of the hammer, a fish is found embedded in the centre. At certain localities of the Devonian, fossil fishes are so abundant that the whole of the stratum is affected by the decomposing remains, emitting a peculiar smell when newly opened, and acquiring a density and durability not possessed by strata without fishes. The flagstones of Caithness are a remarkable instance of this.

The fish-remains of the Carboniferous formation show a great similarity to those of the preceding. They occur throughout the series, but are very irregularly distributed, being extremely rare in some countries, whilst in others entire beds (the so-called bone-beds) are composed of ichthyolites. In the ironstones they frequently form the nuclei of nodules, as in the Devonian.

Of Chondropterygians the spines of *Onchus* and others still occur, with the addition of teeth indicative of the existence of fishes allied to the Cestracion type (*Cochliodus, Psammodus*), a type which henceforth plays an important part in the composition of the extinct marine fish faunæ. Another extinct Selachian family, that of the Hybodonts, makes its appearance, but is known from the teeth only.

Of the Ganoid fishes, the family *Palæoniscidæ* (Traquair) is numerously represented; others are Cœlacanths (*Cœlacanthus, Rhizodus*), and *Saurodipterini* (*Megalichthys*). None of these fishes have an ossified vertebral column, but in some (*Megalichthys*) the outer surface of the vertebræ is ossified into a ring; the termination of their tail is heterocercal. The Carboniferous *Uronemus* and the Devonian *Phaneropleuron* are probably generically the same; and the Devonian *Dipnoi* are continued as, and well represented by, *Ctenodus*.

The fishes of the Permian group are very similar to those of the Carboniferous. A type which in the latter was but very scantily represented, namely the *Platysomidæ*, is much developed. They were deep-bodied fish, covered with hard rhomboid scales possessing a strong anterior rib, and provided with a heterocercal caudal, long dorsal and anal, short non-lobate paired fins (when present), and branchiostegals. *Palæoniscus* appears in many species; the *Sauridæ* are represented by *Pygopterus* and *Acrolepis*, and Cestracionts by *Janassa* and *Strophodus*.

The passage from the Palæozoic into the Mesozoic era is not indicated by any marked change so far as fishes are concerned. The more remarkable forms of the Trias are shark-like fishes represented by ichthyodorulites, like *Nemacanthus, Liacanthus*, and *Hybodus*; and Cestracionts represented by species of *Acrodus* and *Strophodus*. Of the Ganoids, *Cœlacanthus, Amblypterus* (*Palæoniscidæ*), and *Saurichthys* persist from the Carboniferous epoch. *Ceratodus* appears for the first time (Muschel Kalk of Germany).

Thanks to the researches of Agassiz, and especially of Sir P. Egerton, the ichthyological fauna of the Lias is perhaps the best known of the Mesozoic era, one hundred and fifty-two species having been described. Of the various localities, Lyme Regis has yielded more than any other, nearly all the Liassic genera being represented there by no fewer than seventy-nine species. The Hybodonts and Cestracionts continue in their fullest development. Holocephales (*Ischyodus*), true sharks (*Palæoscyllium*), rays (*Squaloraia*, *Arthropterus*), and sturgeons (*Chondrosteus*) make their first appearance; but they are sufficiently distinct from living types to be classed in separate genera, or even families. The Ganoids, especially Lepidosteoids, predominate over all the other fishes: *Lepidotus*, *Semionotus*, *Pholidophorus*, *Pachycormus*, *Eugnathus*, *Tetragonolepis*, are represented by numerous species; other remarkable genera are *Aspidorhynchus*, *Belonostomus*, *Saurostomus*, *Sauropsis*, *Thrissonotus*, *Conodus*, *Ptycholepis*, *Endactis*, *Centrolepis*, *Legnonotus*, *Oxygnathus*, *Heterolepidotus*, *Isocolum*, *Osteorhachis*, *Mesodon*. These genera afford evidence of a great change since the preceding period, the majority not being represented in older strata, whilst, on the other hand, many are continued into the succeeding Oolitic formations. The homocercal termination of the vertebral column begins to supersede the heterocercal, and many of the genera have well-ossified and distinctly segmented spinal columns. The cycloid form of scales also becomes more common,—one genus (*Leptolepis*) being, with regard to the preserved hard portions of its organization, so similar to the Teleosteous type that some palæontologists refer it (with much reason) to that subclass.

As already mentioned, the Oolitic formations show a great similarity of their fish fauna to that of the Lias; but still more apparent is its approach to the existing fauna. Teeth have been found which cannot even generically be distinguished from *Notidanus*. The rays are represented by genera like *Spathobatis*, *Belemnobatis*, *Thaumas*; the *Holocephali* are more numerous than in the Lias (*Ischyodus*, *Ganodus*). The most common Ganoid genera are *Caturus*, *Pycnodus*, *Pholidophorus*, *Lepidotus*, *Leptolepis*, all of which had been more or less fully represented in the Lias. *Ceratodus* also is continued into it.

The Cretaceous group gives clear evidence of the further advance towards the existing fauna. Teeth of sharks of existing genera, *Carcharias* (*Corax*), *Scyllium*, *Notidanus*, and *Galeocerdo*, are common in some of the marine strata, whilst Hybodonts and Cestracionts are represented by a small number of species only; of the latter one new genus, *Ptychodus*, appears and disappears. A very characteristic Ganoid genus, *Macropoma*, comprises homocercal fishes with rounded ganoid scales sculptured externally and pierced by prominent mucous tubes. *Caturus* becomes extinct. Teeth and scales of *Lepidotus* (with *Sphærodus* as subgenus), clearly a freshwater fish, are widely distributed in the Wealden, and finally disappear in the Chalk; its body was covered with large rhomboidal ganoid scales. *Gyrodus* and *Aspidorhynchus* occur in the beds of Voirons, *Cœlodus* and *Amiopsis* (allied to *Amia*) in those of Comen, in Istria. But the *Palæichthyes* are now in the minority; undoubted Teleosteans have appeared for the first time on the stage of life in numerous genera, many of which are identical with still existing fishes. The most of these are Acanthopterygians, but Physostomes and Plectognaths are likewise well represented, most of them being marine. Of Acanthopterygian families the first to appear are the *Berycidæ*, represented by several very distinct genera:—*Beryx*; *Pseudoberyx*, with abdominal ventral fins; *Berycopsis*, with cycloid scales; *Homonotus*, *Stenostoma*, *Sphenocephalus*, *Acanus*, *Hoplopteryx*, *Platycornus*, with granular scales; *Podocys*, with a dorsal extending to the neck; *Acrogaster*, *Macrolepis*, *Rhacolepis*, from the Chalk of Brazil. The position of *Pycnosterynx* is uncertain; it approaches certain Pharyngognaths. True *Percidæ* are absent, whilst the *Carangidæ*, *Sphyrænidæ*, *Cataphracti*, *Gobiidæ*, *Cottidæ*, and *Sparidæ* are represented by one or more genera. Somewhat less diversified are the Physostomes, which belong principally to the *Clupeidæ* and *Dercetidæ*, most of the genera being extinct; *Clupea* is abundant in some localities. *Scopelidæ* (*Hemisaurida* and *Saurocephalus*) occur in the Chalk of Comen in Istria, and of Maestricht. Of all Cretaceous deposits none surpass those of the Lebanon for the number of genera, species, and individuals; the forms are exclusively marine, and the remains in the most perfect condition.

In the Tertiary epoch the Teleosteans have almost entirely replaced the Ganoids; a few species only of the latter make their appearance, and they belong to existing genera (*Lepidosteus*, *Acipenser*). The Chondropterygians merge more and more into recent forms; *Holocephali* continue, and still are better represented than in the present fauna. The Teleosteans show even in the Eocene a large proportion of existing genera, and the fauna of some localities of the Miocene (Oeningen) is almost wholly composed of them. Of the whole more than one-half have already been found to belong to existing genera, and there is no doubt that the number of distinct genera now seemingly extinct will be lessened as the fossils come to be examined with a better knowledge of the living forms. The distribution of the fishes differed widely from that of our period, many of our tropical genera occurring in localities which are now included within our temperate zone, and being mixed with others that nowadays are restricted to a colder climate,—a combination which continues throughout the Pliocene.

A few families of fishes, like the freshwater *Salmonidæ*, seem to have put in their appearance in Post-Pliocene times; not much attention, however, has been paid to fish-remains of these deposits; and such as have been incidentally examined furnish evidence of the fact that the distribution of fishes has not undergone any further essential change down to the present period.

GEOGRAPHICAL DISTRIBUTION.

In an account of the geographical distribution of fishes the freshwater forms are to be kept separate from the marine. When we attempt, however, to draw a line between these two kinds of fishes, we meet with a great number of species and of facts which would seem to render that distinction very vague. There are not only species which can gradually accommodate themselves to a sojourn in either salt or fresh water, but there are also some that seem to be quite indifferent to a rapid change from the one into the other; so that individuals of one and the same species (*Gastrosteus*, *Gobius*, *Blennius*, *Osmerus*, *Retropinna*, *Clupea*, *Syngnathus*, &c.) may be found some distance out at sea, whilst others live in rivers far beyond the influence of the tide, or even in inland fresh waters without outlet to the sea. The majority of these fishes belong to forms of brackish-water fauna; and, as they are not an insignificant portion of the fauna of almost every coast, we shall have to treat of them in a separate chapter.

Almost every large river offers instances of truly marine fishes ascending for hundreds of miles of their course, and not periodically, or from any apparent physiological necessity, but sporadically throughout the year. This is evidently the commencement of a change in a fish's habits; and, indeed, not a few of such fishes have actually taken up their permanent residence in fresh waters, as species of *Ambassis*, *Apogon*, *Dules*, *Therapon*, *Sciæna*, *Blennius*, *Gobius*, *Atherina*, *Mugil*, *Myxus*, *Hemirhamphus*, *Clupea*, *Anguilla*, *Tetrodon*, *Trygon*,—all forms originally marine.

On the other hand, we find fishes belonging to freshwater genera descending rivers and sojourning in the sea for a more or less limited period; but these instances are much less in number than those in which the reverse obtains. We may mention species of *Salmo* (the common trout, the northern charr), and Siluroids (as *Arius*, *Plotosus*). *Coregonus*, a genus so characteristic of the inland lakes of Europe, Northern Asia, and North America, nevertheless offers some instances of species wandering by the effluents into the sea, and taking up their residence in salt water, apparently by preference, as *Coregonus oxyrhynchus*. But of all the freshwater families none exhibit so great a capability of surviving the change from fresh into salt water as the *Gastrosteidæ* (sticklebacks) of the northern hemisphere, and the equally diminutive *Cyprinodontidæ* of the tropics; not only do they enter into, and live freely in, the sea, but many species of the latter family inhabit inland waters, which, not having an outlet, have become briny, or impregnated with a larger proportion of salts than pure sea-water. During the voyage of the "Challenger" a species of *Fundulus* (*F. nigrofasciatus*) which inhabits the fresh and the brackish waters of the Atlantic States of North America was obtained, with Scopelids and other pelagic forms, in the tow-net, midway between St Thomas and Teneriffe.

Some fishes annually or periodically ascend rivers for the purpose of spawning, passing the rest of the year in the sea, as sturgeons, many Salmonoids, some Clupeoids, lampreys, &c. The first two evidently belonged originally to the freshwater series, and it was only in the course of their existence that they acquired the habit of descending to the sea, perhaps because their freshwater home did not furnish a sufficient supply of food. These migrations of freshwater fishes have been compared with the migrations of birds; but they are much more limited in extent, and do not, as is the case with birds, impart an additional element to the fauna of the place to which the fishes migrate.

The distinction between freshwater and marine fishes is further obscured by geological changes, in consequence of which the salt water is gradually being changed into fresh, or *vice versa*. These changes are so gradual, and spread over so long a time, that many of the fishes inhabiting such localities accommodate themselves to the new conditions. One of the most remarkable and best studied instances of such an alteration is the Baltic, which, during the second half of the Glacial period, was in open and wide communication with the Arctic Ocean, and evidently had the same marine fauna as the White Sea. Since then, by the rising of the land of Northern Scandinavia and Finland, this great gulf of the Arctic Ocean has become an inland sea, with a narrow outlet into the North Sea, and, in consequence of the excess of fresh water pouring into it over the loss by evaporation, it has been so much diluted as to be nearly fresh at its northern extremities; and yet nine species, the origin of which from the Arctic Ocean can be proved, have survived the changes, propagating their species, and agreeing with their brethren in the Arctic Ocean in every point, but remaining comparatively smaller. On the other hand, fishes which we must regard as true freshwater fishes, like the rudd, roach, pike, perch, enter freely the brackish water of the Baltic. Instances of marine fishes being permanently retained in fresh water in consequence of geological changes are well known: as *Cottus quadricornis* in the large lakes of Scandinavia; species of *Gobius*, *Blennius*, and *Atherina* in the lakes of northern Italy; *Comephorus*, which seems to be a dwarfed Gadoid, in the depths of Lake Baikal. *Carcharias gangeticus* in inland lakes of the Fiji Islands, is another instance of a marine fish which has permanently established itself in fresh water.

Thus there is a constant interchange of species in progress between the freshwater and marine faunæ, and in not a few cases it would seem almost arbitrary to refer a genus or even a larger group of fishes to the one or the other; yet there are certain groups of fishes which entirely, or with but few exceptions, are, and apparently during the whole period of their existence have been, inhabitants either of the sea or of fresh water; and, as the agencies operating upon the distribution of marine fishes differ greatly from those influencing the dispersal of freshwater fishes, the two series must be treated separately. The most obvious fact that dry land, which intervenes between river systems, presents to the rapid spreading of a freshwater fish an obstacle which can be surmounted only exceptionally or by a most circuitous route, whilst marine fishes may readily and voluntarily extend their original limits, could be illustrated by a great number of instances. Without entering into details, it may suffice to state, as the general result, that no species or genus of freshwater fishes has anything like the immense range of the corresponding categories of marine fishes, and that, with the exception of the Siluroids, no freshwater family is so widely spread as the families of marine fishes. Surface temperature or climate, which is, if not the most, one of the most important physical factors in the limitation of freshwater fishes, similarly affects the distribution of marine fishes, but in a less degree, and only in the case of those which live near the shore or the surface of the ocean; it ceases to exercise its influence in proportion to the depth, the true deep-sea forms being entirely exempt from its operation. Light, which is pretty equally distributed over the localities inhabited by freshwater fishes, cannot be considered as an important factor in their distribution, but it contributes to the formation of the impassable barrier between the surface and abyssal forms of marine fishes. Altitude has stamped the fishes of the various alpine provinces of the globe with a certain character, and limited their distribution; but the number of these alpine forms is comparatively small, ichthyic life being extinguished at great elevations even before the mean temperature equals that of the high latitudes of the Arctic region, in which some freshwater fishes flourish. On the other hand, the depths of the ocean, far exceeding the altitude of the highest mountains, still swarm with forms specially adapted for abyssal life. That other physical conditions of minor and local importance, under which freshwater fishes live, and by which their dispersal is regulated, are more complicated than similar ones of the ocean, is probable, though perhaps less so than is generally supposed; for the fact is that the former are more accessible to observation than the latter, and are therefore more generally and more readily comprehended and acknowledged. It will thus be necessary to treat of the two series separately, not only because many of the most characteristic forms of the marine and the freshwater series are found, on taking a broader view of the subject, to be sufficiently distinct, but also because their distribution depends on causes different in their nature as well as in the degree of their action. Whether the oceanic areas correspond in any way to the terrestrial will be seen in the sequel.

Freshwater Fishes.

Having shown above that numerous marine fishes enter fresh waters, and that some of them have permanently established themselves therein, we have to eliminate from the category of freshwater fishes all such adventitious elements. They are derived from forms the distribution of which is regulated by other agencies, and which therefore would obscure the relations of the faunæ of terrestrial regions if they were included in them. They will be mentioned with greater propriety along with the fishes constituting the fauna of brackish water.

The true freshwater fishes are all embraced in the following families and groups :—

Dipnoi, with 4 species; Acipenseridæ and Polyodontidæ, 26; Amiidæ, 1; Polypteridæ, 2; Lepidosteidæ, 3; Percina, 46; Grystina, 11; Aphredoderidæ, 1; Centrarchina, 26; Dules, 10; Nandidæ, 7; Polycentridæ, 3; Labyrinthici, 30; Luciocephalidæ, 1; Gastrosteus, 10; Ophiocephalidæ, 31; Mastacembelidæ, 13; Chromides, 105; Comephoridæ, 1; Gadopsidæ, 1; Siluridæ, 572; Characinidæ, 261; Haplochitonidæ, 3; Salmonidæ (3 genera excepted), 135; Percopsidæ, 1; Galaxiidæ, 15; Mormyridæ (and Gymnarchidæ), 52; Esocidæ, 8; Umbridæ, 2; Cyprinodontidæ, 112; Heteropygii, 2; Cyprinidæ, 724; Kneriidæ, 2; Hyodontidæ, 1; Pantodontidæ, 1; Osteoglossidæ, 5; Notopteridæ, 5; Gymnotidæ, 20; Symbranchidæ, 5; Petromyzontidæ, 12. Total, 2270 species.

As in every other class of animals, these freshwater genera and families vary exceedingly with regard to the extent of their geographical range,—some extending over more than the half of the continental areas, whilst others are limited to one continent only, or even to a very small portion of it. As a general rule, a genus or family of freshwater fishes is regularly dispersed and most developed within a certain district, the species and individuals becoming fewer towards the periphery as the type recedes more from its central home, some outposts, however, frequently being pushed far beyond the outskirts of the area occupied by it. At the same time remarkable instances exist of closely allied forms occurring, almost isolated, at most distant points, without being connected by allied species in the intervening space, and of members of the same family, genus, or species inhabiting the opposite shores of an ocean, and separated by many degrees of abyssal depths.

The dispersal of freshwater fishes has been effected in various ways; probably all the causes are still in operation, most of them working so slowly and imperceptibly as to escape direct observation. From the great number of freshwater forms which we see at the present day already acclimatized or gradually becoming acclimatized in the sea, or periodically or sporadically migrating to it, we must conclude that, under certain circumstances, salt water may cease to be an impassable barrier at some period of the existence of freshwater species, and that many of them have passed from one river through salt water into another. Secondly, the headwaters of some of the largest rivers, the mouths of which are at opposite ends of the continents which they drain, are sometimes distant from each other a few miles only; the intervening space may easily have been bridged over for the passage of fishes by a slight geological change affecting the level of the watershed, or even by temporary floods; and a communication of this kind, if existing for a limited period only, would afford the ready means for an exchange of a number of species previously peculiar to one or the other of those river or lake systems. Some fishes provided with gill-openings so narrow that the water moistening the gills cannot readily evaporate, and endowed, besides, with an extraordinary degree of vitality, like many Siluroids (*Clarias*, *Callichthys*), eels, &c., are enabled to wander for some distance over land, and thus may reach a watercourse leading them thousands of miles from their original home. Finally, fishes or their ova may be accidentally carried by waterspouts, or by aquatic birds or insects, to considerable distances.

Freshwater fishes of the present fauna were already in existence when the great changes in the distribution of land and water took place in the Tertiary epoch; and, having seen that salt water is not an absolute barrier to the spreading of freshwater fishes, we can now more easily account for those instances of singular disconnexion of certain families or genera. It is not necessary to assume that there was a continuity of land stretching from the present coast of Africa to South America, or from South America to New Zealand and Australia, to explain the presence of identical forms in localities so distant; it suffices to assume that the distances were lessened by intervening archipelagoes, or that an alteration has taken place in the level of the land area.

Dispersal of a type over several distant continental areas may be evidence of its great antiquity, but does not prove that it is of greater antiquity than another limited to one region only. Geological evidence is the only proof of the antiquity of a type. Thus, although the *Dipnoi* occur in the continents of Africa, South America, and Australia, and their present distribution is evidently the consequence of their wide range in Palæozoic and Secondary epochs, the proof of their high antiquity can be found in their fossil remains only. The Siluroids, for example, have a still greater range, but their wide distribution is of comparatively recent date, as the few fossil remains that have been found belong to the Tertiary epoch. The rapidity of dispersal of a type depends entirely on its power to accommodate itself to a variety of physical conditions, and on the degree of vitality by which it is enabled to survive more or less sudden changes under unfavourable conditions; proof of this is afforded by the family of Siluroids, many of which can suspend for some time the energy of their respiratory functions, and readily survive a change of water.

To trace the geological sequence of the distribution of an ichthyic type, and to recognize the various laws which have governed and are still governing its dispersal, is one of the ultimate tasks of ichthyology. But the endeavour to establish by means of our present fragmentary geological knowledge the divisions of the fauna of the globe leads us into a maze of conflicting evidence; as Mr Wallace truly observes, "any attempt to exhibit the regions of former geological ages in combination with those of our own period must lead to confusion." Nevertheless, as the different types of animals found at the present day within a particular area have made their appearance therein at distant periods, we should endeavour, in giving an account of the several zoo-geographical divisions, to decide, so far as we can, the following questions :—

1. Which of the fishes of an area should be considered to be the remnants of ancient types, probably spread over much larger areas in preceding epochs?

2. Which are to be considered to be autochthonous species, that is, forms which in the Tertiary epoch or later came into existence within the area to which they are still limited, or from which they have since spread?

3. Which are the forms which must be considered to be immigrants from some other region?

It is the aim of every philosophical classification to indicate the degrees of affinity which obtain between the various categories. In dividing the earth's surface into zoological regions, the two families, *Cyprinidæ* and *Siluridæ*, the former of which yields a contingent of one-third and the latter of one-fourth of all the known freshwater species of our period, afford most important guidance for the estimation of those degrees of affinity. The Cyprinoids may be assumed to have originated in the alpine region dividing the temperate and tropical parts of Asia; endowed with a greater capability than any other family of freshwater fishes of acclimatizing themselves in a temperate as well as in a tropical region, they spread north and south as well as east and west; in the Pre-Glacial epoch they reached North America, but they have not had time to penetrate into South America, Australia, or the islands of the Pacific. The Siluroids, principally fishes of the sluggish waters of the plains, well adapted for surviving changes of the water in which they live, and for living either in mud or in sea-water, flourish most in the tropical climate in which this type evidently had its origin. They came into existence after the Cyprinoids, their fossil remains being found only in Tertiary deposits in India, none in Europe. They rapidly spread over the areas of land within the tropical zone, reaching Northern Australia from India, and one species migrating even into the Sandwich Islands, probably from South America. The coral islands of the Pacific still remain untenanted by them. Their progress into temperate regions was evidently slow, only very few species having penetrated into the temperate parts of Asia and Europe, and the North American species, although more numerous, showing no great variety of structure, all belonging to the same group (*Amiurina*). Towards the south their progress was still slower, Tasmania, New Zealand, and Patagonia being without any representative, whilst the streams of the Andes of Chili are inhabited by a few dwarfed forms identical with such as are characteristic of similar localities in the more northern and warmer parts of the South American continent.

These remarks may serve to introduce the following division of the fauna of freshwater fishes :—

I. THE NORTHERN ZONE.—Characterized by Acipenseridæ. Few Siluridæ. Numerous Cyprinidæ. Salmonidæ, Esocidæ.
   1. *Europo-Asiatic or Palæarctic Region.*—Characterized by absence of osseous Ganoidei ; Cobitidæ and Barbus numerous.
   2. *North American Region.*—Characterized by osseous Ganoidei, Amiurina, and Catostomina ; but no Cobitidæ or Barbus.

II. THE EQUATORIAL ZONE.—Characterized by the development of Siluridæ.
   A. *Cyprinoid Division.*—Characterized by presence of Cyprinidæ and Labyrinthici.
      1. *Indian Region.*—Characterized by [absence of Dipnoi[1]] Ophiocephalidæ, Mastacembelidæ. Cobitidæ numerous.
      2. *African Region.*—Characterized by presence of Dipnoi and Polypteridæ. Chromides and Characinidæ numerous. Mormyridæ. Cobitidæ absent.
   A. *Acyprinoid Division.*—Characterized by absence of Cyprinidæ and Labyrinthici.
      1. *Tropical American or Neotropical Region.*—Characterized by presence of Dipnoi. Chromides and Characinidæ numerous. Gymnotidæ.
      2. *Tropical Pacific Region.*—Characterized by presence of Dipnoi. Chromides and Characinidæ absent.

III. THE SOUTHERN ZONE.—Characterized by absence of Cyprinidæ, and scarcity of Siluridæ. Haplochitonidæ and Galaxiidæ represent the Salmonoids and Esoces of the northern zone. One region only.
   1. *Antarctic Region.*—Characterized by the small number of species ; the fishes of—
      a. The Tasmanian sub-region,
      b. The New Zealand sub-region, and
      c. The Patagonian sub-region,
   being almost identical.[2]

In the following account we begin with a description of the equatorial zone, this being the one from which the two principal families of freshwater fishes seem to have spread.

EQUATORIAL ZONE.—Roughly speaking, the borders of this zoological zone coincide with the geographical limits of the Tropics of Cancer and Capricorn ; its characteristic forms, however, extend in undulating lines several degrees both northwards and southwards. Commencing from the west coast of Africa, the desert of the Sahara forms a well-marked boundary between the equatorial and northern zones ; as the boundary approaches the Nile, it makes a sudden sweep towards the north as far as northern Syria (*Mastacembelus*, near Aleppo and in the Tigris ; *Clarias* and *Chromides*, in the Lake of Galilee), crosses through Persia and Afghanistan (*Ophiocephalus*) to the southern ranges of the Himalayas, and follows the course of the Yang-tse-Keang, which receives its contingent of equatorial fishes through its southern tributaries. Its continuation through the North Pacific may be considered as indicated by the tropic, which strikes the coast of Mexico at the southern end of the Gulf of California. Equatorial types of South America are known to extend so far northwards ; and, by following the same line, the West India Islands are naturally included in this zone.

Towards the south the equatorial zone embraces the whole of Africa and Madagascar, and seems to extend still farther south in Australia, its boundary probably following the southern coast of that continent ; the detailed distribution of the freshwater fishes of south-western Australia has been but little studied, but the few facts which we know show that the tropical fishes of that region follow the principal water-course, the Murray river, far towards the south and probably to its mouth. The boundary line then stretches to the north of Tasmania and New Zealand, coinciding with the tropic until it strikes the western slope of the Andes, on the South American continent, where it again bends southward to embrace the system of the Rio de la Plata.

The four regions into which the equatorial zone is divided arrange themselves into two well-marked divisions, one of which is characterized by the presence of Cyprinoid fishes, combined with the development of *Labyrinthici*, whilst in the other both these types are absent. The boundary between the Cyprinoid and Acyprinoid division seems to follow Wallace's line,—a line drawn from the south of the Philippines between Borneo and Celebes, and farther south between Bali and Lombok. Borneo abounds in Cyprinoids ; from the Philippine Islands a few only are known at present, and in Bali two species have been found ; but none are known from Celebes or Lombok, or from islands situated farther east.

Taking into consideration the manner in which Cyprinoids and Siluroids have been dispersed, we are obliged to place the Indian region as the first in the order of our treatment ; and indeed the number of freshwater fishes which appear to have spread from it into the neighbouring regions far exceeds that of the species which it has received from them.

The *Indian Region* comprises the whole continent of Asia south of the Himalayas and the Yang-tse-Keang, and includes the islands to the west of Wallace's line. Towards the north-east the island of Formosa, which also by other parts of its fauna shows the characters of the equatorial zone, has received some characteristic Japanese freshwater fishes, for instance, the singular Salmonoid *Plecoglossus*. Within the geographical boundaries of China the freshwater fishes of the tropics pass gradually into those of the northern zone, both being separated by a broad debateable ground. The affluents of the great river traversing this district are more numerous from the south than from the north, and carry the southern fishes far into the temperate zone. Scarcely better defined is the boundary of this region towards the north-west. Before Persia passed through the geological changes by which its waters were converted into brine and finally dried up, it seems to have been inhabited by many characteristic Indian forms, of which a few still survive in the tract intervening between Afghanistan and Syria ; *Ophiocephalus* and *Discognathus* have each at least one representative, *Macrones* has survived in the Tigris, and *Mastacembelus* has penetrated as far as Aleppo. Thus freshwater fishes belonging to India, Africa, and Europe are intermingled in a district which forms the connecting link between the three continents. Of the freshwater fishes of Arabia we are almost entirely ignorant ; we only

[1] These will probably be found.

[2] We distinguish these sub-regions, because their distinction is justified by other classes of animals ; as regards freshwater fishes they are even less distinct than Europe and northern Asia.

know that the Indian *Discognathus lamta* occurs in the reservoirs of Aden (having also found its way to the opposite African coast), and that the ubiquitous Cyprinodonts thrive in the brackish pools of northern Arabia.

In analysing the list of Indian fishes, we find that out of 40 families or groups of freshwater fishes 12 are represented in this region, and that 625 species are known to occur in it, or two-sevenths of the entire number of freshwater fishes known. This large proportion is principally due to the development of numerous local forms of Siluroids and Cyprinoids, of which the former show a contingent of about 200, and the latter of about 330 species. The combined development of those two families, therefore, and their undue preponderance over the other freshwater types, is the principal characteristic of the Indian region. The second important character of its fauna is the apparently total absence of Ganoid and Cyclostomous fishes. Every other region has representatives of either Ganoids or Cyclostomes, some of both.

Of the autochthonous freshwater fishes of the Indian region, some are still limited to it, viz., the *Nandina*, the *Luciocephalidæ* (of which one species only exists in the archipelago), of Siluroids the *Chacina* and *Bagariina*, of Cyprinoids the *Semiplotina* and *Homalopterina*; others are very nearly so, such as the *Labyrinthici*, *Ophiocephalidæ*, *Mastacembelidæ*, of Siluroids the *Silurina*, of Cyprinoids the *Rasborina* and *Danionina*, and the *Symbranchidæ*.

The regions to which the Indian has least similarity are the North American and the Antarctic, as they are the most distant. Its affinity to the other regions is of very different degrees:—

1. Its affinity to the Europo-Asiatic region is very slight, and is indicated almost solely by three groups of Cyprinoids, viz., the *Cyprinina*, *Abramidina*, and *Cobitidina*. The development of these groups north and south of the Himalayas is due to their common origin in the highlands of Asia; but the forms which descended into the tropical climate of the south are now so different from their northern brethren that most of them are referred to distinct genera. The only genera which are still common to both regions are (1) the true barbels (*Barbus*), a genus which of all Cyprinoids has the largest range over the Old World, and of which some one hundred and sixty species have been described, and (2) the mountain barbels (*Schizothorax*, &c.), which, peculiar to the alpine waters of Central Asia, descend a short distance only towards the tropical plains, but extend farther into rivers within the northern temperate districts. The origin and the laws of the distribution of the *Cobitidina* appear to have been identical with those of *Barbus*, but they have not spread into Africa.

2. There exists a great affinity between the Indian and African regions; seventeen out of the twenty-six families or groups found in the former are represented by one or more species in Africa, and many of the African species are not even generically different from the Indian. As the majority of these groups have many more representatives in India than in Africa, we may reasonably assume that the African species have been derived from the Indian stock; but probably this is not the case with the Siluroid group of *Clariina*, which with regard to species is nearly equally distributed between the two regions, the African species being referable to three genera (*Clarias*, *Heterobranchus*, *Gymnallabes*, with the sub-genus *Channallabes*), whilst the Indian species belong to two genera only, viz., *Clarias* and *Heterobranchus*. On the other hand, the Indian region has derived from Africa one freshwater form only, viz., *Etroplus*, a member of the family of *Chromides*, so well represented in tropical Africa and South America. *Etroplus* inhabits southern and western India and Ceylon, and has its nearest ally in a Madagascar freshwater fish, *Paretroplus*. Considering that other African *Chromides* have acclimatized themselves at the present day in saline water, we think it more probable that *Etroplus* should have found its way to India through the ocean than over the connecting land area, where, besides, it does not occur.

3. No closer affinity exists between the Indian and Tropical American regions than is indicated by the character of the equatorial zone generally. With two exceptions, no genus of freshwater fishes occurs in India and South America without being found in the intermediate African region. Four small Indian Siluroids (*Sisor*, *Erethistes*, *Pseudecheneis*, and *Exostoma*) have been referred to the South American *Hypostomatina*; but it remains to be seen whether this combination is based upon a sufficient agreement of their internal structure, or whether it is not rather artificial. On the other hand, the occurrence and wide distribution in tropical America of a fish of the Indian family *Symbranchidæ* (*Symbranchus marmoratus*), which is not only congeneric with, but also most closely allied to, the Indian *Symbranchus bengalensis*, furnishes one of those extraordinary anomalies in the distribution of animals of which no satisfactory explanation can at present be given.

4. The relation of the Indian to the Tropical Pacific region consists only in its having contributed a few species to the poor fauna of the latter. This immigration must have taken place within a recent period, because some species now inhabit the fresh waters of tropical Australia and the South Sea Islands without having in any way changed their specific characters, as *Lates calcarifer*, species of *Dules*, *Plotosus anguillaris*; others (species of *Arius*) differ but little from their Indian congeners. All these fishes must have migrated by the sea, a supposition which is supported by what we know of their habits. We need not add that India has not received a single addition to its freshwater fish fauna from the Pacific region.

It may be mentioned, before concluding these remarks on the Indian region, that peculiar genera of Cyprinoids and Siluroids inhabit the streams and lakes of its alpine ranges in the north. Some of them, like the Siluroid genera *Glyptosternum*, *Euglyptosternum*, *Pseudecheneis*, have a folded disk on the thorax between their horizontally spread pectoral fins; by means of this they adhere to stones at the bottom of the mountain torrents, and without it they would be swept away into the lower courses of the rivers. The Cyprinoid genera inhabiting similar localities and the lakes into which alpine rivers pass,—such as *Oreinus*, *Schizothorax*, *Ptychobarbus*, *Schizopygopsis*, *Diptychus*, *Gymnocypris*,—are distinguished by peculiarly enlarged scales near the vent, the physiological use of which has not yet been ascertained. These alpine genera extend far into the Europo-Asiatic region, where the climate is similar to that of their southern home. No observations have been made by which the altitudinal limits of fish life in the Himalayas can be fixed, but it is probable that it reaches the line of perpetual snow, as in the European Alps, which at that height are inhabited by Salmonoids. Griffith found an *Oreinus* and a loach, the former in abundance, in the Helmund at Gridun Dewar, altitude 10,500 feet, and another loach at Kaloo at 11,000 feet.

The *African Region* comprises the whole of the African continent south of the Atlas and the Sahara. It might have been conjectured that the more temperate climate of its southern extremity would have been accompanied by a conspicuous difference in the fish fauna. But this is not the case; the difference between the tropical and southern parts of Africa consists simply in the gradual disappearance of specifically tropical forms, whilst Siluroids, Cyprinoids, and even *Labyrinthici* penetrate to its southern coast; no new form has entered to impart to South Africa a character distinct from the central portion of the continent. In the north-east the African fauna passes the Isthmus of Suez and penetrates into Syria; the system of the Jordan presents so many African types that it has to be included in a description of the African region as well as of the Europo-Asiatic. This river is inhabited by three species of *Chromis*, one of *Hemichromis*, and *Clarias macracanthus*, a common fish of the upper Nile. Madagascar clearly belongs to this region. Besides some gobies and *Dules*, which are not true freshwater fishes, four *Chromides* are known. To judge from general accounts, its freshwater fauna is poorer than might be expected; but, singular as it may appear, collectors have hitherto paid but little attention to the freshwater fishes of this island. The fishes found in the freshwaters of the Seychelles and Mascarenes are brackish-water fishes, such as *Fundulus*, *Haplochilus*, *Elops*, *Mugil*, &c.

Out of the 40 families or groups of freshwater fishes 15 are represented in the African region, or three more than in the Indian region; of two of them, however, viz., the *Ophiocephalidæ* and *Mastacembelidæ*, a few species only have found their way into Africa. On the other hand, the number of species is much less, viz., 255, being only two-fifths of the known Indian species. The small degree of specialization and localization is principally due to the greater uniformity of the physical conditions of this continent, and to the almost perfect continuity of the great river systems, which take their origin from the lakes in its centre. This is best shown by a comparison of the fauna of the upper Nile with that of the West African rivers. The number of species known from the upper Nile amounts to 56, and of these not less than 25 are absolutely identical with West African species. There is an uninterrupted continuity of the fish fauna from the west to the north-east, and the species known to be common to both extremities may be reasonably assumed to inhabit also the great reservoirs of water in the centre of the continent. A greater dissimilarity is noticeable between the west and north-east fauna on the one hand and that of the Zambezi on the other; the affinity between them is merely generic, and all the fishes hitherto collected in Lake Nyassa have proved to be distinct from those of the Nile, and even from those of other parts of the system of the Zambezi.

Unlike India, Africa does not possess either alpine ranges or outlying archipelagoes, the fresh waters of which would swell the number of its indigenous species; but, when its fauna becomes better known than at present, the great difference in the number of species between this and the Indian regions may possibly be somewhat lessened.

The most numerously represented families are the Siluroids, with 61 species; the Cyprinoids, with 52; the *Mormyridæ*, with 51; the *Characinidæ*, with 35; and the *Chromides*, with 29. There is not, therefore, that great preponderance of the first two families over the rest which we noticed in the Indian region; in Africa there is a comparatively greater variety of distinct freshwater types, making the study of its fauna an unflagging pleasure such as is scarcely reached in the study of the other region. With the forms peculiar to it there are combined those of India as well as of South America.

In tropical Africa there are still remnants of Ganoids,—*Protopterus* (*Lepidosiren*) *annectens* and *Polypterus bichir*, with the singularly modified *Calamoichthys*. The first two range from east to west, and are accompanied by an Osteoglossoid (*Heterotis*), which has hitherto been found in the Nile and on the west coast only. Autochthonous and limited to this region are the *Mormyridæ*, *Pantodontidæ*, and *Kneriidæ*, a singular type somewhat akin to the loaches. Of Siluroid genera the most characteristic are *Synodontis*, *Rhinoglanis*, and the electric *Malapterurus*; of Characinoids, *Citharinus*, *Alestes*, *Xenocharax*, *Hydrocyon*, *Distichodon*, *Ichthyborus*.

The regions to which Africa (like India) has least similarity are again the North American and Antarctic. Its affinity with the Europo-Asiatic region consists only in its having received, like the latter, a branch of the Cyprinoids, the African carps and barbels, which on the whole resemble Indian more than Europo-Asiatic forms. Its similarity to Australia is limited to the two regions possessing Dipnoous and Osteoglossoid types. But its relations to the other two regions of the equatorial zone are near and of great interest.

1. Africa has in common with India the Siluroid groups of the *Clariina*, *Silurina*, and *Bagrina*, and more especially the small but very natural family of *Notopteridæ*, represented by three species in India, and by two on the west coast of Africa. It would be hazardous to state at present in which of the two regions these fishes first made their appearance, but the discovery of remains of *Notopteridæ* and *Silurina* in Tertiary deposits of Sumatra points to the Indian region as their original home. We are in less doubt about the other fishes common to the two regions; they are clearly immigrants into Africa from the east, and it is a remarkable fact that these immigrants have penetrated to the most distant limits of Africa in the west as well as in the south, viz., the *Labyrinthici*, represented by two genera closely allied to the Indian *Anabas*; the *Ophiocephalidæ* and *Mastacembelidæ*, a few species of which have penetrated to the west coast, while, singularly enough, they are absent from the eastern rivers; the *Ariina*, represented by several species, of which one or two are identical with Indian, having extended their range along the intervening coasts to the east coast of Africa. The Cyprinoids also afford an instance of an Indian species ranging into Africa, viz., *Discognathus lamta*, which seems to have crossed at the southern extremity of the Red Sea, as it is found in the reservoirs at Aden and in the hill-streams of the opposite coast-region of Abyssinia.

2. No such direct influx of species and genera has occurred from South America into Africa, yet the affinity of their freshwater fishes is striking. Two of the most natural families of fishes, the *Chromides* and *Characinidæ*, are peculiar and (with the exception of *Etroplus*) restricted to them. The African and South American *Dipnoi* are closely allied to each other. The *Pimelodina*, so characteristic of tropical America, have three representatives in Africa, viz., *Pimelodus platychir*, *P. balayi*, and *Auchenoglanis biscutatus*; the *Doradina* are another Siluroid group restricted to these two continents.[1] Yet, with all these points of close resemblance, the African and South American series are, with the exception of the two species of *Pimelodus*, generically distinct,—which shows that the separation of the continents must have been of old date. On the other hand, the existence of so many similar forms on both sides of the Atlantic affords much support to the supposition that at a former period the distance between the present Atlantic continents was much less, and that the fishes which have diverged towards the east and west are descendants of a common stock which had its home in a region now submerged under some intervening part of that ocean. Be this as it may, it is evident that the physical conditions of Africa and South America have remained unchanged for a considerable period, and are still sufficiently alike to preserve the identity of a number of peculiar freshwater forms on both sides of the Atlantic. Africa and South America are, moreover, the only continents which have produced in freshwater fishes, though in very different families, one of the most extraordinary modifications of an organ—the conversion, that is, of muscle into an apparatus creating electric force.

The boundaries of the *Neotropical* or *Tropical American Region* have been sufficiently indicated in the definition of the equatorial zone. A broad and most irregular band of country, in which the South and North American forms are mixed, exists in the north, offering some peculiarities which deserve fuller attention in the subsequent description of the relations between the South and North American faunæ.

Out of the 40 families or groups of freshwater fishes, 9 only are represented in the tropical American region. This may be accounted for by the fact that South America is too much isolated from the other regions of the equatorial zone to have received recent additions to its fauna. On the other hand, the number of species (672) exceeds that of every other region, even of the Indian, with which, in regard to the comparative development of families, the neotropical region shows a close analogy, as will be seen from the following table:—

Indian.—Siluridæ, 200 species; Cyprinidæ, 330; Labyrinthici, 25; Ophiocephalidæ, 30; Mastacembelidæ, 10.

Neotropical.—Siluridæ, 276 species; Characinidæ, 226; Chromides, 80; Cyprinodontidæ, 60; Gymnotidæ, 20.

In both regions the great number of species is due to the development of numerous local forms of two families, the *Characinidæ* in the New World taking the place of the *Cyprinidæ* of the Old. To these are added a few smaller families with a moderately large number of species, which, however, is only a fraction of that of the leading families, the remainder being represented by a few species only. The number of genera within each of the two regions belonging to the two principal families is also singularly alike; the Indian region having produced about 45 Siluroid and as many Cyprinoid genera, whilst the Neotropical region is tenanted by 54 Siluroid and 40 Chara-

[1] We have left out of consideration here the *Ariina* and Cyprinodonts, which can pass with impunity through salt water, and are spread over much larger areas.

cinoid genera. These points of similarity between the two regions cannot be accidental; they indicate that agreement in their physical and hydrographical features which in reality exists. Of Ganoids, we find in tropical America one species only, *Lepidosiren paradoxa*, accompanied by two Osteoglossoids (*Osteoglossum bicirrhosum* and *Arapaima gigas*). Autochthonous and limited to this region are the *Polycentridæ*; all the non-African genera of *Chromides* and *Characinidæ*; of Siluroids, the *Hypophthalmina*, *Aspredinina*, and *Stegophilina*, and the majority of *Pimelodina*, *Hypostomatina*, and *Doradina*; the herbivorous Cyprinodonts or *Limnophagæ*, and numerous insectivorous Cyprinodonts or *Carnivoræ*; and the *Gymnotidæ* (electric eel).

The relations to the other regions are as follows:—

1. The resemblances to the Indian and Tropical Pacific regions partly date from remote geological epochs, or are partly due to that similarity of physical conditions to which we have already referred. We have again to draw attention to the unexplained presence in South America of a representative of a truly Indian type (not found in Africa), viz., *Symbranchus marmoratus*. On the other hand, a direct genetic affinity exists between the Neotropical and African regions, as has been noticed in the description of the latter, a great part of their freshwater fauna consisting of descendants from a common stock.

2. A comparison of the specifically Neotropical with the specifically North American types shows that no two regions can be more dissimilar. It is only in the intervening borderland, and in the large West Indian islands, that the two faunæ mix with each other. We need not enter into the details of the physical features of Central America and Mexico; the broken ground, the diversity of climate (produced by different altitudes) within limited districts, the hot and moist alluvial plains surrounding the Mexican Gulf, offer a variety of conditions most favourable to the intermixture of the types from the north and the south. Still the interchange of peculiar forms appears to be only beginning; none have yet penetrated beyond the debateable ground, and it is evident that the land connexion between the two continents is of comparatively recent date,—a view which is confirmed by the identity of the marine fishes on both sides of Central America.

Cuba—which is the only island in the West Indies that has a number of freshwater fishes sufficient for the determination of its zoo-geographical relations—is inhabited by several kinds of a perch (*Centropomus*), freshwater mullets, Cyprinodonts, one species of Chromid (an *Acara*), and *Symbranchus marmoratus*. All these fishes are found in Central America, and, as they belong to forms known to enter brackish water more or less freely, it is evident that they have crossed either from that region or from the mainland of South America. But with them there came a remarkable North American type, *Lepidosteus*. *Lepidosteus viridis*, which is found in the United States, has penetrated on the mainland to the Pacific coast of Guatemala, where it is common at the mouth of the rivers and in brackish-water lakes along the coast; it probably crossed into Cuba from Florida. A perfectly isolated type of fishes inhabits the subterranean waters in the caves of Cuba (two species of *Lucifuga*). The eyes are absent, or quite rudimentary, as in most other cave animals. Singularly, it belongs to a family (*Ophidiidæ*) the members of which are strictly marine; and its nearest ally is a genus, *Brotula*, the species of which are distributed over the Indo-Pacific Ocean, one only occurring in the Caribbean Sea. This type must have witnessed all the geological changes which have taken place since Cuba rose above the surface of the sea. A similar mixture of forms of the tropical and temperate types of freshwater fishes takes place in the south of South America; its details have not yet been so well studied as in the north, but this much is evident, that, whilst in the east tropical forms follow the Plate river far into the temperate region, in the west the temperate fauna finds still a congenial climate in ranges of the Andes, situated close to, or even north of, the tropic.

Like the Indian region, the Tropical American has a peculiar alpine fauna, the freshwater fishes of which, however, belong to the Siluroids and Cyprinodonts. The former are small, dwarfed forms (*Arges*, *Stygogenes*, *Brontes*, *Astroblepus*, *Trichomycterus*, *Eremophilus*), and have a perfectly naked body, whilst the representatives in the lowlands of at least the first four genera are mailed. The alpine Cyprinodonts, on the other hand (*Orestias*), exceed the usual small size of the other members of this family, and are covered with thick scales, but have lost their ventral fins. Some of these alpine forms, like *Trichomycterus*, follow the range of the Andes far into the Southern Temperate region. The majority are found at a height of 15,000 feet above the level of the sea, and a few still higher.

The *Tropical Pacific Region* includes all the islands east of Wallace's line, New Guinea, Australia (with the exception of its south-eastern portion), and all the islands of the tropical Pacific to the Sandwich group. Comparing the area of this region with that of the others, we find it to be the poorest, not only in point of the number of its species generally (36), but also in the possession of peculiar forms. The paucity of freshwater fishes is due, in the first place, to the arid climate and the deficiency of water in the Australian continent, as well as to the insignificant size of the freshwater courses in the smaller islands. Still this cannot be the only cause; the large island of Celebes, which, by its mountainous portions, as well as by its extensive plains and lowlands, would seem to offer a favourable variety of conditions for the development of a freshwater fauna, is, so far as has been ascertained, tenanted by seven freshwater fishes only, viz., 2 *Arius*, 2 *Plotosus*, 1 *Anabas*, 1 *Ophiocephalus*, 1 *Monopterus*, all of which are the commonest species of the Indian region. New Guinea has not yet been explored, but, from the faunæ nearest to this island, we expect its freshwater fishes will prove to be equally few in number, and identical with those of Celebes and North Australia,—a supposition confirmed by the few small collections which have reached Europe. Finding, then, that even those parts of this region which are favourable to the development of freshwater fishes have not produced any distinct forms, and that the few species which inhabit them are unchanged or but slightly modified Indian species, we must conclude that the whole of this area has remained geologically isolated from the other regions of this zone since the commencement of the existence of *Teleostei*, and that, with the exception of *Ceratodus* and *Osteoglossum*, the immigration of the other species is of very recent date.

Fossil remains of *Ceratodus* have been found in the Liassic and Triassic formations of North America, England, Germany, and India; it is, therefore, a type which was widely spread in the Mesozoic epoch. Although it would be rash to conclude that its occupation of Australia dates equally far back, for it may have reached that continent long afterwards, yet it is evident that, as it is one of the most ancient of the existing types, so it is certainly the first of the freshwater fishes which appeared in Australia. *Osteoglossum*, of which no fossil remains have yet been found, is proved by its distribution to be one of the oldest Teleosteous types. There must have been a long gap of time before these ancient types were joined by the other *Teleostei*. All of them migrated through the intervening parts of the ocean from India. Most of the *Plotosina*, some of the *Arii*, *Dules*, and *Atherinichthys*, also *Nannoperca* (allied to *Apogon*), were among the earliest arrivals, being sufficiently differentiated to be specifically or even generically (*Cnidoglanis*, *Nannoperca*) distinguished; but some others, like *Anabas scandens*, *Lates calcarifer*, *Dules marginatus*, must have reached the Australian continent quite recently, for they are undistinguishable from Indian specimens.

In south-western Australia a mingling of the scanty fauna with that of the southern temperate parts takes place. *Oligorus macquariensis* (the Murray cod), which has a congener on the coast of New Zealand, ascends high up the Murray river, so that we cannot decide whether this Percoid should be located in the tropical or the temperate part of Australia. Several *Galaxias* also extend to the confines of Queensland, and will probably some day be found members of this region.

In the smaller Pacific islands the freshwater fishes exhibit a remarkable sameness ; they comprise two or three species of *Dules*, several eels, an atherine, and some gobies, mullets, and other fishes which with equal readiness exchange fresh for salt water, and which would at once reach and occupy any streams or freshwater lakes that might be formed on an island.

The Sandwich Islands are the only group among the smaller islands which are tenanted by a Siluroid, a species of *Arius*, which is closely allied to Central American species, and therefore probably migrated from tropical America.

NORTHERN ZONE.—The boundaries of the northern zone coincide in the main with the northern limit of the equatorial zone ; but, as has been already indicated, they overlap the latter at three different points. This happens in Syria, as well as east of it, where the mixed faunæ of the Jordan and the rivers of Mesopotamia demand the inclusion of this territory in the northern zone as well as in the equatorial ; in the island of Formosa, where a Salmonoid and several Japanese Cyprinoids flourish ; and in Central America, where a *Lepidosteus*, a Cyprinoid (*Sclerognathus meridionalis*), and an *Amiurus* (*A. meridionalis*) represent the North American fauna in the midst of a host of tropical forms.

There is no separate arctic zone for freshwater fishes; ichthyic life becomes extinct towards the pole wherever the fresh water remains frozen throughout the year, or thaws for a few weeks only ; and the few fishes which extend into high latitudes, in which lakes are open for two or three months in the year, belong to types in no wise differing from those of the more temperate south. The highest latitude at which fishes have been obtained is 82° N. lat., whence the late Arctic Expedition brought back specimens of charr (*Salmo arcturus* and *Salmo naresii*).

The ichthyological features of this zone are well marked. The Chondrosteous Ganoids or sturgeons, and the families of *Salmonidæ* and *Esocidæ*, are limited to and characteristic of it; Cyprinoids flourish with the Salmonoids, both families preponderating in numbers over the others, whilst the Siluroids are few in number and in variety.

The two regions into which this zone is divided are very closely related to one another, and their affinity is not unlike that which obtains between the sub-regions of the southern zone. Several species are common to both, viz., *Acipenser sturio, A. maculatus, Perca fluviatilis, Gastrosteus pungitius, Salmo salar, Esox lucius, Lota vulgaris, Petromyzon marinus, P. fluviatilis*, and *P. branchialis* ; and all recent investigations have resulted in giving additional evidence of the affinity and not of the diversity of the two regions.

In Europe and temperate Asia, as well as in North America, mountain ranges elevated above the line of perpetual snow would seem to offer physical conditions favourable for the development of a distinct alpine fauna. But this is not the case, because the difference of climate between the mountain districts and the lowlands is much less in this zone than in the equatorial. Consequently the alpine freshwater fishes do not essentially differ from those of the plains ; they are principally Salmonoids, and in Asia there are also mountain-barbels and loaches. *Salmo orientalis* was found by Griffith to abound in the tributaries of the Bamian river at an altitude of about 11 000 feet.

The Palæarctic or *Europo-Asiatic Region.*—The western and southern boundaries of this region coincide with those of the northern zone, so that only those which divide it from North America need to be indicated. Behring's Strait and the Kamtchatka Sea have been conventionally taken as the boundary, but this is shown to be artificial by the fact that the animals of both coasts, so far as they are known at present, are not sufficiently distinct to be referred to two different regions. As to the freshwater fishes, those of north-western America and of Kamtchatka are but imperfectly known, but there can be little doubt that the same agreement exists between them as is the case with other classes of animals. The Japanese islands exhibit a decided Palæarctic fish fauna, which includes *Barbus* and Cobitioids, forms strange to the North American fauna. A slight influx of tropical forms is perceived in the south of Japan, where two *Bagrina* (*Pseudobagrus aurantiacus* and *Liocassis longirostris*) have established themselves for a considerable period, for both are peculiar to the island, and have not been found elsewhere.

In the east, as well as in the west, the distinction between the Europo-Asiatic and the North American regions disappears almost entirely as we advance farther towards the north. Of four species of the genus *Salmo* known from Iceland, one (*S. salar*) is common to both regions, two are European (*S. fario* and *S. alpinus*), and one is a peculiarly Icelandic race (*S. nivalis*). So far as we know the Salmonoids of Greenland and the tract adjoining Baffin's Bay, they are all very closely allied to European species, though they may be distinguished as local races.

Finally, as we have seen above, the Europo-Asiatic fauna mingles with African and Indian forms in Syria, Persia, and Afghanistan. *Capoeta*, a Cyprinoid genus, is characteristic of this district, and well represented in the Jordan and the rivers of Mesopotamia. Out of the 40 families of freshwater fishes 13 are represented in this region; the number of species is comparatively small, viz., 360.

Assuming that the distribution of Cyprinoids has taken its origin from the alpine tract of country dividing the Indian and Palæarctic regions, we find that this type has found in the temperate region as favourable conditions for its development as in the tropical. Out of the 360 species no less than 215 are Cyprinoids. In the countries and on the plateaus immediately adjoining the Himalayan ranges those mountain forms which we mentioned as peculiar to the Indian Alps abound, and extend for a considerable distance towards the west and east, mixed with other *Cyprinina* and *Cobitidina*. The representatives of these two groups are more numerous in Central and Eastern Asia than in Europe and the northern parts of Asia, where the *Leuciscina* predominate. *Abramidina* or breams are more numerous in the south and east of Asia, but they spread to the extreme north-western and northern limits to which the Cyprinoid type reaches. The *Rhodeina* are a small family especially characteristic of the East, but with one or two offshoots in Central Europe. Very significant is the appearance in China of a species of the *Catostomina*, a group otherwise limited to North America.

The Cyprinoids, in their dispersal northwards from the south, are met from the opposite direction by the freshwater Salmonoids. These fishes are, without doubt, one of the youngest families of *Teleostei*, for they did not appear before the Pliocene era; they flourished at any rate during the Glacial period, and, as is testified by the survivors which we find in isolated elevated positions, like the trout of the Atlas, of the mountains of Asia Minor, and of the Hindu Kush, they spread to the extreme south of this region. At the present day they are most numerously represented in its northern temperate parts; towards the south they become fewer, but increase again in numbers and species wherever a great elevation offers them the snow-fed waters which they affect. In the rivers of the Mediterranean, Salmonoids are by no means rare, but they prefer the upper courses of those rivers, and do not migrate to the sea, with the exception, perhaps, of some species in the rivers of the North Adriatic.

The pike, *Umbra*, and several species of perch and stickleback are also clearly autochthonous species of this region. Others belong to marine types, and seem to have been retained in fresh water at various epochs,—as the freshwater *Cottus* (miller's thumb); *Cottus quadricornis*, which inhabits lakes of Scandinavia, whilst other individuals of the same species are strictly marine; the burbot (*Lota vulgaris*); and the singular *Comephorus*, a dwarfed and much changed Gadoid which inhabits the greatest depths of Lake Baikal.

Remnants of the Palæichthyic fauna exist in the sturgeons and lampreys. The former inhabit in abundance the great rivers of eastern Europe and Asia, periodically ascending them from the sea; their southernmost limits are the Yang-tse-Keang in the east, and towards the centre of this region the rivers flowing into the Adriatic, Black, and Caspian Seas, and Lake Aral. None are known to have gone beyond the boundaries of the northern zone. If the lampreys are justly reckoned among freshwater fishes, their distribution is unique and exceptional. In the Palæarctic region some of the species descend periodically to the sea, whilst others remain stationary in the rivers; the same has been observed in the lampreys of North America. They are entirely absent in the equatorial zone, but reappear in the temperate zone of the southern hemisphere. Many points in the organization of the Cyclostomes indicate that they are a type of great antiquity.

The remaining Palæarctic fishes are clearly immigrants from neighbouring regions: thus *Silurus*, *Macrones*, and *Pseudobagrus* have migrated from the Indian region, *Amiurus* and, as mentioned above, *Catostomus* from North America. The Cyprinodonts are restricted to the southern and warmer parts, and all belong to the carnivorous division. The facility with which these fishes accommodate themselves to a sojourn in fresh, brackish, or salt water, and even in thermal springs, renders their general distribution easily comprehensible, but it is impossible to decide to which region they originally belonged; their remains in Tertiary deposits round the Mediterranean are not rare.

The boundaries of the *North American* or *Nearctic Region* have been sufficiently indicated. The main features and the distribution of this fauna are identical with those of the preceding region. Out of the 40 families of freshwater fishes 19 are found in this region. The proportion of Cyprinoid species to the total number of North American fishes (135 : 339) appears to be considerably less than in the Palæarctic region, but we cannot admit that these figures approach the truth, as the Cyprinoids of North America have been much less studied than those of Europe; of many scarcely more than the name is known. This also applies in a great measure to the Salmonoids, of which only half as many as are found in the Palæarctic region have been sufficiently described to be worthy of consideration. North America will, without doubt, in the end show as many distinct races as Europe and Asia.

Cyprinoids belonging to living as well as extinct genera existed in North America in the Tertiary period. At present the *Cyprinina*, *Leuciscina*, and *Abramidina* are well represented, but there is no representative of the Old World genus *Barbus*, or of the *Cobitidina*;[1] *Rhodeina* are also absent. On the other hand, a well-marked Cyprinoid type is developed—the *Catostomina*, of which one species has, as it were, returned into Asia. Very characteristic is the group of *Centrarchina*, allied to the perch, of which there are some thirty species; there are two *Grystina*. Of the sticklebacks there are as many species as in Europe, and of pike not less than seven species have been distinguished. *Umbra* appears to be as local as in Europe. Some very remarkable forms, types of distinct families, though represented by one or two species only, complete the number of North American autochthonous fishes, viz., *Aphredoderus*, *Percopsis*, *Hyodon*, and the *Heteropygii* (*Amblyopsis* and *Chologaster*). The last are allied to the Cyprinodonts, differing from them in some points of the structure of their intestines. The two genera are extremely similar, but *Chologaster*, which is found in ditches in the rice-fields of South Carolina, is provided with eyes, and wants the ventral fins. *Amblyopsis* is the celebrated blind fish of the Mammoth Cave of Kentucky; it is colourless and eyeless, and has rudimentary ventral fins, which occasionally may be entirely absent.

A peculiar feature of the North American fish fauna is that it has retained, besides the sturgeons and lampreys, representatives of two Ganoid families, *Lepidosteus* and *Amia*. Both these genera occur in Tertiary formations; whilst the former is represented in Europe as well as in North America, fossil remains of *Amia* have been found in the western hemisphere only.

It is difficult to account for the presence of the *Amiurina* in North America. They form a well-marked division of the *Bagrina*, which are well represented in Africa and the East Indies, but are absent in South America; it is evident, therefore, that they should not be regarded as immigrants from the south, as is the case with the Palæarctic Siluroids. Nor again, has the connexion between South and North America been established sufficiently long to admit of the supposition that these Siluroids could have spread in the interval from the south to the northern parts of the continent, for some of the species are found as far north as Pine Islands Lake (54° N. lat.).[2]

Southern Zone.—The boundaries of this zone have been indicated in the description of the equatorial zone; they overlap the southern boundaries of the latter in South Australia and South America, but we have not at present the means of exactly defining the limits to which southern types extend northwards. This zone includes Tasmania, with at least a portion of south-eastern Australia (*Tasmanian sub-region*), New Zealand and the Auckland Islands (*New Zealand sub-region*), and Chili, Patagonia, Tierra del Fuego, and the Falkland Islands (*Fuegian sub-region*). No freshwater fishes are known from Kerguelen's Land, or from islands beyond 55° S. lat. The southern extremity of Africa has to be excluded from this zone so far as freshwater fishes are concerned.

With regard to its extent as well as to the number of species, this zone is the smallest of the three, the number of species known being 11 in the Tasmanian, 8 in the New Zealand, and 18 in the Fuegian sub-region. Yet the ichthyological features of this zone are well marked; they consist in the presence of two peculiar families, each of which is analogous to a northern type, viz., the *Haplochitonidæ*, which represent the *Salmonidæ* (*Haplochiton* being

[1] Cope has discovered in a Tertiary freshwater deposit at Idaho an extinct genus of this group, *Diastichus*. He considers this interesting fact to be strongly suggestive of continuity of territory between Asia and North America.—*Proc. Am. Phil. Soc.*, 1873, p. 55.

[2] Leidy describes a Siluroid (*Pimelodus*) from the Tertiary deposits of Wyoming territory.—*Contrib. to the Extinct Vert. Fauna of the Western Territ.*, 1873, p. 193.

the analogue of *Salmo*, and *Prototroctes* that of *Coregonus*), and the *Galaxiidæ*, which are the pikes of the southern hemisphere.

Although geographically widely separate from each other, the freshwater fishes of the three divisions are nevertheless so closely allied that conclusions drawn from this group of animals alone would hardly justify us in regarding these divisions as sub-regions. One species of *Galaxias* (*G. attenuatus*) and three of lampreys are found in all three, or at least in two of the sub regions. *Percichthys* is in Chili the autochthonous form of the cosmopolitan group of *Percina*. *Diplomystax*, an Arioid fish of Chili, and *Nematogenys* seem to have crossed the Andes from tropical America at a comparatively early period, as these genera are not represented on the eastern side of South America; *Trichomycterina* occur on both sides of the Andes, which they ascend to a considerable height. *Retropinna* is a true Salmonoid, allied to the northern smelt (*Osmerus*), and representing it in the southern hemisphere. In both these genera part of the specimens live in the sea, and ascend rivers periodically to spawn; another part remain in rivers and lakes, where they propagate, never descending to the sea, this freshwater race being constantly smaller than their marine brethren. That this small Teleostean of the northern hemisphere should reappear, though in a generically modified form, in New Zealand, without having spread over other parts of the southern zone, is one of the most remarkable and at present inexplicable facts of the geographical distribution of freshwater fishes.

Brackish-Water Fishes.

On those parts of a coast at which there is a mixture of fresh and salt water, either in consequence of some river emptying itself into the sea, or from accumulations on the land-surface forming lagoons which are in uninterrupted or temporary communication with the sea, there flourishes a peculiar brackish-water fauna characterized by the presence of fishes found sometimes in the sea, and sometimes in pure fresh water.

This fauna can be somewhat sharply defined if a limited district only is taken into consideration; thus, the species of the brackish-water fauna of Great Britain, of the Pacific coast of Central America, of the larger East India islands, &c., can be enumerated without much hesitation. But difficulties occur when we attempt to generalize in the enumeration of the forms referable to the brackish-water fauna, because the genera and families enumerated include certain species and genera which have habituated themselves exclusively either to a freshwater or a marine existence, and also because a species of fish may be at one locality an inhabitant of brackish water, at another of the sea, and at a third of fresh water. The circumstance that these fishes can live either in the sea or in fresh water has enabled them to spread readily over the globe, a few only being limited to particular regions; in dividing the earth's surface into natural zoological regions, therefore, the taxonomist receives no assistance from the brackish-water forms. The following fishes may be referred to this fauna:—

1. Species of *Raiidæ* (*Raia*, *Trygon*). 2. *Ambassis*. 3. *Therapon*. 4. Numerous *Sciænidæ* of the equatorial zone. 5. *Polynemidæ*. 6. Numerous species of *Caranx* (or horse mackerels) of the equatorial zone. 7. Species of *Gastrosteus*. 8. The most important genera of the gobies (*Gobiina*); *Gobius* (nearly cosmopolitan), *Sicydium*, *Boleophthalmus*, *Periophthalmus*, *Eleotris* (equatorial). 9. *Amblyopina*. 10. *Trypauchenina*. 11. Many species of *Blennius*. 12. The majority of *Atherinidæ*. 13. Most *Mugilidæ*. 14. Many *Pleuronectidæ*. 15. Several *Siluridæ*, as especially the genera *Plotosus*, *Cnidoglanis*, *Arius*. 16. Many *Cyprinodontidæ*. 17. Species of *Clupea*. 18. *Chatoessus*. 19. *Megalops*. 20. *Anguilla* (eels). 21. Numerous *Syngnathidæ*.

This list could be considerably increased if an enumeration of species, especially of certain localities, were attempted; but this is more a subject of local interest, and would carry us beyond the scope of a general account of the distribution of fishes.

Marine Fishes.

Marine fishes fall, with regard to their mode of life and distribution, into three distinct categories:—

1. *Shore Fishes*—that is, fishes which chiefly inhabit parts of the sea in the immediate neighbourhood of land either actually raised above, or at least but little submerged below, the surface of the water. They do not descend to any great depth,—very few to 300 fathoms, and the majority live close to the surface. The distribution of these fishes is determined, not only by the temperature of the surface water, but also by the nature of the adjacent land and its animal and vegetable products,—some being confined to flat coasts with soft or sandy bottoms, others to rocky and fissured coasts, others to living coral formations. If it were not for the frequent mechanical and involuntary removals to which these fishes are exposed, their distribution within certain limits, as it no doubt originally existed, would resemble still more that of freshwater fishes than we find it actually does at the present period.

2. *Pelagic Fishes*—that is, fishes which inhabit the surface and uppermost strata of the open ocean, and approach the shores only accidentally, or occasionally (in search of prey), or periodically (for the purpose of spawning). The majority spawn in the open sea, their ova and young being always found at a great distance from the shore. With regard to their distribution, they are still subject to the influences of light and the temperature of the surface water; but they are independent of the variable local conditions which tie the shore fish to its original home, and therefore roam freely over a space which would take a freshwater or shore fish thousands of years to cover in its gradual dispersal. Such as are devoid of rapidity of motion are dispersed over similarly large areas by the oceanic currents, more slowly than the strong swimmers, but not less surely. An accurate definition, therefore, of their distribution within certain areas equivalent to the terrestrial regions is much less feasible than in the case of shore fishes.

3. *Deep-Sea Fishes*—that is, fishes which inhabit such depths of the ocean that they are but little or not at all influenced by light or the surface temperature, and which, by their organization, are prevented from reaching the surface stratum in a healthy condition. Living almost under identical tellurian conditions, the same type, the same species, may inhabit an abyssal depth under the equator as well as one near the arctic or antarctic circle; and all that we know of these fishes points to the conclusion that no separate horizontal regions can be distinguished in the abyssal fauna, and that no division into bathymetrical strata can be attempted on the base of generic much less of family characters.

Chondropterygii, *Acanthopterygii*, Anacanths, Myxinoids, and *Pharyngobranchii* furnish the principal contingents to the marine fauna; whilst the majority of Physostomes, the Ganoids, and Cyclostomes are freshwater fishes.

Shore Fishes.

The principal types of shore fishes are the following:—

CHONDROPTERYGII.—*Holocephala*, 4 species. *Plagiostomata*—Carchariidæ (part), 12; Scylliidæ, 30; Cestraciontidæ, 4; Spinacidæ (part), 8; Rhinidæ, 1; Pristiophoridæ, 4; Pristidæ, 5; Rhinobatidæ, 14; Torpedinidæ, 15; Raiidæ, 34; Trygonidæ, 47.

ACANTHOPTERYGII.—Percidæ (part, includ. Pristipomatidæ), 625 species; Mullidæ, 35; Sparidæ, 130; Squamipinnes, 130; Cirrhitidæ, 40; Heterolepidina, 12; Scorpænidæ, 120; Cottidæ (part), 100; Cataphracti (part), 20; Trachinidæ, 100; Sciænidæ, 100; Sphyrænidæ, 15; Trichiuridæ, 17; Elacate, 1; Nomeidæ (part), 5; Cyttidæ, 8; Stromateus, 9; Mene, 1; Carangidæ (part), 130; Kurtidæ, 7; Gobiodon, 7; Callionymina, 30; Discoboli, 11; Batrachidæ, 14; Pediculati (part), 11; Blenniidæ, 90; Acanthoclinidæ, 1; Teuthididæ, 30; Acronuridæ, 60; Hoplognathidæ, 3; Malacanthidæ, 3; Plesiopina, 4; Trichonotidæ, 2; Cepolidæ, 7; Gobiesocidæ, 21; Psychrolutidæ, 2; Centriscidæ, 7; Fistulariidæ, 4.

ACANTHOPTERYGII PHARYNGOGNATHI. — Pomacentridæ, 150 species; Labridæ, 400; Embiotocidæ, 17.

ANACANTHINI.—Gadopsidæ, 1 species; Lycodidæ, 15; Gadidæ (part), 50; Ophidiidæ (part), 40; Pleuronectidæ, 160.

PHYSOSTOMI.—Saurina (part), 16 species; Salmonidæ (part), 7; Clupeidæ (part), 130; Chirocentridæ, 1; Chilobranchus, 1; Murænidæ (part), 200; Pegasidæ, 4.

LOPHOBRANCHII, 120 species.

PLECTOGNATHI, 178 species.

CYCLOSTOMATA.—*Myxinidæ*, 5 species.

LEPTOCARDII, 2 species.

Total number, 3587 species.

These types of shore fishes are distributed over the following oceanic areas:—

- I. The Arctic Ocean.
- II. The Northern Temperate Zone.
  - A. The Temperate North Atlantic.
    1. The British district.
    2. The Mediterranean district.
    3. The North American district.
  - B. The Temperate North Pacific.
    1. The Kamtchatkan district.
    2. The Japanese district.
    3. The Californian district.
- III. The Equatorial Zone.
  - A. The Tropical Atlantic.
  - B. The Tropical Indo-Pacific.
  - C. The Pacific coast of Tropical America.
    1. The Central American district.
    2. The Galapagos district.
    3. The Peruvian district.
- IV. The Southern Temperate Zone.
    1. The Cape of Good Hope district.
    2. The South Australian district.
    3. The Chilian district.
    4. The Patagonian district.
- V. The Antarctic Ocean.

As with freshwater fishes, the main divisions of the shore-fish faunæ are determined by their distance from the equator, the equatorial zone of the freshwater series corresponding entirely to that of the shore-fish series. But as marine fishes extend farther towards the poles than freshwater fishes, and as the polar types are more specialized, a distinct arctic and antarctic fauna may be separated from the faunæ of the temperate zones. The two subdivisions of the northern temperate zone in the freshwater series are quite analogous to the corresponding divisions in the coast s ries. In the southern hemisphere the shore fishes of the extremity of Africa form a separate district of the temperate zone, whilst the freshwater fishes of South Africa were found to be tropical types. The marine series of the southern temperate zone is also much more diversified than the freshwater series, and admits of further subdivision, which, although in some degree indicated in the freshwater series, does not entirely correspond to that proposed for the latter.

ARCTIC OCEAN.—The shore fishes clearly prove a continuity of the arctic circumpolar fauna, as the southern limit of which we may indicate the southern extremity of Greenland and the Aleutian Archipelago, or 60° N. lat.

Towards the north, fishes become less in variety of species and fewer in number of individuals, and only very few genera are restricted to this fauna.

The highest latitude at which shore fishes have been observed is 83° N. The late Arctic Expedition collected at and near that latitude specimens of *Cottus quadricornis*, *Icelus hamatus*, *Cyclopterus spinosus*, *Liparis fabricii*, *Gymnelis viridis*, and *Gadus fabricii*. The number would probably have been larger were it not that the difficulties of collecting fishes in these high latitudes are almost insuperable for the greater part of the year.

So far as we know, the fishes north and south of Behring's Straits belong to the same generic or family types as those of the corresponding latitudes of the eastern hemisphere, though the majority are specifically distinct. But the information we possess of the fishes of the northernmost extremity of the Pacific is extremely scanty and vague. Farther south, whence now and then a collection reaches Europe, we meet with some European species, as the herring, holibut, and hake.

Chondropterygians are very rare. Of Acanthopterygians the families of *Cottidæ*, *Cataphracti*, *Discoboli*, and *Blenniidæ* are well represented, and several of the genera are characteristic of the arctic fauna. Characteristic also is the development of Gadoid fishes, of which some thirteen species, belonging to *Gadus*, *Merluccius*, and *Molva*, form one of the principal articles of food for the inhabitants of the coasts of the Arctic Ocean. The Blennoid *Anacanthini* or *Lycodidæ* are limited to the Arctic and Antarctic coasts. *Ammodytes* and a few flat-fishes (*Hippoglossoides* and *Pleuronectes*) are common in the more temperate parts. Labroids only exceptionally penetrate so far towards the north. Physostomes are very rare, and are represented only by a few species of *Clupea* and by *Mallotus*. The arctic climate is still less favourable to the existence of Lophobranchs, only a few of *Syngnathus* and *Nerophis* being present in the more southern latitudes, to which they have been carried by oceanic currents from their more congenial home in the south. Sclerodermis and Plectognaths are entirely absent. The Gadoids are accompanied by *Myxine*, which thrives in them as a parasite.

NORTHERN TEMPERATE ZONE.—*Temperate North Atlantic.*—This part of the fauna may be subdivided into three districts:—

1. The fishes of the north-eastern shores, viz., of the British Islands, of Scandinavia so far as it is not included in the arctic fauna, and of the continent of Europe southwards to about 40° N. lat.: British district.

2. The fishes of the Mediterranean shores and of the adjoining shores of the Atlantic, including the Azores, Madeira, and the Canary Islands: Mediterranean district.

3. The fishes of the western shores, from 60° to about 30° N. lat.: North American district.

1. The British district shows scarcely any marked distinctive features; the character of its fauna is simply intermediate between that of the Arctic Ocean and the Mediterranean district; truly arctic forms disappear, while such as are also found in the Mediterranean make their appearance. With regard to the abundance of individuals and variety of fishes also, this district forms a transition from the north towards the south.

Besides the few arctic Chondropterygians, all of which extend into this district, the small shore dog-fishes are well represented (*Mustelus*, *Galeus*, *Scyllium*, *Pristiurus*); the ubiquitous *Rhina* or monk-fish is common; of rays, *Raia* predominates in a variety of species over *Torpedo* and *Trygon*, which are still rare.

Of Acanthopterygians, *Centridermichthys*, *Icelus*, *Triglops*, and *Aspidophoroides* do not extend from the north into this district; and *Cottus*, *Anarrhichas*, *Centronotus*, *Stichæus*, and the *Discoboli* disappear within its limits. Nearly all the remainder are genera which are also found in the Mediterranean district. The following are the principal forms known to propagate on these shores: *Labrax*; *Serranus*, *Polyprion*, *Dentex*; *Mullus*; *Cantharus*, *Pagrus*, *Pagellus*; *Sebastes*; *Cottus*, *Trigla*, *Agonus*; *Trachinus*; *Sciæna* (?); *Zeus*; *Trachurus*, *Capros*; *Callionymus*; *Discoboli*; *Lophius*; *Anarrhichas*, *Centronotus*, *Stichæus*; *Blenniops*, *Zoarces* (not in the Mediterranean); *Cepola*; *Lepadogaster*.

Of the *Anacanthini* the Gadoids are as numerous as in the Arctic Ocean, most being common to both districts; but, whilst the majority show their northern origin by not extending into the Mediterranean, *Ammodytes* and most *Pleuronectidæ* prove themselves to be the more southern representatives of this order. In the British district we find *Hippoglossus*, *Hippoglossoides*, *Rhombus*, *Phrynorhombus*, *Pleuronectes*, *Solea*, and only the first two are not met with in the Mediterranean.

Labroids are common; with the exception of the North American *Tautoga*, all the other genera are met with.

Physostomes are not well represented, viz., by one species of *Osmerus*, one of *Engraulis*, one of *Conger*, and about five of *Clupea*.

Syngnathus and *Nerophis* become more common as we proceed southwards; but the existence of Sclerodenns and Plectognaths is indicated by single individuals only, stragglers from their southern home, unable to establish themselves in a climate ungenial to them.

The Gadoids are accompanied by *Myxine*; and *Branchiostoma* may be found in all suitable localities.

2. The Mediterranean district is distinguished by a great variety of forms; yet, with the exception of a few genera established for single species, none of the forms can be considered peculiar to it; and even that small number of peculiar genera is more and more diminished as our knowledge of the distribution of fishes advances. Some genera are identical with those found on the western coasts of the Atlantic and in the West Indies; but a most remarkable and unexpected affinity obtains with another very distant fauna, viz., that of Japan. The number of genera common to the Mediterranean district and the Japanese coasts is larger than that of the genera common to the Mediterranean and the opposite American coasts.

The Chondropterygians found in the British district continue in the Mediterranean, their number being increased by *Centrina*, *Spinax*, *Pteroplatea*, and some species of *Rhinobatus*, a genus more numerously represented in the tropics. *Torpedo* and *Trygon* are common.

The greatest variety belong to the Acanthopterygians, which are represented by fifty-seven genera.

The *Labridæ* are as common as in the British district, or even more so, and are represented by the same genera. But, besides these, some other Pharyngognaths, properly belonging to the tropical Atlantic, have fully established themselves, though only by a few species, viz., *Glyphidodon* and *Heliastes*, *Cossyphus*, *Novacula*, *Julis*, *Coris*, and *Scarus*.

The Gadoids show a marked decrease of development; and the species of *Gadus*, *Gadiculus*, *Mora*, *Strinsia*, *Phycis*, and *Molva* which are peculiar to the Mediterranean seem to inhabit rather the colder water of moderate depths than the surface near the shore. *Motella*, however, proves also to be a true shore fish in the Mediterranean, at least in its adult state. *Ophidium* and *Fierasfer* appear now besides *Ammodytes*. As the Gadoids decrease, so the *Pleuronectidæ* increase, 9 genera being found in this district.

The variety of Physostomes is small, the following only having to be added to those of the British district: *Saurus* (a tropical genus), *Aulopus*; *Congromuræna*, *Heteroconger*, *Myrus*, *Ophichthys*, *Muræna*.

The Lophobranchs are more numerous in species and individuals than in the British district; and, besides *Syngnathus* and *Nerophis*, several species of *Hippocampus* are common. A few species of *Balistes* also occur.

Myxine is lost in this district, whilst *Branchiostoma* is abundant.

3. The shore fishes of the North American district consist, as on the eastern coasts of the North Atlantic, of northern (about 50 genera) and southern (about 30) elements; but they are still more mixed with each other than on the European coasts, so that a boundary line cannot be drawn between them. The affinity to the fauna of the eastern shores is great, but almost entirely limited to the genera composing the fauna of the British district. British genera not found on the American coasts are—*Galeus*, *Scyllium*, *Chimæra*, *Mullus*, *Pagellus*, *Trigla*, *Trachinus*, *Zeus*, *Callionymus*. The southern elements of North America are rather derived from the West Indies, and have no special affinity to Mediterranean forms; very few of the non-British Mediterranean forms extend across the Atlantic; instead of a Mediterranean we find a West Indian element. Many of the British *species* range across the Atlantic, and inhabit in an unchanged condition the northern parts of this district; and from the frequent occurrence of isolated specimens of other British species on the North American coast, we may presume that many more occasionally cross the Atlantic, but without being able to obtain a permanent footing.

The genera peculiar to this district are few in number, and composed of very few species, viz., *Hemitripterus*, *Pammelas*, *Chasmodes*, *Cryptacanthodes*, and *Tautoga*.

Temperate North Pacific.—This fauna shows a great affinity to that of the Temperate North Atlantic, not only in including a considerable proportion of identical genera, and even of species, but also in having its constituent parts similarly distributed. Our knowledge of the ichthyology of this fauna, however, is by no means complete, and the details of the distribution of the fishes of these shores have still to be worked out; nevertheless, three divisions may be recognized which, for the present, may be defined as follows:—

1. The fishes of the north-western shores, to about 37° N. lat., including the corresponding northern parts of Japan: Kamtchatkan district. This corresponds to the British district of the Atlantic.

2. The fishes of southern Japan and the corresponding shores of the continent of Asia, between 37° and 30° N. lat.: Japanese district, which corresponds to the Mediterranean.

3. The fishes of the eastern shores southwards to the latitude of San Francisco: Californian district. This corresponds to the North American district of the Atlantic.

Too little is known of the shore fishes of the coasts between San Francisco and the tropic to enable us to treat of it as a separate division.

The shore fishes of the North Pacific generally are composed of the following elements:—

a. Arctic forms which extend into the Arctic Ocean, and the majority of which are also found in the British district.

b. Peculiar forms limited to the North Pacific, like the *Heterolepidina*, *Embiotocidæ*, and certain Cottoid and Blennioid genera.

c. Forms identical with fishes of the Mediterranean.

d. Peculiar forms limited to the southern parts of Japan.

e. Tropical forms which have entered the North Pacific from the south.

1. To the Kamtchatkan district we can assign but a small list of fishes, probably because of the imperfect manner in which its fauna has been explored. At present we have positive knowledge of the occurrence of only two Chondropterygians, viz., *Chimæra* and *Raia*; the species of the latter genus seem to be much less numerous than in the Atlantic. Of Acanthopterygians 15 genera are known. Labroids are absent; they are clearly a type unable to endure great cold; of the Embiotocoids which represent them in the Pacific, one species only (a species of *Ditrema*) is known from this district.

The Gadoids are, so far as we know at present, sparsely represented, viz., by isolated species of *Gadus*, *Motella*, and *Lotella*, the last being an inhabitant of moderate depths rather than of the surface. *Hippoglossus*, *Pleuronectes*, and *Parophrys* seem to occur everywhere in suitable localities.

The Physostomes are nearly the same as in the British district, viz., a smelt (*Hypomesus*), probably also the arctic *Mallotus*, an anchovy, several species of *Clupea*, and the conger-eel. A very singular Salmonoid fish, *Salanx*, which is limited to the north-western Pacific, occurs in great abundance. The Lophobranchs also correspond in their development to those of the British district, *Nerophis* being replaced by *Urocampus*. Neither Myxinoids nor *Branchiostoma* have as yet been found.

2. The Japanese district is, like the Mediterranean, distinguished by a great variety of forms. Of 102 genera known to inhabit these coasts, 13 are peculiar to it, 53 occur in the Mediterranean, though also in other districts. This resemblance to the Mediterranean is even greater than would appear from a comparison of the genera, inasmuch as a considerable number of species are identical in both districts. Three of the Berycoid genera have hitherto been found in the Japanese and Mediterranean districts and nowhere else. Another very singular fact is that some of the most characteristic genera, like *Mullus*, *Zeus*, *Callionymus*, *Centriscus*, inhabit the Mediterranean and Japanese districts, but have never reached the opposite American coasts, either in the Atlantic or the Pacific; although, at least in the latter, the oceanic currents would rather favour than obstruct their dispersal in the direction of America. Bold as the hypothesis may appear, we can only account for the singular distribution of these shore fishes by assuming that the Mediterranean and Japanese seas were in direct and open communication with each other within the period of the existence of the present Teleosteous fauna.

Gadoids have disappeared, or are represented by forms inhabiting moderate depths. Neither *Myxine* nor *Branchiostoma* are as yet known to have been found.

3. The Californian district includes a marked northern element, the principal constituents of which are identical with types occurring in the corresponding district of the Atlantic, viz., the North American, as exemplified by *Discoboli*, *Anarrhichas*, *Centronotus*, *Cottus*, *Hippoglossus*, *Clupea* (*harengus*), &c. But it possesses also, in the greatest degree of development, some types almost peculiar to itself, as the *Heterolepidina*, some remarkable Cottoid and Blennioid genera, and more especially the Embiotocoids—viviparous Pharyngognaths—which replace the Labroids of the other hemi-

sphere. Gadoids are much less numerous than in the North American district. The southern forms are but little known, but it may be anticipated that, owing to the partial identity of the faunæ of the two coasts of the isthmus of Panama, a fair proportion of West Indian forms will be found to have entered this district from the south.

EQUATORIAL ZONE.—As we approach the tropic from the north, the types characteristic of the arctic and temperate zones become rarer, and disappear altogether, to be replaced by the greater variety of tropical types. Of Chondropterygians, the *Chimæridæ*, *Spinacidæ*, *Mustelus*, and *Raia* do not pass the tropic, or appear in single species only; and of Teleosteans, the *Berycidæ*, *Pagrus*, the *Heterolepidina*, *Cottus* and allied genera, *Lophius*, *Anarrhichas*, *Stichæus*, *Lepadogaster*, *Psychrolutes*, *Centriscus*, *Notacanthus*, the *Labridæ* and *Embiotocidæ*, the *Lycodidæ*, *Gadidæ*, and marine *Salmonidæ* either entirely disappear, or retire from the shores and surface into the depths of the ocean.

With regard to variety of forms, as well as to number of individuals, this zone far surpasses either of the temperate zones; in this respect, the life in the sea is like that on the land. Shore fishes are not confined to the actual coast line, but abound on the coral reefs with which some parts of the Atlantic and Pacific are studded, and many of which are below the surface of the water. The abundance of animal and vegetable life which flourishes on these renders them the favourite pasture grounds for the endless variety of coral-fishes (*Squamipinnes*, *Acronuridæ*, *Pomacentridæ*, *Julidæ*, *Plectognathi*, &c.) and for the larger predatory kinds. The colours and grotesque forms of the fishes of the tropics justly excited the admiration of the earliest observers. Scarlet, black, blue, pink, red, yellow, &c., are arranged in patterns of the most bizarre fashion, mingling in spots, lines, or bands, and reminding us of the words of Captain Cook when describing the coral-reefs of Palmerston Island: "The glowing appearance of the mollusks was still inferior to that of the multitude of fishes that glided gently along, seemingly with the most perfect security. The colours of the different sorts were the most beautiful that can be imagined—the yellow, blue, red, black, &c., far exceeding anything that art can produce. Their various forms, also, contributed to increase the richness of this submarine grotto, which could not be surveyed without a pleasing transport."

Of Chondropterygians the *Scylliidæ*, *Pristis* (saw-fishes), *Rhinobatidæ*, and *Trygonidæ* attain to the greatest development. Of Acanthopterygians *Centropristis*, *Serranus*, *Plectropoma*, *Mesoprion*, *Priacanthus*, *Apogon*, *Pristipoma*, *Hæmulon*, *Diagramma*, *Gerres*, *Scolopsis*, *Synagris*, *Cæsio*, *Mullidæ*, *Lethrinus*, *Squamipinnes*, *Cirrhites*, some genera of *Scorpænidæ*, *Platycephalus*, *Sciænidæ*, *Sphyræna*, *Caranx*, *Equula*, *Callionymus*, *Teuthis*, *Acanthurus*, *Naseus*, are represented by numerous species; and the majority of these genera and families are limited to this zone. Of Pharyngognaths the *Pomacentridæ*, *Julidina*, and *Scarina* are met with near every coral formation in a living condition. Of Gadoids, a singular minute form, *Bregmaceros*, is almost the only representative, the other forms belonging to deep water, and rarely ascending to the surface. Flat-fishes (*Pleuronectidæ*) are common on sandy coasts, and the majority of the genera are peculiar to the tropics. Of *Physostomi* only the *Saurina*, *Clupeidæ*, and *Murænidæ* are represented, the *Clupeidæ* being exceedingly numerous in individuals, whilst the *Murænidæ* live more isolated, but show a still greater variety of species *Lophobranchii* and *Sclerodermi* are generally distributed *Branchiostoma* has been found on several coasts.

Geographically it is convenient to describe the coast fauna of the tropical Atlantic separately from that of the Indo-Pacific Ocean. The differences between them, however, are far less numerous and important than between the freshwater or terrestrial faunæ of continental regions. The majority of the principal types are found in both, many of the species being even identical; but the species are far more abundant in the Indo-Pacific than in the Atlantic, owing to the greater extent of the archipelagoes in the former. But for the broken and varied character of the coasts of the West Indies, the shores of the tropical Atlantic would, by their general uniformity, afford but a limited variety of conditions for the development of specific and generic forms, whereas the deep inlets of the Indian Ocean, with the varying configuration of their coasts and the different nature of the bottom, its long peninsulas, and its archipelagoes, and the scattered islands of the tropical Pacific, render this part of the globe the most perfect for the development of fish life. The fishes of the Indian and Pacific Oceans (between the tropics) are almost identical, and the number of species ranging from the Red Sea and the east coast of Africa to Polynesia, even to its most westerly islands, is very great indeed. This Indo-Pacific fauna, however, does not reach the Pacific coast of South America. The wide space devoid of islands east of the Sandwich Islands and the Marquesas group, together with the current of cold water which sweeps northwards along the South American coast, has proved to be a very effectual barrier to the eastward extension of the Indo-Pacific fauna of coast fishes; and, consequently, we find an assemblage of fishes on the American coast and at the Galapagos Islands, sufficiently marked to constitute a distinct zoological division.

Tropical Atlantic.—The boundaries of the tropical Atlantic extend zoologically a few degrees beyond the northern and southern tropics, but, as the mixture with the types of the temperate zone is very gradual, no distinct boundary line can be drawn between the tropical and temperate faunæ.

Types almost exclusively limited to it and not found in the Indo-Pacific are few in number, as *Centropristis*, *Rhypticus*, *Hæmulon*, *Malthe*. A few others preponderate with regard to the number of species, as *Plectropoma*, *Sargus*, *Trachynotus*, *Batrachidæ*, and *Gobiesocidæ*. The Sciænoids are equally represented in both oceans. All the remainder are found in both, but are in a minority in the Atlantic, where they are sometimes represented by one or two species only (for instance, *Lethrinus*).

Tropical Indo-Pacific Ocean.—The ichthyological boundaries of this part of the tropical zone may be approximately given at 30° N. and S. lat.; on the Australian coasts it should probably be placed still farther south, viz., at 34°; it includes, as mentioned above, the Sandwich Islands, and all the islands of the South Sea, but not the American coasts.

Some eighty genera of shore fishes are peculiar to the Indo-Pacific, but the greater number consist of one or a few species only; comparatively few have a plurality of species, as *Diagramma*, *Lethrinus*, *Equula*, *Teuthis*, *Amphiprion*, *Dascyllus*, *Chœrops*, *Chilinus*, *Anampses*, *Stethojulis*, *Coris*, *Coilia*.

The sea-perches, large and small, which feed on crustaceans and on other small fishes, and the coral-feeding Pharyngognaths, are the types which show the greatest generic and specific variety in the Indo-Pacific. Then follow the *Squamipinnes* and *Murænidæ*, the *Clupeidæ* and *Carangidæ*,—families in which the variety is more that of species than of genus. The *Scorpænidæ*, *Pleuronectidæ*, *Acronuridæ*, *Sciænidæ*, *Syngnathidæ*, and *Teuthyes* are those which contribute the next largest contingents. Of shore-loving Chondropterygians the *Scylliidæ* and *Trygonidæ* only are represented in moderate numbers, though they are more numerous in this ocean than in any other.

Pacific Coasts of Tropical America.—As boundaries within which this fauna is comprised may be indicated 30° N. and S. lat., as in the Indo-Pacific. Its distinction from the Indo-Pacific lies in the almost entire absence of coral-feeding fishes. There are scarcely any *Squamipinnes*, Pharyngognaths, or *Acronuridæ*, and the *Teuthyes* are entirely absent. The genera that remain are such as are found in the tropical zone generally, but the species are entirely different from those of the Indo-Pacific. They are mixed with a sprinkling of peculiar genera, consisting of one or two species, like *Discopyge*, *Hoplopagrus*, *Doydixodon*, but they are too few in number to give a strikingly peculiar character to this fauna.

Three districts are distinguishable, viz., the Central American, the Galapagos, and Peruvian. We add a few remarks on the first only.[1] That district shows so close an affinity to the Tropical Atlantic that, if the two were not separated by the neck of land uniting North and South America, they would most assuredly be regarded as embracing a single fauna. With scarcely any exceptions the genera are identical, and of the species found on the Pacific side nearly one-half have proved to be the same as those of the Atlantic. The explanation of this fact has been found in the existence of communications between the two oceans by channels and straits which must have been open till within a recent period. The isthmus of Central America was then partially submerged, and appeared as a chain of islands similar to that of the Antilles; but as the reef-building corals flourished chiefly north and east of those islands, and were absent to the south and west of them, reef fishes were excluded from the Pacific shores when the communications were destroyed by the upheaval of the land.

SOUTHERN TEMPERATE ZONE.—This zone includes the coasts of the southern extremity of Africa from about 30° S lat., of the south of Australia, with Tasmania, and of New Zealand, and the Pacific and Atlantic coasts of South America between 30° and 50° S lat.

The most striking character of this fauna is the reappearance of types inhabiting the corresponding latitudes of the northern hemisphere, and not found in the intervening tropical zone. This interruption of the continuity in the geographical distribution of shore fishes is exemplified by species as well as genera, for instance—*Chimæra monstrosa*, *Galeus canis*, *Acanthias vulgaris*, *Acanthias blainvillii*, *Rhina squatina*, *Zeus faber*, *Lophius piscatorius*, *Centriscus scolopax*, *Engraulis encrasicholus*, *Clupea sprattus*, *Conger vulgaris*. Instances of genera are still more numerous:—*Cestracion*, *Spinax*, *Pristiophorus*, *Raia*; *Callanthias*, *Polyprion*, *Histiopterus*, *Cantharus*, *Box*, *Girella*, *Pagellus*, *Chilodactylus*, *Sebastes*, *Aploactis*, *Agonus*, *Lepidopus*, *Cyttus*, *Psychrolutidæ*, *Notacanthus*; *Lycodes*, *Merluccius*, *Lotella*, *Phycis*, *Motella*; *Aulopus*; *Urocampus*, *Solenognathus*, *Myxine*.

Naturally, where the coasts of the tropical zone are continuous with those of the temperate, a number of tropical genera enter the latter, and genera which we have found between the tropics, as well as in the temperate zone of the northern hemisphere, extend in a similar manner towards the south. But the truly tropical forms are absent; there are no *Squamipinnes*, scarcely any *Mullidæ*, no *Acronuri*, no *Teuthyes*, no *Pomacentridæ* (with a single exception on the coast of Chili), only one genus of *Julidina*, no *Scarina*, which are replaced by another group of Pharyngognaths, the *Odacina*. The *Labrina*, so characteristic of the temperate zone of the northern hemisphere, reappear in a distinct genus (*Malacopterus*) on the coast of Juan Fernandez.

The family of *Berycidæ*, equally interesting with regard to their distribution in time and in space, consists of temperate and tropical genera. The genus by which this family is represented in the southern temperate zone (*Trachichthys*) is much more nearly allied to the northern than to the tropical genera.

The true *Cottina* and *Heterolepidina* (forms with a bony stay of the præoperculum, which is generally armed) have not crossed the tropical zone; they are replaced by fishes extremely similar in general form, and having the same habits, but lacking that osteological peculiarity. Their southern analogues belong chiefly to the family *Trachinidæ*, and are types of genera peculiar to the southern hemisphere.

The *Discoboli* of the northern hemisphere likewise have not penetrated to the south, where they are represented by *Gobiesocidæ*. These two families replace each other in their distribution over the globe.

Nearly all the *Pleuronectidæ* (but they are not numerous) belong to distinct genera, some, however, being remarkably similar in general form to the northern *Pleuronectes*.

With Gadoids *Myxinidæ* reappear, one species being extremely similar to the European *Myxine*. *Bdellostoma* is a genus peculiar to the southern temperate zone.

As in the northern temperate zone, so in the southern the number of individuals and the variety of forms is much less than between the tropics. This is especially apparent on comparing the numbers of species constituting a genus. In this zone genera composed of more than ten species are the exception, the majority having only from one to five.

The proportion of genera limited to this zone is very high, about 65 out of a total number of 170 being peculiar to it.

1. The Cape of Good Hope district. Many of the genera found in this district are northern forms (*Chimæra*, *Galeus*, *Scyllium*, *Acanthias*, *Torpedo*, *Raia*, *Dentex*, *Cantharus*, *Box*, *Sagrus*, *Pagrus*, *Pagellus*, *Chrysophrys*; *Sebastes*, *Sphyræna*; *Lepidopus*, *Thyrsites*; *Zeus*; *Lophius*; *Motella*), which in conjunction with the peculiarly southern types (*Callorhynchus*, *Chilodactylus*, *Agriopus*, *Clinus*, *Genypterus*, *Bdellostoma*) leave no doubt that this district belongs to the southern temperate zone, whilst the freshwater fishes of South Africa are members of the tropical fauna. Only a few (*Rhinobatus*, *Narcine*, *Astrape*, and *Sphyræna*) have entered from the neighbouring tropical coasts. The development of Sparoids is greater than in any of the other districts of this zone, and may be regarded as one of its distinguishing features.

2. The South Australian district comprises the southern coasts of Australia (northwards to about the latitude of Sydney), Tasmania, and New Zealand. It is the richest in the southern temperate zone, partly in consequence of a considerable influx of tropical forms on the eastern coast of Australia, where they penetrate farther southwards than would be expected from merely geographical considerations, partly in consequence of the thorough manner in which the ichthyology of New South Wales and New Zealand has been explored. Of the 120 genera hitherto found in this district 42 are peculiar.

The shore fishes of New Zealand are not so distinct from those of south-eastern Australia as to deserve to be placed in a separate district. With the exception of the genera which enter this zone from the tropics, and which are more numerous on the Australian coast than on that of New Zealand, and a few very local genera in addition, the remainder are identical. Many of the South Australian species, too, are found also on the coasts of New Zealand. The principal points of difference are the extraordinary development of *Monacanthus* on the coast of South Australia, and the apparently total absence in Australia of Gadoids, which in the New Zealand fauna are represented by 6 genera.

3. The Chilian district extends over 20 degrees of latitude only, and is nearly straight. In its northern and warmer parts it is of a very uniform character; it is there exposed to high and irregular tides, and to remarkable and sudden changes in the levels of land and water, which must seriously interfere with fishes living and propagating near the shore. No river of considerable size interrupts the monotony of the physical conditions, to offer an additional element in favour of the development of littoral animals. In the southern parts, where the coast is lined with archipelagoes, the climate is too severe for most fishes. All these conditions combine to render this district comparatively poor as regards variety of shore fishes; they belong to 45 genera, of which 6 only are not found in

[1] For the others the reader is referred to Günther's *Introduction to the Study of Fishes*, p. 280.

other districts of this zone. Three are peculiar, viz., *Mendosoma*, *Myxodes*, and *Malacopterus*; *Porichthys* and *Agonus* have penetrated thus far southwards from the Peruvian and Californian districts; and *Polyprion* is one of those extraordinary instances in which a very specialized form occurs at almost opposite points of the globe, without having left a trace of its previous existence in, or of its passage through, the intermediate space.

4. Our knowledge of the fauna of the Patagonian district is, with the exception of the neighbourhood of the mouth of the Rio de la Plata, in too fragmentary a state to deserve further notice here.

ANTARCTIC OCEAN.—To this fauna we refer the shore fishes of the southernmost extremity of South America, from 50° S. lat., with Tierra del Fuego and the Falkland Islands, and those of Kerguelen's Land, with Prince Edward's Island. No fishes are known from the other oceanic islands of these latitudes.

In the southern hemisphere surface fishes do not extend so far towards the pole as in the northern; none are known beyond 60° S. lat., and the Antarctic fauna which is analogous to the Arctic inhabits coasts more than ten degrees nearer to the equator. It is very probable that the shores between 60° and the Antarctic Circle are inhabited by fishes sufficiently numerous to supply part of the means of subsistence for the large seals which there pass at least some portion of the year, but hitherto none have been obtained by naturalists; all that the present state of our knowledge justifies us in saying is, that the general character of the fauna of Magellan's Straits and Kerguelen's Land is extremely similar to that of Iceland and Greenland.

As in the Arctic fauna, Chondropterygians are rare, and are represented by *Acanthias vulgaris* and species of *Raia*. *Holocephali* have not yet been found so far south, but *Callorhynchus*, which is not uncommon near the northern boundary of this fauna, may prove to extend into it.

As to Acanthopterygians, *Cataphracti* and *Scorpænidæ* are represented as in the Arctic fauna, two of the genera (*Sebastes* and *Agonus*) being identical. The *Cottidæ* are replaced by six genera of *Trachinidæ*, remarkably similar in form to Arctic types; but *Discoboli* and the characteristic Arctic Blennioids are absent.

Gadoid fishes reappear, but are less developed; as usual they are accompanied by *Myxine*. The reappearance of so specialized a genus as *Lycodes* is most remarkable. Flatfishes are few as in the north, and belong to peculiar genera.

Physostomes are probably not entirely absent, but hitherto none have been met with so far south. Lophobranchs are rare, as in the Arctic zone; it is noteworthy, however, that a peculiar genus, with persistent embryonic characters (*Protocampus*), is rather common on the shores of the Falkland Islands.

Pelagic Fishes.

Pelagic fishes,—that is, fishes inhabiting the surface of mid-ocean,—belong to various orders, viz., Chondropterygians, Acanthopterygians, Physostomes, Lophobranchs, and Plectognaths. Neither Anacanths nor Pharyngognaths contribute to this series of the marine fauna. The following genera and families are included in it:—

Chondropterygii.—Carcharias, Galeocerdo, Thalassorhinus, Zygæna, Triænodon, Lamnidæ, Rhinodon, Notidanidæ, Læmargus, Euprotomicrus, Echinorhinus, Isistius; Myliobatidæ.

Acanthopterygii.—Dactylopterus, Micropteryx, Scombrina, Gastrochisma, Nomeus, Centrolophus, Coryphænina, Seriola, Temnodon, Naucrates, Psenes, Xiphiidæ, Antennarius.

Physostomi.—Sternoptychidæ, Scopelus, Astronesthes, Scombresocidæ (majority).

Lophobranchii.—Hippocampus.

Plectognathi.—Orthagoriscus, and some other Gymnodonts.

Pelagic fishes differ much from one another in their mode of life. The majority are excellent swimmers, which not only can move with great rapidity, but are also possessed of great powers of endurance, and are thus enabled to continue their course for weeks, apparently without the necessity of rest; such are many sharks, scombroids, dolphins, pilot-fish, sword-fishes. In some, as in *Dactylopterus* and *Exocœtus*, the ability to take flying leaps out of the water is superadded to the power of swimming (flying-fishes). But in others the power of swimming is greatly reduced, as in *Antennarius*, *Hippocampus*, and Gymnodonts; they frequent places in the ocean covered with floating seaweed, or drift on the surface without resistance, at the mercy of wind and current. The *Echeneis* or sucking-fishes attach themselves to other large fishes, ships, or floating objects, and allow themselves to be carried about, unless change of climate or want of food obliges them to abandon their temporary carrier. Finally, another class of pelagic fishes come to the surface of the ocean during the night only; in the day time they descend to some depth, where they are undisturbed by the rays of the sun or the agitation of the surface-water; such are *Brama*, the *Sternoptychidæ*, *Scopelus*, *Astronesthes*,—fishes the majority of which are provided with those extraordinary visual organs that we find so much developed in the true deep-sea fishes. Indeed, this last kind of pelagic fishes constitutes a connecting link with the deep-sea forms.

Pelagic fishes, like shore fishes, are most numerous in the tropical zone; and, with few exceptions (*Echinorhinus*, *Psenes*, *Sternoptychidæ*, *Astronesthes*), the same genera are represented in the tropical Atlantic as well as in the Indo-Pacific. The number of identical species occurring in both these oceans is great, and probably still greater than would appear from systematic lists, in which there are retained many specific names that were given at a time when species were believed to have a very limited range. The pelagic fauna of the tropics gradually passes into that of the temperate zones, only a few genera, like *Cybium*, *Psenes*, *Antennarius*, being almost entirely confined to the tropics. All the other tropical genera range into the temperate zones, but their representatives become fewer with the increasing distance from the equator. North of 40° N. lat. many genera have disappeared, or are met with in isolated examples only, as *Carcharias*, *Zygæna*, *Notidanus*, *Myliobatidæ*, *Dactylopterus*, *Echeneis*, *Nomeus*, *Coryphæna*, *Schedophilus*, *Seriola*, *Temnodon*, *Antennarius*, *Sternoptychidæ*, *Astronesthes*, *Exocœtus*, *Tetrodon*, *Diodon*; and only one genus of sharks, *Galeocerdo*, approaches the Arctic Circle. Some few species, like *Antennarius*, *Scopelus*, are carried by currents near to the farther confines of the temperate zones; but such occurrences are accidental, and these fishes must be regarded as entirely foreign to the fauna of those latitudes. On the other hand, some pelagic fishes inhabit the temperate zones, whilst their occurrence within the tropics is very problematical; thus, in the Atlantic, *Thalassorhinus*, *Selache*, *Læmargus*, *Centrolophus*, *Diana*, *Ausonia*, *Lampris* (all genera composed of one or two species only). Besides the shark mentioned, no other pelagic fishes are known from the Arctic Ocean.

We possess very little information about the pelagic fish-fauna of the southern oceans. This much only is certain, that the tropical forms gradually disappear; but it would be hazardous, in the present state of our knowledge, to state even approximately the limits of the southward range of a single genus. Scarcely more is known about the appearance of types peculiar to the southern temperate zone,—for instance, the gigantic shark *Rhinodon* representing the northern *Selache*, near the coasts of South Africa, and the Scombroid genus *Gastrochisma*, in the South Pacific.

The largest of marine fishes, *Rhinodon*, *Selache*, *Carcharodon*, *Myliobatidæ*, *Thynnus*, *Xiphiidæ*, *Orthagoriscus*, belong to the pelagic fauna. Young fishes are frequently found in mid-ocean, which are the offspring of shore fishes normally depositing their spawn near the coast. The manner in which this fry passes into the open sea is unknown; for it has not yet been ascertained whether it is carried by currents from the place where it was deposited originally, or whether shore fishes sometimes spawn at a distance from the coast. We may remember that shore fishes inhabit not only coasts but also submerged banks with some depth of water above, and that, by the action of the water, spawn deposited on these latter localities is very liable to be dispersed over wide areas of the ocean. Embryos of at least some shore fishes hatched under abnormal conditions seem to have an abnormal growth up to a certain period of their life, when they perish. The *Leptocephali* must be regarded as such abnormally developed forms. Fishes of a similar condition are the so-called pelagic *Plagusiæ*, young Pleuronectoids, the origin of which is still unknown. As already mentioned, flat-fishes, like all the other Anacanths, are not otherwise represented in the pelagic fauna.

Deep-Sea Fishes.

The knowledge of the existence of deep-sea fishes is one of the recent discoveries of ichthyology. It was only about twenty years ago that, from the evidence afforded by the anatomical structure of a few singular fishes obtained in the North Atlantic, an opinion was expressed that these fishes inhabited great depths of the ocean, and that their organization was specially adapted for living under the physical abyssal conditions. These fishes agreed in the character of their connective tissue, which was so extremely weak as to yield to, and to break under, the slightest pressure, so that the greatest difficulty was experienced in preserving their body in its continuity. Another singular circumstance was that some of the examples were picked up floating on the surface of the water, having met their death whilst engaged in swallowing or digesting other fishes not much smaller in size if not actually larger than themselves.

The first peculiarity was accounted for by the fact that, if those fishes really inhabited the great depths supposed, their removal from the enormous pressure under which they lived would be accompanied by such an expansion of gases within their tissues as to rupture them, and to cause a separation of the parts which had been held together by the pressure. The second circumstance was explained thus. A raptorial fish organized to live at a depth of between 500 and 800 fathoms seizes another usually inhabiting a depth of between 300 and 500 fathoms. In its struggles to escape, the fish seized, being nearly as large or strong as the attacking fish, carries the latter out of its depth into a higher stratum, where the diminished pressure causes such an expansion of gases as to make the destroyer with its victim rise with increasing rapidity towards the surface, which they reach dead or in a dying condition. Specimens in this state are not rarely picked up; and as, of course, it is but comparatively few that can by accident fall into the hands of naturalists, occurrences of this kind must happen very often.

The existence of fishes peculiarly adapted for the deep sea has thus been a fact maintained and admitted for some time in ichthyology; and as the same genera and species were found at very distant parts of the ocean, it was further stated that those deep-sea fishes were not limited in their range, and that, consequently, the physical conditions of the depths of the ocean must be the same or nearly the same over the whole globe. That deep-sea fishes were not of a peculiar order, but chiefly modified forms of surface types, was another conclusion arrived at from the sporadic evidence collected during the period which preceded systematic deep-sea dredging.

Nothing, however, was positively known as to the exact depths inhabited by those fishes until observations were made during the voyage of H.M.S. "Challenger." The results obtained by this expedition afforded a surer and more extended basis for our knowledge of deep-sea fishes.

The physical conditions of the deep sea, which must affect the organization and distribution of fishes, are the following:—

1. Absence of sunlight. Probably the rays of the sun do not penetrate to, and certainly do not extend beyond, a depth of 200 fathoms, therefore we may consider this to be the depth where the deep-sea fauna commences. Absence of light is, of necessity, accompanied by modifications of the organs of vision and by simplification of colours.

2. The absence of sunlight is in some measure compensated by the presence of phosphorescent light, produced by many marine animals, and also by numerous deep-sea fishes.

3. Depression and equality of the temperature. At a depth of 500 fathoms the temperature of the water is already as low as 40° Fahr., and perfectly independent of the temperature of the surface-water; and from the greatest depth to about 1000 fathoms beneath the surface the temperature is uniformly but a few degrees above the freezing point. Temperature, therefore, ceases to offer an obstacle to the unlimited dispersal of the deep-sea fishes.

4. The increase of pressure by the water. The pressure of the atmosphere on the body of an animal at the level of the sea is 15 ℔ per square inch of surface; but under water the pressure amounts to a ton weight for every 1000 fathoms of depth.

5. With the sunlight, vegetable life ceases in the depths of the sea. All deep-sea fishes are therefore carnivorous,—the most voracious feeding frequently on their own offspring, and the toothless kinds being nourished by the animalcules which live on the bottom, or which, "like a constant rain," settle down from the upper strata towards the bottom of the sea.

6. The perfect quiet of the water at great depths. The agitation of the water caused by the disturbances of the air does not extend beyond the depth of a few fathoms; below this surface-stratum there is no movement except the quiet flow of ocean-currents, and near the bottom of the deep sea the water is probably in a state of almost entire quiescence.

The effect upon fishes of the physical conditions described is clearly testified by the modification of one or more parts of their organization, so that every deep-sea fish may be recognized as such without the accompanying positive evidence that it has been caught at a great depth; and, *vice versa*, fishes reputed to have been obtained at a great depth, and not having any of the characteristics of the dwellers of the deep sea, must be regarded as surface fishes.

The most striking characteristic found in many deep-sea fishes is in relation to the tremendous pressure under which they live. Their osseous and muscular systems are, as compared with the same parts of surface fishes, very feebly developed. The bones have a fibrous, fissured, and cavernous texture; they are light, with scarcely any calcareous matter, so that the point of a needle will readily penetrate them without breaking. The bones, especially the vertebræ, appear to be very loosely connected with one another; and it requires the most careful handling to avoid the breaking of the connective ligaments. The muscles, especially the great lateral muscles of the trunk and tail, are thin, the fascicles being readily separated from one another or torn, and the connective tissue being extremely loose, feeble, or apparently absent. This peculiarity has been observed in the *Trachypteridæ*, *Plagyodus*, *Chiasmodus*, *Melanocetus*, *Saccopharynx*. But we cannot assume that it actually obtains whilst those fishes exist under their natural conditions. Some of them are most rapacious creatures, which must be able to execute rapid and powerful movements to catch and overpower their prey; and for that object their muscular system, thin as its layers may be, must be as firm, and the chain of the segments of their vertebral column as firmly linked together as in surface fishes. It is evident, therefore, that the change which the body of those fishes has undergone on their withdrawal from the pressure under which they live is a much aggravated form of the affection that is experienced by persons reaching great altitudes in their ascent of a mountain or in a balloon. In every living organism with an intestinal tract there are accumulations of free gases; and, moreover, the blood and other fluids, which penetrate every part of the body, contain gases in solution. Under greatly diminished pressure these gases expand, so that, if the withdrawal from a depth is not an extremely slow and gradual process, the various tissues must be distended, loosened, ruptured; and what is a vigorous fish at a depth of 500 fathoms or more appears at the surface as a loosely-jointed body which, if the skin is not of sufficient toughness, can only be kept together with difficulty. At great depths a fibrous osseous structure and a thin layer of muscles suffice to obtain the same results for which, at the surface, thickness of muscle and firm osseous or cartilaginous tissue are necessary.

The muciferous system of many deep-sea fishes is developed in an extraordinary degree. We find in fishes which are comparatively little removed from the surface (that is, to depths of from 100 to 200 fathoms) the lateral line much wider than in their congeners or nearest allies which live on the surface, as in *Trachichthys*, *Hoplostethus*, many *Scorpænidæ*. But in fishes inhabiting depths of 1000 fathoms and more the whole muciferous system is dilated; it is especially the surface of the skull which is occupied by large cavities (*Macruridæ*, deep-sea *Ophidiidæ*), and the whole body seems to be covered with a layer of mucus. These cavities collapse and shrink in specimens which have been preserved in spirit for some time, but a brief re-immersion in water generally suffices to show the immense quantity of mucus secreted by them. The physiological use of this secretion is unknown; it has been observed to have phosphorescent properties in perfectly fresh specimens.

The colours of deep-sea fishes are extremely simple, their bodies being either black or silvery; in a few only are some filaments or the fin-rays of a bright scarlet colour. Among the black forms albinoes are not rare.

The organ of sight is the first to be affected by a sojourn in deep water. Even in fishes which habitually live at a depth of only 80 fathoms, we find the eye of a proportionally larger size than in their representatives at the surface. In such fishes the eyes increase in size with the depth inhabited by them, down to the depth of 200 fathoms, the large organs being necessary to collect as many rays of light as possible. Beyond that depth small-eyed as well as large-eyed fishes occur, the former having their want of vision compensated by tentacular organs of touch, whilst the latter have no such accessory organs, and evidently see only by the aid of phosphorescence. In the greatest depths blind fishes occur, with rudimentary eyes and without special organs of touch.

Many fishes of the deep sea are provided with more or less numerous, round, shining, mother-of-pearl-coloured bodies, imbedded in the skin. These so-called phosphorescent or luminous organs are either larger bodies of an oval or irregularly elliptical shape placed on the head, in the vicinity of the eye, or smaller round globular bodies arranged symmetrically in series along the side of the body and tail, especially near the abdominal profile, less frequently along the back. The former kind of organs possess in the interior a lenticular body, like the lens of an eye, and are considered by some naturalists true organs of vision (accessory eyes), the function of the latter, which have a glandular structure, being left unexplained by them.

There is no doubt that the functions of these organs have some relation to the peculiar conditions of light under which the fishes provided with them live, these fishes being either deep-sea forms or nocturnal pelagic kinds. And it is highly probable that all produce and emit phosphorescent light, enabling the fishes to see in the darkness of the night or of the depths of the sea.

Whenever we find in a fish long delicate filaments developed in connexion with the fins or the extremity of the tail, we may conclude that it is an inhabitant of still water and of quiet habits. Many deep-sea fishes (*Trachypteridæ*, *Macruridæ*, *Ophidiidæ*, *Bathypterois*) are provided with such filamentous prolongations, the development of which is perfectly in accordance with their sojourn in the absolutely quiet waters of abyssal depths.

Some of the raptatorial deep-sea fishes have a stomach so distensible and capacious that it can receive a fish of twice or thrice the bulk of the destroyer (*Melanocetus*, *Chiasmodus*, *Saccopharynx*). Deglutition is performed in them, not by means of the muscles of the pharynx, as in other fishes, but by the independent and alternate action of the jaws, as in snakes. These fishes cannot be said to swallow their food; they rather draw themselves over their victim, after the fashion of an *Actinia*.

Before the voyage of H.M.S. "Challenger," scarcely thirty deep-sea fishes were known. This number is now much increased, six times as many new species and genera having been discovered. Modifications of certain organs, perfectly novel, and of the greatest interest, were found; but, singularly, no new types of families were discovered,—nothing but what might have been expected from our previous knowledge of this group of fishes.

The fish fauna of the deep sea is chiefly composed of forms or modifications of forms which we find represented at the surface in the cold and temperate zones, or which belong to the class of nocturnal pelagic fishes. The Chondropterygians are few in number, not descending to a greater depth than 600 fathoms. The Acanthopterygians, which form the majority of the coast and surface faunas, are also scantily represented; genera identical with surface types are confined to the same inconsiderable depth as the Chondropterygians, whilst those Acanthopterygians which are so much specialized for a life in the deep sea as to deserve generic separation range from 200 to 2400 fathoms. Three distinct families of Acanthopterygians belong to the deep-sea fauna, viz., *Trachypteridæ*, *Lophotidæ*, and *Notacanthidæ*; they consist of three, one, and two genera respectively.

Gadidæ, *Ophidiidæ*, and *Macruridæ* are very numerous, ranging through all depths; they constitute about one-fourth of the whole deep-sea fauna.

Of *Physostomi*, the families of *Sternoptychidæ*, *Scopelidæ*, *Stomiatidæ*, *Salmonidæ*, *Bathythrissidæ*, *Alepocephalidæ*, *Halosauridæ*, and *Murænidæ* are represented. Of these the Scopeloids are the most numerous, constituting nearly another fourth of the fauna. *Salmonidæ* are only represented by three small genera. *Bathythrissidæ* include one species only, which is probably confined in its vertical as well as its horizontal range; it occurs at a depth of about 350 fathoms in the sea of Japan. The *Alepocephalidæ* and *Halosauridæ*, known before the "Challenger" expedition from isolated examples only, prove to be true, widely-spread, deep-sea types. Eels are well represented, and seem to descend to the greatest depths. *Myxine* has been obtained from a depth of 345 fathoms.

The greatest depth hitherto reached by a dredge in which fishes were enclosed is 2900 fathoms. But the specimens thus obtained belong to a species (*Gonostoma microdon*) which seems to be extremely abundant in upper strata of the Atlantic and Pacific, and were therefore most likely caught by the dredge in its ascent. The next greatest depth, viz., 2750 fathoms, must be accepted as one at which fishes do undoubtedly live,—the fish obtained from this depth of the Atlantic, *Bathyophis ferox*, showing by its whole habit that it is a form living on the bottom of the ocean.

CLASSIFICATION.

The class of fishes is divided into four subclasses:—

I. *Palæichthyes.*—Heart with a contractile conus arteriosus; intestine with a spiral valve; optic nerves non-decussating, or only partially decussating.

II. *Teleostei.*—Heart with a non-contractile bulbus arteriosus; intestine without spiral valve; optic nerves decussating. Skeleton ossified, with completely separated vertebræ.

III. *Cyclostomata.*—Heart without bulbus arteriosus; intestine simple. Skeleton cartilaginous and notochordal. One nasal aperture only. No jaws; mouth surrounded by a circular lip.

IV. *Leptocardii.*—Heart replaced by pulsating sinuses; intestine simple. Skeleton membrano-cartilaginous and notochordal. No brain; no skull.

Subclass I.—Palæichthyes.

This subclass comprises the sharks and rays and the Ganoid fishes. Though it is based upon a singular concurrence of most important characters, its members exhibit as great a diversity of form, and as manifold modifications in the remainder of their organization, as the *Teleostei*. The *Palæichthyes* stand to the *Teleostei* in the same relation as the Marsupials to the *Placentalia*. Geologically, as a subclass, they were the predecessors of Teleosteous fishes; and it is a remarkable fact that all those modifications which show an approach of the ichthyic type to the Batrachians are found in this subclass. It is divided into two orders,—the *Chondropterygii* and the *Ganoidei*.

ORDER I.—*Chondropterygii.*

Skeleton cartilaginous. Body with medial and paired fins, the hinder pair abdominal. Vertebral column generally heterocercal, the upper lobe of the caudal fin produced. Gills attached to the skin by the outer margin, with several intervening gill-openings; rarely one external gill-opening only. No gill-cover. No air-bladder. Two, three, or more series of valves in the conus arteriosus. Ova large and few in number, impregnated and, in some species, developed within a uterine cavity. Embryo with deciduous external gills. Males with intromittent organs attached to the ventral fins.

This order, for which, also, the name *Elasmobranchii* has been proposed (by Bonaparte), comprises the sharks, rays, and chimæras. It is divided into two suborders,—*Plagiostomata* and *Holocephala*.

SUBORDER I. *Plagiostomata.*—From five to seven gill-openings. Skull with a suspensorium and the palatal apparatus detached. Teeth numerous.

The Plagiostomes differ greatly from each other with regard to the general form of the body. In the sharks, or *Selachoidei*, the body is elongate, more or less cylindrical, gradually passing into the tail; the gill-openings are lateral. In the rays, or *Batoidei*, the gill-openings are always placed on the abdominal aspect of the fish; the body is depressed, and the trunk, which is surrounded by the immensely developed pectoral fins, forms a broad flat disk, of which the tail appears as a thin and slender appendage. Spiracles are always present; the number of gill-openings is constantly five; there is no anal fin; the dorsal fins, if present, are situated on the tail. Some of the rays, however, approach the sharks in having the caudal portion less abruptly contracted behind the trunk.

Fossil Plagiostomes are very numerous in all formations. Some of the earliest determinable fish remains are, or are believed to be, derived from Plagiostomes. Those which can be referred to any of the families specified below will be mentioned in due course; but there are others, especially fin-spines, which leave us in doubt to which group of Plagiostomes their owners had affinity: as *Onchus*, from the Upper Silurian, continuing to Carboniferous formations; *Dimeracanthus*, *Homacanthus*, from the Devonian; *Oracanthus*, *Gyracanthus*, *Tristychius*, *Astroptychius*, *Ptychacanthus*, *Sphenacanthus*, &c., from Carboniferous formations; *Leptacanthus*, from the Coal to the Oolite; *Cladacanthus*, *Cricacanthus*, *Gyropristis*, and *Lepracanthus*, from the Coal-measures; *Nemacanthus*, *Liacanthus*, from the Trias; *Astracanthus*, *Myriacanthus*, *Pristacanthus* from the Jurassic group.

A. *Selachoidei*, Sharks.

Family 1. *Carchariidæ.*—Eye with a nictitating membrane. Mouth crescent-shaped, inferior. Anal fin present. Two dorsal fins, the first opposite to the space between the pectoral and ventral fins, without spine in front.

Genera: *Carcharias* (Blue Shark), *Galeocerdo*, *Galeus* (Tope), *Zygæna* (Hammerhead), *Mustelus* (Hound), *Hemigaleus*, *Loxodon*, *Thalassorhinus*, *Triænodon*, *Leptocarcharias*, and *Triacis*. Fossil: *Corax* and *Hemipristis*.

Family 2. *Lamnidæ.*—Eye without nictitating membrane. Anal fin present. Two dorsal fins, the first opposite to the space between the pectoral and ventral fins, without spine in front. Nostrils not confluent with the mouth, which is inferior. Spiracles absent or minute.

Genera: *Lamna* (Porbeagle), *Carcharodon*, *Odontaspis*, *Alopecias* (Fox-Shark), and *Selache* (Basking Shark). Fossil: *Carcharopsis*, *Oxytes*, *Sphenodus*, *Gomphodus*, and *Ancistrodon*.

Family 3. *Rhinodontidæ.*—No nictitating membrane. Anal fin present. Two dorsal fins, the first nearly opposite to the ventrals, without spine in front. Mouth and nostril near the extremity of the snout.

This small family comprises one species only, *Rhinodon typicus*, a gigantic shark, which is known to exceed 50 feet in length.

Family 4. *Notidanidæ.*—No nictitating membrane. One dorsal fin only, without spine, opposite to the anal. Dentition unequal in the jaws; in the upper jaw one or two pairs of awl-shaped teeth, the following six being broader, and provided with several cusps, one of which is much stronger than the others. Lower jaw with six large comb-like teeth on each side, besides the smaller posterior teeth. Gill-openings wide, six in number in *Hexanchus*, seven in *Heptanchus*. Fossil teeth belonging to this type have been found in Jurassic and later formations (*Notidanus* and *Ællopos*).

Family 5. *Scylliidæ.*—Two dorsal fins, without spine, the first above or behind the ventrals; anal fin present. No nictitating membrane. Spiracle always distinct. Mouth inferior. Teeth small, several series generally being in function.

Genera: *Scyllium* (Dog-Fishes), *Pristiurus*, *Parascyllium*, *Ginglymostoma*, *Stegostoma*, *Chiloscyllium*, *Crossorhinus*. Fossil: *Scylliodus*, *Palæoscyllium*, *Thyellina*.

Family 6. *Hybodontidæ.*—Two dorsal fins, each with a serrated spine. Teeth rounded, longitudinally striated, with one larger and from two to four smaller lateral cusps. Skin covered with shagreen.

Extinct. From Carboniferous, Liassic, and Triassic formations. Several genera have been distinguished; and, if *Cladodus* belongs to this family, it was represented even in the Devonian.

Family 7. *Cestraciontidæ.*—No nictitating membrane. Two dorsal fins, the first opposite to the space between the pectoral and ventral fins; anal fin present. Nasal and buccal cavities confluent. Teeth obtuse, several series being in function.

This family is one of particular interest, because representatives of it occur in numerous modifications in Primary and Secondary strata. Their dentition is uniformly adapted for the prehension and mastication of crustaceous and hard-shelled animals. The fossil forms far exceeded in size the species of the only surviving genus, *Cestracion* (the Port Jackson Shark); they make their appearance with *Ctenoptychius* in the Devonian; this is succeeded in the Coal-measures by *Psammodus*, *Chomatodus*, *Petrodus*, *Cochliodus*, *Polyrhizodus*, &c., and in the Trias and Chalk by *Strophodus*, *Acrodus*, *Thectodus*, and *Ptychodus*. Of the 25 genera known, 22 have lived in the periods preceding the Oolitic.

Family 8. *Spinacidæ.*—No membrana nictitans. Two dorsal fins; no anal. Mouth but slightly arched; a long, deep, straight, oblique groove on each side of the mouth. Spiracles present; gill-openings narrow. Pectoral fins not notched at their origin.

Genera: *Centrina*, *Acanthias* (Spiny Dog-Fish), *Centrophorus*, *Spinax*, *Centroscyllium*, *Scymnus*, *Læmargus* (Greenland Shark), *Echinorhinus*, *Euprotomicrus* and *Isistius*. The largest of these fishes is the Greenland shark, which attains to a length of 15 feet, and is common in the Arctic regions. Fossil genera: *Palæospinax* and *Drepanephorus*, from Cretaceous and Jurassic formations.

Family 9. *Rhinidæ.*—No anal fin; two dorsal fins. Spiracles present. Pectoral fins large, with the basal portion prolonged forwards, but not grown to the head. Gill-openings rather wide, lateral, partly covered by the base of the pectoral. Spiracles wide, behind the eyes. Teeth conical.

One genus only: the "Angel-Fish," or "Monk-Fish" (*Rhina squatina*), which approaches the rays as regards general form and habits. Extinct forms, closely allied to the "Angel-Fish," are found in the Oolite, and have been described as *Thaumas*. The Carboniferous genus *Orthacanthus* may have been allied to this family, but it was armed with a spine immediately behind the head.

Family 10. *Pristiophoridæ*.—The rostral cartilage is produced into an exceedingly long, flat lamina, armed along each edge with a series of teeth (saw).

These sharks so greatly resemble the common saw-fishes as to be easily confounded with them, but their gill-openings are lateral, and not inferior. Only one genus is known, *Pristiophorus*, which occurs in the Australian and Japanese seas. *Squaloraia*, from the Lias, is supposed to have its nearest affinities to this family.

B. *Batoidei*, Rays.

Family 1. *Pristidæ*.—The snout is produced into an exceedingly long flat lamina, armed with a series of strong teeth along each edge (saw).

One genus only: *Pristis* (Saw-Fishes).

Family 2. *Rhinobatidæ*.—Tail strong and long, with two well-developed dorsal fins, and a longitudinal fold on each side; caudal developed. Disk not excessively dilated, the rayed portion of the pectoral fins not being continued to the snout. Teeth obtuse, granular, the dental surfaces of the jaws being undulated.

Genera: *Rhynchobatus*, *Rhinobatus*, and *Trygonorhina*. Fossil: *Spathobatis* and *Trigorhina*.

Family 3. *Torpedinidæ* ((Electric Rays).—Trunk a broad, smooth disk. Tail with a longitudinal fold on each side; a rayed dorsal fin is generally, and a caudal always, present. Anterior nasal valves confluent into a quadrangular lobe. An electric organ composed of vertical hexagonal prisms between the pectoral fins and the head.

Genera: *Torpedo*, *Narcine*, *Hypnos*, *Discopyge* (from Peru), *Astrape*, and *Temera*. A large fish, with the general appearance of a torpedo, has been found at Monte Bolca; and *Cyclobatis*, from the Upper Cretaceous Limestone of Lebanon, is probably another extinct representative of this family.

Family 4. *Raiidæ*.—Disk broad, rhombic, generally with asperities or spines; tail with a longitudinal fold on each side. The pectoral fins extend to the snout. No electric organ; no serrated caudal spine.

Genera: *Raia* (Rays and Skates), *Psammobatis*, *Sympterygia*, *Platyrhina*. Fossil: *Arthropterus*.

Family 5. *Trygonidæ*.—The pectoral fins are uninterruptedly continued to, and are confluent at, the extremity of the snout. Tail long and slender, without lateral longitudinal folds; vertical fins none, or imperfectly developed, often replaced by a strong serrated spine.

Genera: *Urogymnus*, *Trygon* (Sting-Rays), *Urolophus*, *Pteroplatea*.

Family 6. *Myliobatidæ* ("Devil-Fishes," "Sea-Devils," or "Eagle-Rays").—The disk is very broad, in consequence of the great development of the pectoral fins, which, however, leave the sides of the head free, and reappear at the extremity of the snout as a pair of detached (cephalic) fins. Viviparous.

Genera: *Myliobatis*, *Aetobatis*, *Rhinoptera*, *Dicerobatis*, *Ceratoptera*. Fragmentary portions of their tessellated dentition are common in Tertiary formations.

SUBORDER II. *Holocephala*.—One external gill-opening only, covered by a fold of the skin, which encloses a rudimentary cartilaginous gill-cover; four branchial clefts within the gill-cavity. The maxillary and palatal apparatus coalescent with the skull.

This suborder is represented in the living fauna by one family only, *Chimæridæ*; it forms a connecting link with the following order of fishes, the Ganoids. In external appearance, and as regards the structure of their organs of propagation, the chimæras are sharks. The females are provided with "claspers" in connexion with the ventral fins, and the ova are large, encased in a horny capsule, and few in number; there is no doubt that they are impregnated within the oviduct, as in sharks. The males are provided with a singular erectile appendage, spiny at its extremity, and received in a groove on the top of the head. On the other hand, the relations of the chimæras to the Ganoid, and, more especially, to the Dipnoous type become manifest in their notochordal skeleton and continuity of cranial cartilage. The spine in front of the first dorsal fin is articulated to the neural apophysis, and not merely implanted in the soft parts; it is immovable as in sharks. A cartilaginous operculum makes its appearance, and the external gill-opening is single. The dentition is that of a Dipnoid, each "jaw" being armed with a pair of broad dental plates, with the addition of a pair of smaller cutting teeth in the upper "jaw." Fossils of similar dental combination are not rare in strata commencing with the Lias and the bottom of the Oolitic series; but it is impossible to decide in every case whether the fossil should be referred to the Holocephalous or the Dipnoous type. According to Newberry, Chimæroid fishes commence in the Devonian with *Rhynchodus*, the remains of which were discovered by him in Ohio. Undoubted Chimæroids are *Elasmodus*, *Psaliodus*, *Ganodus*, *Ischyodus*, *Edaphodon*, and *Elasmognathus*, principally from Mesozoic and Tertiary formations. Very similar fossils occur in the corresponding strata of North America. A single species of *Callorhynchus* has been discovered by Hector in the Lower Greensand of New Zealand.

The living chimæras are few in number, and remain within very moderate dimensions, probably not exceeding a length of 5 feet, inclusive of their long filamentous, diphycercal tail. They are referred to two genera, *Chimæra* and *Callorhynchus*.

ORDER II.—*Ganoidei*.

Skeleton cartilaginous or ossified. Body with medial and paired fins, the hinder pair abdominal. Gills free, rarely partially attached to the walls of the gill-cavity. One external gill-opening only on each side; a gill-cover. Air-bladder with a pneumatic duct. Ova small, impregnated after exclusion. Embryo sometimes with external gills.

To this order belong the majority of the fossil fish remains of Palæozoic and Mesozoic age, whilst it is very scantily represented in the recent fauna, and evidently verging towards total extinction. The knowledge of the fossil forms, based on mere fragments of the hard parts of the body only, is very incomplete, and therefore their classification is in a most unsatisfactory state. In the following list only the most important groups will be mentioned.[1]

Eight suborders may be distinguished at present.

SUBORDER I. *Placodermi*.—Extinct. The head and pectoral region of the body encased in great bony sculptured plates, with dots of enamel; the remainder of the body naked, or with ganoid scales; skeleton notochordal.

Comprises the oldest vertebrate remains, from Devonian and Carboniferous formations.

Genera: *Pterichthys*, *Coccosteus*, *Dinichthys*, *Cephalaspis*, *Auchenaspis*, *Didymaspis*, *Pteraspis*, *Scaphaspis*, *Cyathaspis*, *Astrolepis*.

SUBORDER II. *Acanthodini*.—Extinct. Body oblong, compressed, covered with shagreen; skull not ossified; caudal fin heterocercal. Large spines, similar to those of Chondropterygians, in front of some of the median and paired fins. The spines are imbedded between the muscles, and not provided with a proximal joint.

Genera: *Acanthodes*, *Chiracanthus*, from Devonian and Carboniferous formations.

SUBORDER III. *Dipnoi*.—Nostrils two pairs, more or less within the mouth; limbs with an axial skeleton. Lungs and gills. Skeleton notochordal. No branchiostegals.

Family 1. *Sirenidæ*.—Caudal fin diphycercal; no gular plates; scales cycloid. A pair of molars, above and below, and one pair of vomerine teeth.

Genera: *Lepidosiren* and *Ceratodus*.

Lepidosiren (including *Protopterus*) has the body eel-shaped, with one continuous vertical fin. The limbs are reduced to filaments. Vomerine teeth conical, pointed. Each dental lamina or molar with strong cusps, supported by vertical ridges. Conus arteriosus with two longitudinal valves. Ovaries closed sacs. Two species are known:—*L. paradoxa*, from the system of the river Amazon, and *L.* (*Protopterus*) *annectens*, which abounds in many localities of the west coast of Africa, is spread over the whole of tropical Africa, and in many districts of the central parts forms a regular article of food.

Ceratodus has the body elongate, compressed, with one continuous vertical fin. The limbs are paddle-shaped, with broad, rayed fringe. Vomerine teeth incisor-like; molars with flat, undulated surface, and lateral prongs. Conus arteriosus with transverse series of valves. Ovaries transversely lamellated.

Two species, *C. forsteri* and *C. miolepis*, are known from fresh waters of Queensland. The specimens obtained hitherto have come from the Burnett, Dawson, and Mary rivers, some from the fresh waters of the upper parts, others from the lower brackish portions. The fish is said to grow to a weight of 20 lb and to a length of 6 feet. Locally, the settlers call it "Flat-head," "Burnett-Salmon," or "Dawson-Salmon," and the aborigines "Barramunda," a name which they appear to apply also to other large-scaled freshwater fishes, as the *Osteoglossum leichardti*. In the stomach there is generally found an enormous quantity of the leaves of plants growing on the banks of rivers, evidently eaten after they had fallen into the water and when in a decomposing condition. The flesh of the fish is salmon-coloured, and is much esteemed as food. The barramunda is said to be in the habit of going on land, or at least on mud-flats; and this assertion appears to be borne out by the fact

[1] For a study of details we have to refer to Agassiz, *Poissons Fossiles*; Owen, *Palæontology*, Edin., 1861, 8vo; Huxley, "Preliminary Essay upon the Systematic Arrangement of the Fishes of the Devonian Epoch," in *Mem. Geolog. Survey*, December 10, 1861, and "Illustrations of the Structure of Crossopterygian Ganoids," *ibid.*, December 12, 1866; Traquair, *The Ganoids of the British Carboniferous Formations*, part i., "Palæoniscidæ," Palæontogr. Soc. Lond., 1877; and "On the Structure and Affinities of the Platysomidæ," in *Trans. Roy. Soc. Edin.* vol. xxix.

that it is provided with a lung. It is much more probable, however, that it rises now and then to the surface of the water in order to fill its lung with air, and descends again until the air is so much deoxygenized as to render a renewal of it necessary. As the barramunda has perfectly developed gills, as well as the lung, we can hardly doubt that, when it is in water of normal composition, and pure enough to yield the necessary supply of oxygen, these organs are sufficient for the purpose of breathing, and that the respiratory function rests with them alone. But when the fish is compelled to sojourn in thick muddy water charged with gases which are the products of decomposing organic matter (and this must very frequently be the case during the droughts which annually exhaust the creeks of tropical Australia), it commences to breathe air with its lung in the way indicated above. If the medium in which it happens to be is altogether unfit for breathing, the gills cease to have any function; if it is irrespirable in a less degree the gills may still continue to assist the lung. The barramunda, in fact, can breathe by either gills or lung alone, or by both simultaneously.

The discovery of *Ceratodus* does not date farther back than the year 1870. It proved to be of the greatest interest, not only on account of the relation of this creature to the other living *Dipnoi* and *Ganoidei*, but also because it threw fresh light on those singular fossil teeth which are found in strata of the Triassic and Jurassic formations in various parts of Europe, India, and America. These teeth vary greatly in general shape and size; they are sometimes 2 inches long, much longer than broad, depressed, with a flat or slightly undulated always punctuated crown, with one margin convex, and with from three to seven prongs projecting on the opposite margin.

Family 2. *Ctenododipteridæ.*—Caudal fin heterocercal; gular plates; scales cycloid. Two pairs of molars and one pair of vomerine teeth.

Extinct. *Dipterus* (*Ctenodus*), *Heliodus*, from Devonian strata.

Family 3. *Phaneropleuridæ.*—Caudal fin diphycercal; vertical fin continuous; gular plates; scales cycloid. Jaws with a series of minute conical teeth on the margin.

Extinct. *Phaneropleuron*, from Devonian and Carboniferous formations.

SUBORDER IV. *Chondrostei.*—Skeleton notochordal; skull cartilaginous, with dermal ossifications; branchiostegals few in number or absent. Teeth minute or absent. Integuments naked or with bucklers. Caudal fin heterocercal, with fulcra. Nostrils double, in front of the eyes.

Family 1. *Acipenseridæ.*—Body elongate, sub-cylindrical, with five rows of osseous bucklers. Snout produced, subspatulate or conical, with the mouth at its lower surface, small, transverse, protractile, toothless. Four barbels in a transverse series on the lower side of the snout. Vertical fins with a single series of fulcra in front. Dorsal and anal fins approximate to the caudal. Branchiostegals none. Air-bladder large, simple, communicating with the dorsal wall of the œsophagus.

Genera: *Acipenser* and *Scaphirhynchus* (Sturgeons, Hausen, Sterlet).

Family 2. *Polyodontidæ.*—Body naked, or with minute stellate ossifications. Mouth lateral, very wide, with minute teeth in both jaws. Barbels none. Caudal fin with fulcra. Dorsal and anal fins approximate to the caudal.

Genera: *Polyodon* and *Psephurus*. Fossil: *Chondrosteus*.

SUBORDER V. *Polypteroidei.*—Paired fins with axial skeleton, fringed; dorsal fins two or more. Branchiostegals absent, but generally gular plates. Vertebral column diphycercal or heterocercal. Body scaly.

Family 1. *Polypteridæ.*—Scales ganoid; fins without fulcra. A series of dorsal spines, to each of which an articulated finlet is attached; anal placed close to the caudal fin, the vent being near the end of the tail. Abdominal portion of the vertebral column much longer than the caudal.

Genera: *Polypterus* and *Calamoichthys*. *Polypterus* is confined to tropical Africa, occurring in abundance in the rivers of the west coast and in the upper Nile; it is rare in the middle and lower Nile. There is only one species known, *Polypterus bichir* ("Bichir" being its vernacular name in Egypt), which varies in the number of the dorsal finlets, the lowest being eight, the highest eighteen. It attains to a length of 4 feet. Nothing is known of its mode of life, observations on which are very desirable. *Calamoichthys* (from Old Calabar) is distinguished from *Polypterus* by its greatly elongated form and the absence of ventral fins.

Family 2. *Saurodipteridæ.*—Scales ganoid, smooth like the surface of the skull. Two dorsal fins; paired fins obtusely lobate. Teeth conical. Caudal fin heterocercal.

Extinct. *Diplopterus*, *Megalichthys*, and *Osteolepis*, from Devonian and Carboniferous formations.

Family 3. *Cœlacanthidæ.*—Scales cycloid. Two dorsal fins, each supported by a single two-pronged interspinous bone; paired fins obtusely lobate. Air-bladder ossified; notochord persistent, diphycercal.

Extinct. *Cœlacanthus*, from Carboniferous strata. Several other genera, from the Coal formations to the Chalk, have been associated with it:—*Undina*, *Graphiurus*, *Macropoma*, *Holophagus*, *Hoplopygus*, *Rhizodus*.

Family 4. *Holoptychidæ.*—Scales cycloid or ganoid, sculptured. Two dorsal fins; pectorals narrow, acutely lobate; dentition dendrodont.

Extinct. Genera: *Holoptychius*, *Saurichthys*, *Glyptolepis*, *Dendrodus*, *Glyptolæmus*, *Glyptopomus*, *Tristichopterus*, *Gyroptychius*, *Strepsodus*, from Devonian and Carboniferous strata.

SUBORDER VI. *Pycnodontoidei.*—Body compressed, high and short or oval, covered with rhombic scales arranged in decussating pleurolepidal lines. Notochord persistent. Paired fins without axial skeleton. Teeth on the palate and hinder part of the lower jaw molar-like. Branchiostegals, but no gular plates. Extinct.

Family 1. *Pleurolepidæ.*—Homocercal. Body less high. Fins with fulcra.

Genera: *Pleurolepis* and *Homœolepis*, from the Lias.

Family 2. *Pycnodontidæ.*—Homocercal. The neural arches and ribs are ossified; the roots of the ribs are but little expanded in the older genera, but are enlarged in the Tertiary forms, so as to simulate vertebræ. Paired fins not lobate. Obtuse teeth on the palate and the sides of the mandible; maxilla toothless; incisor-like teeth in the intermaxillary and front of the mandible. Fulcra absent in all the fins.

Genera: *Gyrodus*, *Mesturus*, *Microdon*, *Cœlodus*, *Pycnodus*, *Mesodon*, from Mesozoic and Tertiary formations.

SUBORDER VII. *Lepidosteoidei.*—Scales ganoid, rhombic; fins generally with fulcra; paired fins not lobate. Præoperculum and interoperculum developed; generally numerous branchiostegals, but no gular plate.

Family 1. *Lepidosteidæ.*—Scales ganoid, lozenge-shaped. Skeleton completely ossified; vertebræ convex in front and concave behind. Fins with fulcra; dorsal and anal composed of articulated rays only, placed far backwards, close to the caudal. Abdominal part of the vertebral column much longer than caudal. Branchiostegals not numerous, without enamelled surface. Heterocercal.

Lepidosteus.—This genus existed as early as Tertiary times; their remains have been found in Europe as well as in North America. In our period they are limited to the temperate parts of North America, Central America, and Cuba. Three species can be distinguished, which attain to a length of about 6 feet. They feed on other fishes; and their general resemblance to a pike has gained for them the vernacular names of "Gar-Pike" or "Bony Pike."

Family 2. *Sauridæ.*—Body oblong, with ganoid scales; vertebræ not completely ossified; termination of the vertebral column homocercal; fins generally with fulcra. Maxillary composed of a single piece; jaws with a single series of conical pointed teeth. Branchiostegals numerous, enamelled, the anterior forming broad gular plates.

Extinct. Genera: *Semionotus*, *Eugnathus*, *Cephenoplosus*, *Macrosemius*, *Propterus*, *Ophiopsis*, *Pholidophorus*, *Pleuropholis*, *Pachycormus*, *Ptycholepis*, *Conodus*, *Eulepidotus*, *Lophiostomus*, &c.

Family 3. *Stylodontidæ.*—Body rhombic or ovate, with ganoid scales; vertebræ not completely ossified; termination of the vertebral column homocercal; fins with fulcra. Maxillary composed of a single piece; jaws with several series of teeth, the outer ones equal, styliform. Dorsal fin very long, extending to the caudal. Branchiostegals numerous.

Extinct. *Tetragonolepis*, from the Lias.

Family 4. *Sphærodontidæ.*—Body oblong, with rhombic ganoid scales; vertebræ ossified, but not completely closed; homocercal; fins with fulcra. Maxillary composed of a single piece; teeth in several series, obtuse; those on the palate globular. Dorsal and anal fins short. Branchiostegals.

Extinct. The type genus of this family is *Lepidotus*.

Family 5. *Aspidorhynchidæ.*—Body elongate, with ganoid scales; jaws prolonged into a beak; termination of the vertebral column homocercal. Fins with fulcra; a series of enlarged scales along the side of the body. Dorsal fin opposite to the anal.

Extinct: Mesozoic. Genera: *Aspidorhynchus* and *Belonostomus*.

Family 6. *Palæoniscidæ.*—Body fusiform, with rhombic ganoid scales. Notochord persistent, with the vertebral arches ossified. Heterocercal. All the fins with fulcra; dorsal short. Branchiostegals numerous, the foremost pair forming broad gulars. Teeth small, conical, or cylindrical.

Extinct. Genera: from the Old Red Sandstone—*Chirolepis* and *Acrolepis*; from Carboniferous rocks—*Cosmoptychius*, *Elonichthys*, *Nematoptychius*, *Cycloptychius*, *Microconodus*, *Gonatodus*, *Rhadinichthys*, *Myriolepis*, *Urosthenes*; from the Permian—*Rhabdolepis*, *Palæoniscus*, *Amblypterus*, and *Pygopterus*; from the Lias—*Centrolepis*, *Oxygnathus*, *Cosmolepis*, and *Thrissonotus*.

Family 7. *Platysomidæ.*—Body generally high, compressed, covered with rhombic ganoid scales arranged in dorso-ventral bands. Notochord persistent, with the vertebral arches ossified. Heterocercal; fins with fulcra; dorsal fin long, occupying the posterior half of the back. Branchiostegals numerous. Teeth tubercular or obtuse.

Extinct. Genera: from Carboniferous and Permian formations—*Eurynotus*, *Benedenius*, *Mesolepis*, *Eurysomus*, *Wardichthys*, *Chirodus* (M'Coy), *Platysomus*.

SUBORDER VIII. *Amioidei.*—Vertebral column more or less completely ossified, heterocercal. Body covered with cycloid scales. Branchiostegals present.

Family 1. *Caturidæ.*—Notochord persistent, with partially ossified vertebræ; homocercal; fins with fulcra. Teeth in a single series, small, pointed.

Extinct. *Caturus*, from the Oolite to the Chalk.

Family 2. *Leptolepidæ.*—Scales cycloid. Vertebræ ossified; homocercal; fins without fulcra; dorsal short. Teeth minute, in bands, with canines in front.

Extinct, but leading to the living representative of this suborder. Genera: *Thrissops*, *Leptolepis*, from the Lias and Oolite. These fishes, so far as the preserved parts are concerned, cannot be distinguished from Teleosteous fishes, to which they are referred by some palæontologists.

Family 3. *Amiidæ.*—Skeleton entirely ossified; a single large gular plate; homocercal; fins without fulcra; a long soft dorsal fin. Abdominal and caudal parts of the vertebral column subequal in extent. Branchiostegals numerous.

Amia.—The "Bow-Fin" or "Mud-Fish" (*A. calva*) is not uncommon in many of the fresh waters of the United States; it grows to a length of 2 feet. Little is known about its habits; small fishes, crustaceans, and aquatic insects have been found in its stomach. Wilder has observed its respiratory actions; it rises to the surface, and, without emitting any air-bubble whatever, opens the jaws widely, and apparently gulps in a large quantity of air; these acts of respiration are more frequently performed when the water is foul or has not been changed; and there is no doubt that a conversion of oxygen into carbonic acid is effected, as in the lungs of aerial vertebrates.

Fossil remains occur in Tertiary deposits of North America, which have been distinguished as *Protamia* and *Hypamia*.

Subclass II.—Teleostei.

Heart with a non-contractile bulbus arteriosus; intestine without spiral valve; optic nerves decussating; skeleton ossified, with completely formed vertebræ; vertebral column diphycercal or homocercal; branchiæ free.

The *Teleostei* form the majority of the fishes of the present fauna, and are the geological successors of the *Palæichthyes*, undoubted *Teleostei* not ranging farther back than the Chalk period. This subclass comprises an infinite variety of forms; and as, naturally, many Ganoid fishes lived under external conditions similar to those of certain *Teleostei*, and led a similar mode of life, we find not a few analogous forms in both series,—some Ganoids resembling externally the Teleosteous Siluroids, others the Clupeoids, others the Chætodonts, others the Scombresoces, &c. But there is no direct genetic relation between these fishes, as some naturalists have been inclined to believe.

The *Teleostei* are divided into six orders:—

I. *Acanthopterygii.*—Part of the rays of the dorsal, anal, and ventral fins non-articulated spines. The lower pharyngeals separate. Air-bladder, if present, without pneumatic duct in the adult.

II. *Acanthopterygii Pharyngognathi.*—Part of the rays of the dorsal, anal, and ventral fins non-articulated spines. The lower pharyngeals coalesced Air-bladder without pneumatic duct.

III. *Anacanthini.*—Vertical and ventral fins without spinous rays. Ventral fins, if present, jugular or thoracic. Air-bladder, if present, without pneumatic duct. Lower pharyngeals separate.

IV. *Physostomi.*—All the fin-rays articulated; only the first of the dorsal and pectoral fins is sometimes ossified. Ventral fins, if present, abdominal, without spine. Air-bladder, if present, with a pneumatic duct.

V. *Lophobranchii.*—Gills not laminated, but composed of small rounded lobes, attached to the branchial arches. Gill-cover reduced to a large simple plate. A dermal skeleton replaces more or less soft integuments.

VI. *Plectognathi.*—A soft dorsal fin opposite to the anal; sometimes elements of a spinous dorsal. Ventral fins none, or reduced to spines. Gills pectinate; air-bladder without pneumatic duct. Skin with rough scutes, or with spines, or naked.

ORDER I.—*Acanthopterygii.*

Part of the rays of the dorsal, anal, and ventral fins are non-articulated, more or less sharp-pointed spines. The lower pharyngeals are generally separate. Air-bladder, if present, without pneumatic duct in the adult.

DIVISION I. *Acanthopterygii Perciformes.*—Body more or less compressed, elevated or oblong, but not elongate; the vent is remote from the extremity of the tail, behind the ventral fins if they are present. No prominent anal papilla. No superbranchial organ. Dorsal fin or fins occupying the greater portion of the back; spinous dorsal well developed, generally with stiff spines, of moderate extent, rather longer than, or as long as, the soft; the soft anal similar to the soft dorsal, of moderate extent or rather short. Ventrals thoracic, with one spine and with four or five rays.

Family 1. *Percidæ.*—The scales extend but rarely over the vertical fins, and the lateral line is generally present, continuous from the head to the caudal fin. All the teeth simple and conical; no barbels. No bony stay for the præoperculum.

A large family, represented by numerous genera and species in fresh waters, and on all the coasts of the temperate and tropical regions. Carnivorous.

Fossil Percoids abound in some formations, for instance, at Monte Bolca, where species of *Labrax*, *Lates*, *Smerdis* and *Cyclopoma* (both extinct), *Dules*, *Serranus*, *Apogon*, *Therapon*, and *Pristipoma* have been recognized. *Paraperca* is a genus recently discovered in the Marls of Aix-en-Provence. A species of *Perca* is known from the freshwater deposits of Oeningen.

The living genera are—*Perca* (Perch), *Siniperca*, *Percichthys*, *Labrax* (Bass), *Lates*, *Psammoperca*, *Percalabrax*, *Acerina* (Pope), *Lucioperca*, *Pileoma*, *Boleosoma*, *Aspro*, *Centropomus*, *Enoplosus*, *Centropristis*, *Anthias*, *Callanthias*, *Serranus* (Sea-Perch), *Anyperodon*, *Prionodes*, *Plectropoma*, *Trachypoma*, *Polyprion*, *Grammistes*, *Rhypticus*, *Aulacocephalus*, *Myriodon*, *Diploprion*, *Mesoprion*, *Glaucosoma*, *Dules*, *Therapon*, *Helotes*, *Pristipoma*, *Conodon*, *Hæmulon*, *Hapalogenys*, *Diagramma*, *Hyperoglyphe*, *Lobotes*, *Histiopterus*, *Gerres*, *Scolopsis*, *Heterognathodon*, *Dentex*, *Symphorus*, *Synagris*, *Mæna*, *Smaris*, *Cæsio*, *Erythrichthys*, *Oligorus* (Murray-Cod), *Grystes*, *Arripis*, *Huro*, *Ambassis*, *Apogon*, *Chilodipterus*, *Lanioperca*, *Acropoma*, *Scombrops*, *Pomatomus*, *Priacanthus*, *Centrarchus*, *Bryttus*, *Pomotis*, *Etelis*, *Niphon*, *Aprion*, *Apsilus*, *Pentaceros*, *Velifer*, *Datnioides*, *Percilia*.

Family 2. *Squamipinnes.*—Body compressed and elevated, covered with scales, either finely ctenoid or smooth. Lateral line continuous, not continued over the caudal fin. Mouth in front of the snout, generally small, with lateral cleft. Teeth villiform or setiform, in bands, without canines or incisors. Dorsal fin consisting of a spinous and soft portion of nearly equal development; anal with three or four spines, similarly developed as the soft dorsal, both being many-rayed. The vertical fins more or less densely covered with small scales. The lower rays of the pectoral fin branched, not enlarged; ventrals thoracic, with one spine and five soft rays.

Genera: *Chætodon*, *Chelmo*, *Heniochus*, *Holacanthus*, *Pomacanthus*, *Scatophagus*, *Ephippus*, *Drepane*, *Hypsinotus*, *Scorpis*, *Atypichthys*, *Toxotes*. Some of these genera occur also in Tertiary formations. The majority of these fishes are inhabitants of the tropical seas, and abound chiefly in the neighbourhood of coral-reefs (Coral-Fishes). The beauty and singularity of distribution of the colours in some of the genera, as *Chætodon*, *Heniochus*, *Holacanthus*, is scarcely surpassed in any other group of fishes. They are of small size, and are carnivorous, feeding on small invertebrates.

Family 3. *Mullidæ.*—Body rather low and slightly compressed, covered with large thin scales, with or without an extremely fine serrature. Two long erectile barbels are suspended from the hyoid, and are received between the rami of the lower jaw and the opercula. Mouth in front of the snout, with the cleft lateral and rather short; teeth very feeble. Eye lateral, of moderate size. Two short dorsal fins remote from each other, the first with feeble spines; anal similar to the second dorsal. Ventrals with one spine and five rays. Pectorals short.

Genera: *Mullus* and *Upeneus* (Red Mullets).

Family 4. *Sparidæ* (Sea-Breams).—Body compressed, oblong, covered with scales, the serrature of which is very minute, and sometimes altogether absent. Mouth in front of the snout, with cleft lateral. Either cutting teeth in front of the jaws, or molar teeth on the side; palate generally toothless. One dorsal fin, formed by a spinous and soft portion of nearly equal development. Anal fin with three spines. The lower rays of the pectoral fin are generally branched, but in one genus simple. Ventrals thoracic, with one spine and five rays.

Genera: *Cantharus*, *Box*, *Scatharus*, *Oblata*, *Crenidens*, *Tri-*

pterodon, *Pachymetopon*, *Dipterodon*, *Gymnocrotaphus*, *Girella*, *Tephræops*, *Doydixodon*, *Haplodactylus*, *Sargus* (Sheep's Head), *Lethrinus*, *Sphærodon*, *Pagrus*, *Pagellus*, *Chrysophrys*, and *Pimelepterus*.

The extinct forms found hitherto are rather numerous; the oldest come from the Cretaceous formation of Mount Lebanon; some belong to living genera, as *Sargus*, *Pagellus*; of others from Eocene and Miocene formations no living representative is known—*Sparnodus*, *Sargodon*, *Capitodus*, *Soricidens*, *Asima*.

The *Hoplognathidæ* are a very small family distinguished by confluent teeth, and allied to the sea-breams.

Family 5. *Cirrhitidæ*.—Body oblong, compressed, covered with cycloid scales; lateral line continuous. Mouth in front of the snout, with lateral cleft. Cheeks without a bony stay for the præoperculum. Dentition more or less complete, composed of small pointed teeth, sometimes with the addition of canines. One dorsal fin formed by a spinous and soft portion, of nearly equal development. Anal with three spines, generally less developed than the soft dorsal. The lower rays of the pectoral fins simple and generally enlarged; ventrals thoracic, but remote from the root of the pectorals, with one spine and five rays.

Genera: *Cirrhites*, *Chironemus*, *Chilodactylus*, *Mendosoma*, *Nemadactylus*, and *Latris*.

Family 6. *Scorpænidæ*.—Body oblong, more or less compressed, covered with ordinary scales or naked. Cleft of the mouth lateral or subvertical. Dentition feeble, consisting of villiform teeth, and generally without canines. Some bones of the head armed, especially the angle of the præoperculum, its armature receiving additional support by a bony stay, connecting it with the infraorbital ring. The spinous portion of the dorsal fin equally or more developed than the soft and the anal. Ventrals thoracic, generally with one spine and five soft rays, sometimes rudimentary.

Genera: *Sebastes*, *Scorpæna*, *Glyptauchen*, *Lioscorpius*, *Setarches*, *Pterois*, *Apistus*, *Agriopus*, *Synanceia*, *Micropus*, *Chorismodactylus*, *Tænianotus*, *Centropogon*, *Pentaroge*, *Tetraroge*, *Prosopodasys*, *Aploactis*, *Trichopleura*, *Hemitripterus*, *Minous*, and *Pelor*.

Family 7. *Nandidæ*.—Body oblong, compressed, covered with scales. Lateral line interrupted. Dorsal fin formed by a spinous and soft portion, the number of spines and rays being nearly equal; anal fin with three spines, and with the soft portion similar to the soft dorsal. Ventral fins thoracic, with one spine, and five or four rays. Dentition more or less complete, but feeble.

Genera: *Plesiops*, *Trachinops*, *Badis*, *Nandus*, and *Catopra*.

Family 8. *Polycentridæ*.—Body compressed, deep, scaly. Lateral line none. Dorsal and anal fins long, both with numerous spines, the spinous portion being the more developed. Ventrals thoracic, with one spine and five soft rays. Teeth feeble. Pseudobranchiæ hidden.

Genera: *Polycentrus* and *Monocirrhus*.

Family 9. *Teuthididæ*.—Body oblong, strongly compressed, covered with very small scales. Lateral line continuous. A single series of cutting incisors in each jaw; palate toothless. One dorsal fin, the spinous portion being the more developed; anal with seven spines. Ventral fins thoracic, with an outer and an inner spine, and with three soft rays between.

Genus: *Teuthis*.

DIVISION II. *Acanthopterygii Beryciformes*.—Body compressed, oblong, or elevated; head with large muciferous cavities, which are covered with a thin skin. Ventral fins thoracic, with one spine and more than five soft rays (in *Monocentris* with two only).

The family of *Berycidæ* has a very remarkable geographical distribution, which has been noticed at pp. 679, 681. Members of this family belong to the oldest Teleosteous fishes, the majority of the Acanthopterygians found in the Chalk being Berycoids. *Beryx*, *Holocentrum*, and *Myripristis* have been found in several species, with other genera now extinct:—*Pseudoberyx*, *Berycopsis*, *Homonotus*, *Stenostoma*, *Sphenocephalus*, *Acanus*, *Hoplopteryx*, *Platycormus*, *Podocys*, *Acrogaster*, *Macrolepis*, and *Rhacolepis*.

Living genera: *Monocentris*, *Hoplostethus*, *Trachichthys*, *Anoplogaster*, *Beryx*, *Melamphaes*, *Polymixia*, *Myripristis*, and *Holocentrum*.

DIVISION III. *Acanthopterygii Kurtiformes*.—One dorsal fin only, much shorter than the anal, which is long and many-rayed. No superbranchial organ.

One family, *Kurtidæ*.

Genera: *Pempheris* and *Kurtus*.

DIVISION IV. *Acanthopterygii Polynemiformes*.—Two rather short dorsal fins, somewhat remote from each other; free filaments at the humeral arch, below the pectoral fins; muciferous canals of the head well developed.

Family. *Polynemidæ*.—Body oblong, rather compressed, covered with smooth or very feebly ciliated scales. Lateral line continuous. Snout projecting beyond the mouth, which is inferior, with lateral cleft. Eye lateral, large. Villiform teeth in the jaws and on the palate. Ventrals thoracic, with one spine and five rays.

Genera: *Polynemus*, *Pentanemus*, and *Galeoides*.

DIVISION V. *Acanthopterygii Sciæniformes*.—The soft dorsal is more, generally much more, developed than the spinous and the anal. No pectoral filaments; head with the muciferous canals well developed.

Family. *Sciænidæ*.—Body rather elongate, compressed, covered with ctenoid scales. Lateral line continuous, and frequently extending over the caudal fin. Mouth in front of the snout. Eye lateral, of moderate size. Teeth in villiform bands, sometimes with the addition of canines; no molars or incisor-like teeth in the jaws; palate toothless. Præoperculum unarmed, and without bony stay. Ventrals thoracic, with one spine and five soft rays. Bones of the head with wide muciferous channels. Air-bladder frequently with numerous appendages.

Genera: *Larimus*, *Pogonias* (Drum), *Micropogon*, *Umbrina*, *Eques*, *Nebris*, *Lonchurus*, *Sciæna* (Meagre), *Pachyurus*, *Otolithus*, *Ancylodon*, and *Collichthys*.

DIVISION VI. *Acanthopterygii Xiphiiformes*.—The upper jaw is produced into a cuneiform weapon.

One family, *Xiphiidæ* (Sword-Fishes), with the genera *Xiphias* and *Histiophorus*.

DIVISION VII. *Acanthopterygii Trichiuriformes*.—Body elongate, compressed or band-like; cleft of the mouth wide, with several strong teeth in the jaws or on the palate. The spinous and soft portions of the dorsal fin and the anal are of nearly equal extent, long, many-rayed, sometimes terminating in finlets; caudal fin forked, if present.

The family of *Trichiuridæ* is composed of the following living genera: *Nealotus*, *Nesiarchus*, *Aphanopus Euoxymetopon*, *Lepidopus* (Scabbard-Fish), *Trichiurus* (Hair-Tail), *Epinnula*, *Thyrsites*, and *Gempylus*. It was well represented in the Chalk and later formations by *Enchodus*, *Anenchelum*, *Nemopteryx*, *Xiphopterus*, *Hemithyrsites*, and *Trichiurichthys*. Two other genera, *Palæorhynchus* and *Hemirhynchus*, belong to a distinct though allied family.

DIVISION VIII. *Acanthopterygii Cotto-scombriformes*.—Spines developed in one of the fins at least. Dorsal fins either continuous or close together; the spinous dorsal, if present, always short; sometimes modified into tentacles, or into a suctorial disk; soft dorsal always long, if the spinous is absent; anal similarly developed as the soft dorsal, and both generally much longer than the spinous, sometimes terminating in finlets. Ventrals, thoracic or jugular, if present, never modified into an adhesive apparatus. No prominent anal papilla.

Family 1. *Acronuridæ*.—Body compressed, oblong or elevated, covered with minute scales. Tail generally armed with one or more bony plates or spines, which are developed with age, but absent in very young individuals. Eye lateral, of moderate size. Mouth small; a single series of more or less compressed, sometimes denticulated, sometimes pointed incisors in each jaw; palate toothless. One dorsal fin, the spinous portion being less developed than the soft; anal with two or three spines; ventral fins thoracic. Nine abdominal and thirteen caudal vertebræ.

Genera: *Acanthurus* (Surgeon), *Naseus*, and *Prionurus*.

Extinct species of *Acanthurus* and *Naseus* have been discovered in the Monte Bolca formation.

Family 2. *Carangidæ*.—Body more or less compressed, oblong or elevated, covered with small scales or naked; eye lateral. Teeth, if present, conical. No bony stay for the præoperculum. The spinous dorsal is less developed than the soft or the anal, either continuous with, or separated from, the soft portion; sometimes rudimentary. Ventrals thoracic, sometimes rudimentary or entirely absent. No prominent papilla near the vent. Gill-opening wide. Ten abdominal and fourteen caudal vertebræ.

Genera: *Caranx* (Horse-Mackerel), *Argyriosus*, *Micropteryx*, *Seriola*, *Seriolella*, *Seriolichthys* (Yellow-Tails), *Naucrates* (Pilot-Fish), *Chorinemus*, *Lichia*, *Temnodon* (Blue-Fish), *Lactarius*, *Paropsis*, *Trachynotus*, *Pammelas*, *Psettus*, *Platax*, *Zanclus*, *Anomalops*, *Capros* (Boar-Fish), *Antigonia*, *Diretmus*, *Equula*, and *Gazza*.—Members of this family appear first in Cretaceous formations, where they are represented by *Platax* and some caranx-like genera (*Vomer* and *Aipichthys*). They are more numerous in Tertiary formations, especially in the strata of Monte Bolca, where some still existing genera occur, as *Zanclus*, *Platax*, *Caranx* (*Carangopsis*), *Argyriosus* (*Vomer*), *Lichia*, *Trachynotus*. Of extinct genera the following belong to this family:—*Pseudovomer* (Licata), *Amphistium*, *Archæus*, *Ductor*, *Pionemus* (?), and *Semiophorus*.

Family 3. *Cyttidæ*.—Body elevated, compressed, covered with small scales, or with bucklers, or naked; eye lateral. Teeth conical, small. No bony stay for the præoperculum. Dorsal fin composed of two distinct portions. Ventrals thoracic. No prominent papilla near the vent. Gill-opening wide. More than ten abdominal and more than fourteen caudal vertebræ.

Genera: *Zeus* (John Dory) and *Cyttus*.

Family 4. *Stromateidæ*.—Body more or less oblong and compressed, covered with very small scales; eye lateral. Dentition very feeble; œsophagus armed with numerous horny, barbed processes. No bony stay for the præoperculum. Dorsal fin single, long, without distinct spinous division. More than ten abdominal and more than fourteen caudal vertebræ.

Genera : *Stromateus* and *Centrolophus.*

Family 5. *Coryphænidæ.*—Body compressed ; eye lateral. Teeth small, conical, if present ; œsophagus smooth. No bony stay for the præoperculum. Dorsal fin single, long, without distinct spinous division. More than ten abdominal and more than fourteen caudal vertebræ.

Genera : *Coryphæna* (Dolphin), *Brama, Taractes, Lampris* (Sun-Fish), *Pteraclis, Schedophilus, Diana, Ausonia, Mene.* Fossil : *Goniognathus.*

Family 6. *Nomeidæ.*—Body oblong, more or less compressed, covered with cycloid scales of moderate size ; eye lateral. No bony stay for the præoperculum. Dorsal fin with a distinct spinous portion separated from the soft ; sometimes finlets ; caudal forked. More than ten abdominal and more than fourteen caudal vertebræ.

Genera : *Gastrochisma, Nomeus, Psenes,* and *Cubiceps.*

Family 7. *Scombridæ.*—Body oblong, scarcely compressed, naked or covered with small scales ; eye lateral. Dentition well developed. No bony stay for the præoperculum. Two dorsal fins ; generally finlets. Ventrals thoracic, with one spine and five rays. More than ten abdominal and more than fourteen caudal vertebræ.

Genera : *Scomber* (Mackerel), *Thynnus* (Tunny, Bonito, Albacore), *Pelamys, Auxis, Cybium, Elacate,* and *Echeneis* (Sucking-Fish).

Family 8. *Trachinidæ.*—Body elongate, low, naked or covered with scales. Teeth small, conical. No bony stay for the præoperculum. One or two dorsal fins, the spinous portion being always shorter and much less developed than the soft ; the anal similarly developed as the soft dorsal ; no finlets. Ventrals with one spine and five rays. Gill-opening more or less wide. Ten or more than ten abdominal and more than fourteen caudal vertebræ.

Genera : *Uranoscopus, Leptoscopus, Agnus, Anema, Kathetostoma, Trachinus* (Weever), *Champsodon, Percis, Sillago, Bovichthys, Bathydraco, Chœnichthys, Aphritis, Acanthaphritis, Eleginus, Chimarrhichthys, Cottoperca, Percophis, Trichodon, Pinguipes, Latilus, Opisthognathus, Pseudochromis, Cichlops, Pseudoplesiops, Notothenia,* and *Harpagifer.* Fossil : *Callipteryx, Trachinopsis,* and *Pseudoeleginus.*

Malacanthus is the type of a family allied to the *Trachinidæ.*

Family 9. *Batrachidæ.*—Head broad and thick ; body elongate, compressed behind ; skin naked or with small scales. No bony stay for the præoperculum. Teeth conical, small or of moderate size. The spinous dorsal consists of two or three spines only ; the soft and the anal long. Ventrals jugular, with two soft rays ; pectorals not pediculated. Gill-opening a more or less vertical slit before the pectoral, rather narrow.

Genera : *Batrachus, Thalassophryne,* and *Porichthys.*—*Psychrolutes* and *Neophrynichthys* are allied forms.

Family 10. *Pediculati.*—Head and anterior part of the body very large, without scales. No bony stay for the præoperculum. Teeth villiform or rasp-like. The spinous dorsal is advanced forwards, composed of a few more or less isolated spines, often transformed into tentacles, or entirely absent. Ventral fins jugular, with four or five soft rays, sometimes absent. The carpal bones are prolonged, forming a sort of arm, terminating in the pectoral. Gill-opening reduced to a small foramen, situated in or near the axil. Gills two and a half, three, or three and a half ; pseudobranchiæ generally absent.

Genera : *Lophius* (Fishing-Frog, Angler), *Ceratias, Himantolophus, Melanocetus, Oneirodes, Antennarius, Brachionichthys, Saccarius, Chaunax, Malthe, Halieutæa, Halieutichthys, Dibranchus,* and *Ægæonichthys.*

Family 11. *Cottidæ.*—Form of the body oblong, sub-cylindrical. Cleft of the mouth lateral. Dentition feeble, generally in villiform bands. Some bones of the head are armed ; and a bony stay connects the præopercular spine with the infraorbital ring. Two dorsal fins (rarely one), the spinous being less developed than the soft and the anal. Ventrals thoracic, with five or less soft rays.

Genera : *Cottus* (Bull-head, Miller's Thumb), *Centridermichthys, Icelus, Platycephalus, Hoplichthys, Bunocottus, Rhamphocottus, Triglops, Podabrus, Blepsias, Nautichthys, Scorpænichthys, Hemilepidotus, Artedius, Ptyonotus, Polycaulus, Bembras,* and *Trigla* (Gurnards).

Family 12. *Cataphracti.*—Form of the body elongate, sub-cylindrical. Dentition feeble. Body completely cuirassed with osseous keeled scales or plates. A bony stay connects the angle of the præoperculum with the infraorbital ring. Ventrals thoracic.

Genera : *Agonus, Aspidophoroides, Siphagonus, Peristethus, Dactylopterus* (Flying Gurnard).

Family 13. *Pegasidæ.*—Body entirely covered with bony plates, anchylosed on the trunk and movable on the tail. Barbels none. The margin of the upper jaw is formed by the intermaxillaries and their cutaneous prolongation, which extends downwards to the extremity of the maxillaries. Gill-cover formed by a large plate, homologous to the operculum, præoperculum, and suboperculum ; interoperculum a long fine bone, hidden below the gill-plate. One rudimentary branchiostegal. The gill-plate is united to the isthmus by a narrow membrane ; gill-openings narrow, in front of the base of the pectoral fin. Gills four, lamellated. Pseudobranchiæ and air-bladder absent. One short dorsal and a similar anal fin, opposite to each other. Ventral fin present. Ovarian sacs closed.

One genus only is known, *Pegasus.*

Division IX. *Acanthopterygii Gobiiformes.*—The spinous dorsal, or spinous portion of the dorsal, is always present, short, either composed of flexible spines, or much less developed than the soft ; the soft dorsal and anal of equal extent. No bony stay for the angle of the præoperculum. Ventrals thoracic or jugular, if present, composed of one spine and five, rarely four, soft rays. A prominent anal papilla.

Family 1. *Discoboli* (Lump-Suckers).—Body thick or oblong, naked or tubercular. Teeth small. Ventral fins with one spine and five rays, all being rudimentary and forming the osseous support of a round disk, which is surrounded by a cutaneous fringe. Gill-openings narrow, the gill-membranes being attached to the isthmus.

Genera : *Cyclopterus* and *Liparis.*

Family 2. *Gobiidæ* (Gobies).—Body elongate, naked or scaly. Teeth generally small, sometimes with canines. The spinous dorsal fin, or portion of the dorsal fin, is the less developed, and composed of flexible spines ; anal similarly developed as the soft dorsal. Sometimes the ventrals are united into a disk. Gill-opening more or less narrow, the gill-membranes being attached to the isthmus.

Genera : *Gobius, Latrunculus, Euctenogobius, Lophiogobius, Doliichthys, Apocryptes, Evorthodus, Gobiosoma, Gobiodon, Triænophorichthys, Sicydium, Periophthalmus, Boleophthalmus, Eleotris, Lentipes, Trypauchen, Callionymus* (Dragonet), *Benthophilus, Amblyopus, Orthostomus, Platyptera, Luciogobius, Oxymetopon,* and, perhaps, *Oxuderces.*

Division X. *Acanthopterygii Blenniiformes.*—Body low, subcylindrical or compressed, elongate. Dorsal fin very long ; the spinous portion of the dorsal, if distinct, is very long, as well developed as the soft, or much more ; sometimes the entire fin is composed of spines only ; anal more or less long ; caudal fin subtruncated or rounded, if present. Ventral fins thoracic or jugular, if present.

Family 1. *Cepolidæ.*—Body very elongate, compressed, covered with very small cycloid scales ; eyes rather large, lateral. Teeth of moderate size. No bony stay for the angle of the præoperculum. One very long dorsal fin, which, like the anal, is composed of soft rays. Ventrals thoracic, composed of one spine and five rays. Gill-opening wide. Caudal vertebræ exceedingly numerous.

Genus: *Cepola* (Band-Fishes). An allied family are the *Trichonotidæ,* with *Trichonotus* and *Hemerocœtes.*

Family 2. *Heterolepidotidæ.*—Body oblong, compressed, scaly ; eyes lateral ; cleft of the mouth lateral ; dentition feeble. The angle of the præoperculum connected by a bony stay with the infraorbital ring. Dorsal long, with the spinous and soft portions equally developed ; anal elongate. Ventrals thoracic, with one spine and five rays.

Genera : *Chirus, Ophiodon, Agrammus, Zaniolepis.*

Family 3. *Blenniidæ.*—Body elongate, low, more or less cylindrical, naked or covered with scales, which generally are small. One, two, or three dorsal fins occupying nearly the whole length of the back, the spinous portion, if distinct, being as much developed as the soft, or more ; sometimes the entire fin is composed of spines ; anal fin long. Ventrals jugular, composed of a few rays, and sometimes rudimentary or entirely absent. Pseudobranchiæ generally present.

Genera : *Anarrhichas* (Wolf-Fish), *Blennius* (Blenny), *Chasmodes, Petroscirtes, Salarias, Clinus, Cristiceps, Cremnobates, Tripterygium, Stichæus, Blenniops, Centronotus, Xiphidion, Cryptacanthodes, Patœcus, Zoarces, Blennophis, Nemophis, Plagiotremus, Neoclinus, Cebidichthys, Myxodes, Heterostichus, Dictyosoma, Lepidoblennius, Dactyloscopus, Gunellichthys, Urocentrus, Stichæopsis, Sticharium, Notograptus, Pholidichthys,* and *Pseudoblennius.*—Closely allied is *Acanthoclinus.*

Family 4. *Mastacembelidæ.*—Body elongate, eel-like, covered with very small scales. Mandible long, but little movable. Dorsal fin very long, the anterior portion composed of numerous short isolated spines ; anal fin with spines anteriorly. Ventrals none. The humeral arch is not suspended from the skull. Gill-openings reduced to a slit at the lower part of the side of the head.

Genera : *Rhynchobdella* and *Mastacembelus.*

Division XI. *Acanthopterygii Mugiliformes.*—Two dorsal fins more or less remote from each other ; the anterior either short, like the posterior, or composed of feeble spines. Ventral fins with one spine and five rays, abdominal.

Family 1. *Sphyrænidæ.*—Body elongate, sub-cylindrical, covered with small cycloid scales ; lateral line continuous. Cleft of the mouth wide, armed with strong teeth. Eye lateral, of moderate size. Vertebræ twenty-four.

Genera : *Sphyræna* (Barracuda) Fossil: *Sphyrænodus, Hypsodon, Portheus, Saurocephalus.*

Family 2. *Atherinidæ.*—Body more or less elongate, sub-cylindrical, covered with scales of moderate size ; lateral line indistinct. Cleft of the mouth of moderate width, with the dentition feeble.

Eye lateral, large or of moderate size. Gill-openings wide. Vertebræ very numerous.

Genera: *Atherina*, *Atherinichthys*, and *Tetragonurus*.

Family 3. *Mugilidæ* (Grey Mullets).—Body more or less oblong and compressed, covered with cycloid scales of moderate size; lateral line none. Cleft of the mouth narrow or of moderate width, with or without feeble teeth. Eye lateral, of moderate size. Gill-opening wide. The anterior dorsal fin composed of four stiff spines. Vertebræ twenty-four.

Genera: *Mugil*, *Agonostoma*, and *Myxus*.

DIVISION XII. *Acanthopterygii Gastrosteiformes*.—The spinous dorsal is composed of isolated spines, if present; the ventrals are either thoracic or have an abdominal position in consequence of the prolongation of the pubic bones which are attached to the humeral arch. Mouth small, at the end of the snout, which is generally more or less produced.

Family 1. *Gastrosteidæ*.—Body elongate, compressed. Cleft of the mouth oblique; villiform teeth in the jaws. Opercular bones not armed; infraorbitals covering the cheek; parts of the skeleton forming incomplete external mail. Scales none, but generally large scutes along the side. Isolated spines in front of the soft dorsal fin. Ventral fins abdominal, joined to the pubic bone, composed of a spine and a small ray. Branchiostegals three.

One genus only: *Gastrosteus* (Sticklebacks).

Family 2. *Fistulariidæ*.—Fishes of greatly elongated form; the anterior bones of the skull are much produced, and form a long tube, terminating in a narrow mouth. Teeth small; scales none, or small. The spinous dorsal fin is either formed by feeble isolated spines or entirely absent; the soft dorsal and anal of moderate length; ventral fins thoracic or abdominal, composed of five or six rays, without spine; if abdominal, they are separate from the pubic bones, which remain attached to the humeral arch. Branchiostegals five.

Genera: *Fistularia*, *Aulostoma*, *Auliscops*, and *Aulorhynchus*. The first three occur also in Eocene formations. Other fossil genera are *Urosphen* and *Rhamphosus*.

DIVISION XIII. *Acanthopterygii Centrisciformes*.—Two dorsal fins; the spinous short, the soft and the anal of moderate extent. Ventral fins truly abdominal, imperfectly developed.

One family, *Centriscidæ*, with two genera, *Centriscus* (Trumpet-Fish, Bellows-Fish) and *Amphisile*.

DIVISION XIV. *Acanthopterygii Gobiesociformes*.—No spinous dorsal; the soft and the anal short or of moderate length, situated on the tail; ventral fins subjugular, with an adhesive apparatus between them. Body naked.

Genera: *Chorisochismus*, *Cotylis*, *Sicyases*, *Gobiesox*, *Diplocrepis*, *Crepidogaster*, *Trachelochismus*, *Lepadogaster*, and *Leptopterygius*.

DIVISION XV. *Acanthopterygii Channiformes*.—Body elongate, covered with scales of moderate size; no spine in any of the fins; dorsal and anal long. No superbranchial organ, only a bony prominence on the anterior surface of the hyomandibular.

Genera: *Ophiocephalus* and *Channa*.

DIVISION XVI. *Acanthopterygii Labyrinthibranchii*.—Body compressed, oblong or elevated, with scales of moderate size. A superbranchial organ in a cavity accessory to that of the gills.

Family 1. *Labyrinthici*.—Dorsal and anal spines present, but in variable number; ventrals thoracic. Lateral line absent, or more or less distinctly interrupted. Gill-opening rather narrow, the gill-membranes of both sides coalescent below the isthmus, and scaly; gills four; pseudobranchiæ rudimentary or absent.

Genera: *Anabas*, *Spirobranchus*, *Ctenopoma*, *Polyacanthus*, (Paradise-Fish), *Osphromenus* (Gouramy), *Trichogaster*, *Betta*, and *Micracanthus*.—Allied to this family is *Luciocephalus*.

DIVISION XVII. *Acanthopterygii Lophotiformes*.—Body ribbon-shaped, with the vent near its extremity; a short anal behind the vent; dorsal fin as long as the body.

Only one genus is known of this division or family, *Lophotes*.

DIVISION XVIII. *Acanthopterygii Tæniiformes* (Ribbon-Fishes).—Body ribbon-shaped; dorsal fin as long as the body; anal absent; caudal rudimentary, or not in the longitudinal axis of the fish.

Genera: *Trachypterus*, *Stylophorus*, and *Regalecus*.

DIVISION XIX. *Acanthopterygii Notacanthiformes*.—Dorsal fin short, composed of short, isolated spines, without a soft portion. Anal fin very long, anteriorly with many spines; ventrals abdominal, with more than five soft and several unarticulated rays.

One genus only: *Notacanthus*.

ORDER II.—*Acanthopterygii Pharyngognathi*.

Part of the rays of the dorsal, anal, and ventral fins are non-articulated spines. The lower pharyngeals coalesced. Air-bladder without pneumatic duct.

Family 1. *Pomacentridæ*.—Body short, compressed, covered with ctenoid scales. Dentition feeble; palate smooth. The lateral line does not extend to the caudal fin, or is interrupted. One dorsal fin, with the spinous portion as well developed as the soft, or more. Two, sometimes three, anal spines; the soft anal similar to the soft dorsal. Ventral fins thoracic, with one spine and five soft rays. Gills three and a half; pseudobranchiæ and air-bladder present. Vertebræ, twelve abdominal and fourteen caudal.

Genera: *Amphiprion*, *Premnas*, *Dascyllus*, *Lepidozygus*, *Pomacentrus*, *Glyphidodon*, *Parma*, and *Heliastes*. Fossil: *Odonteus*.

Family 2. *Labridæ*.—Body oblong or elongate, covered with cycloid scales. The lateral line extends to the caudal, or is interrupted. One dorsal fin, with the spinous portion as well developed as the soft, or more so. The soft anal similar to the soft dorsal. Ventral fins thoracic, with one spine and five soft rays. Palate without teeth. Branchiostegals five or six; gills three and a half; pseudobranchiæ and air-bladder present. Pyloric appendages none; stomach without cæcal sac.

Genera: *Labrus* and *Crenilabrus* (Wrasses), *Tautoga*, *Ctenolabrus*, *Acantholabrus*, *Centrolabrus*, *Lachnolæmus*, *Malacopterus*, *Cossyphus*, *Chilinus*, *Epibulus*, *Anampses*, *Platyglossus*, *Novacula*, *Julis*, *Coris*, *Chœrops*, *Xiphochilus*, *Semicossyphus*, *Trochocopus*, *Decodon*, *Pteragogus*, *Clepticus*, *Labrichthys*, *Labroides*, *Duymæria*, *Cirrhilabrus*, *Doratonotus*, *Pseudochilinus*, *Hemigymnus*, *Gomphosus*, *Cheilio*, *Cymolutes*, *Pseudodax*, *Scarus*, *Scarichthys*, *Callyodon*, *Pseudoscarus*, *Odax*, *Coridodax*, *Olistherops*, and *Siphonognathus*. Fossil: *Nummopalatus*, *Phyllodus*, *Taurinichthys*, and *Egertonia*.

Family 3. *Embiotocidæ*.—Body compressed, elevated or oblong, covered with cycloid scales; lateral line continuous. One dorsal fin, with a spinous portion, and with a scaly sheath along the base, which is separated by a groove from the other scales; anal with three spines and numerous rays; ventral fin thoracic, with one spine and five rays. Small teeth in the jaws, none on the palate. Pseudobranchiæ present. Stomach siphonal; pyloric appendages none. Viviparous.

Genera: *Ditrema* and *Hysterocarpus*.

Family 4. *Chromides*.—Body elevated, oblong or elongate, scaly, the scales being generally ctenoid. Lateral line interrupted or nearly so. One dorsal fin, with a spinous portion; three or more anal spines; the soft anal similar to the soft dorsal. Ventral fins thoracic, with one spine and five rays. Teeth in the jaws small, palate smooth. Pseudobranchiæ none. Stomach cæcal; pyloric appendages none.

Genera: *Etroplus*, *Chromis*, *Hemichromis*, *Paretroplus*, *Acara*, *Heros*, *Neetroplus*, *Mesonauta*, *Pelcnia*, *Uaru*, *Hygrogonus*, *Cichla*, *Crenicichla*, *Chætobranchus*, *Mesops*, *Satanoperca*, *Geophagus*, *Symphysodon*, and *Pterophyllum*.

ORDER III.—*Anacanthini*.

Vertical and ventral fins without spinous rays. The ventral fins, if present, are jugular or thoracic. Air-bladder, if present, without pneumatic duct.

DIVISION I. *Anacanthini Gadoidei*.—Head and body symmetrically formed.

Family 1. *Lycodidæ*.—Vertical fins confluent. Ventral fin, if present, small, attached to the humeral arch, jugular. Gill-opening narrow, the gill-membrane being attached to the isthmus.

Genera: *Lycodes*, *Gymnelis*, *Uronectes*, *Microdesmus*, *Blennodesmus*, and *Maynea*.

Family 2. *Gadidæ*.—Body more or less elongate, covered with small smooth scales. One, two, or three dorsal fins, occupying nearly the whole of the back; rays of the posterior dorsal well developed; one or two anal fins. Caudal free from dorsal and anal, or, if they are united, the dorsal with a separate anterior portion. Ventrals jugular, composed of several rays, or, if they are reduced to a filament, the dorsal is divided into two. Gill-opening wide; the gill-membranes generally not attached to the isthmus. Pseudobranchiæ none, or glandular, rudimentary. An air-bladder and pyloric appendages generally present.

Genera: *Gadus* (Cod-Fish, Haddock, Whiting, Pollack, Coal-Fish), *Gadiculus*, *Mora*, *Strinsia*, *Halargyreus*, *Melanonus*, *Merluccius* (Hake), *Pseudophycis*, *Lotella*, *Physiculus*, *Uraleptus*, *Læmonema*, *Phycis*, *Haloporphyrus*, *Lota* (Burbot), *Molva* (Ling), *Motella* (Rockling), *Raniceps*, *Bregmaceros*, *Murænolepis*, *Chiasmodus*, and *Brosmius*. Fossil remains are rare: *Nemopteryx* and *Palæogadus* from the schists of Glarus, a formation believed to have been the bottom of a very deep sea. In the clay of Sheppey species occur allied to *Gadus*, *Merluccius*, and *Phycis*.

Family 3. *Ophidiidæ*.—Body more or less elongate, naked or scaly. Vertical fins generally united; no separate anterior dorsal or anal; dorsal occupying the greater portion of the back. Ventral fins rudimentary or absent, jugular. Gill-openings wide, the gill-membranes not attached to the isthmus.

1. *Brotulina*: Ventral fins present, attached to the humeral arch. Genera: *Brotula*, *Lucifuga*, *Bathynectes*, *Acanthonus*, *Typhlonus*, *Aphyonus*, *Rhinonus*, *Sirembo*, *Pteridium*, *Brotulophis*, *Halidesmus*, *Dinematichthys*, and *Bythites*.

2. *Ophidiina*: Ventral fins replaced by a pair of bifid filaments (barbels) inserted below the glossohyal. Genera: *Ophidium* and *Genypterus*.

3. *Fierasferina*: No ventral fins whatever; vent at the throat. Genera: *Fierasfer* and *Encheliophis*.

4. *Ammodytina*: No ventral fins whatever; vent remote from the

head; gill-openings very wide, the gill-membranes not being united. Genera: *Ammodytes* (Sand-Eels) and *Bleekeria*.

5. *Congrogadina*: No ventral fins whatever; vent remote from the head; gill-openings of moderate width, the gill-membranes being united below the throat, not attached to the isthmus. Genera: *Congrogadus* and *Haliophis*.

Family 4. *Macruridæ*.—Body terminating in a long, compressed, tapering tail, covered with spiny, keeled, or striated scales. One short anterior dorsal; the second very long, continued to the end of the tail, and composed of very feeble rays; anal of an extent similar to that of the second dorsal; no caudal. Ventral fins thoracic or jugular, composed of several rays. Deep-sea Gadoids.

Genera: *Macrurus, Coryphænoides, Macruronus, Malacocephalus*, and *Bathygadus*.

DIVISION II. *Anacanthini Pleuronectoidei*.—Head and part of the body unsymmetrically formed. This division consists of one family only: *Pleuronectidæ* (Flat-Fishes).

Genera: *Psettodes, Hippoglossus* (Holibut), *Hippoglossoides, Tephritis, Rhombus* (Turbot, Brill, Whiff), *Phrynorhombus* (Top-Knot), *Arnoglossus, Pseudorhombus, Rhomboidichthys, Citharus, Anticitharus, Brachypleura, Samaris, Psettichthys, Citharichthys, Hemirhombus, Paralichthys, Liopsetta, Lophonectes, Lepidopsetta, Thysanopsetta, Pleuronectes* (Plaice, Dab, Flounder), *Rhombosolea, Parophrys, Psammodiscus, Ammotretis, Peltorhamphus, Nematops, Lœops, Pœcilopsetta, Solea* (Sole), *Synaptura, Æsopia, Gymnachirus, Cynoglossus, Soleotalpa, Apionichthys, Ammopleurops, Aphoristia*, and *Plagusia*

ORDER IV.—*Physostomi*.

All the fin-rays articulated, only the first of the dorsal and pectoral fins is sometimes ossified. Ventral fins, if present, abdominal, without spine. Air-bladder, if present, with a pneumatic duct (except in *Scombresocidæ*).

Family 1. *Siluridæ*.—Skin naked or with osseous scutes, but without scales. Barbels always present; maxillary bone rudimentary, almost always forming a support to a maxillary barbel. Margin of the upper jaw formed by the intermaxillaries only. Suboperculum absent. Air-bladder generally present, communicating with the organ of hearing by means of the auditory ossicles. Adipose fin present or absent.

A large family of freshwater fishes, represented by numerous genera, which exhibit a great variety of form and structure of the fins. Their first appearance is indicated by some fossil remains in Tertiary deposits of the highlands of Padang in Sumatra, where *Pseudeutropius* and *Bagarius*, types well represented in the living Indian fauna, have been found. In North America also spines referable to "Cat-Fishes" have been found in Tertiary formations.

From the great number of different generic types this family has been arranged under eight subdivisions:—

1. *Siluridæ Homalopteræ*.
   - A. *Clariina*: Clarias, Heterobranchus.
   - B. *Plotosina*: Plotosus, Cnidoglanis, Copidoglanis, Chaca.
2. *Siluridæ Heteropteræ*.
   - A. *Silurina*: Saccobranchus, Silurus, Schilbe, Eutropius, Silurichthys, Wallago, Belodontichthys, Eutropiichthys, Cryptopterus, Callichrous, Hemisilurus, Siluranodon, Ailia, Schilbichthys, Lais, Pseudeutropius, Pangasius, Helicophagus, Silondia.
3. *Siluridæ Anomalopteræ*.
   - A. *Hypophthalmina*: Hypophthalmus, Helogenes.
4. *Siluridæ Proteropteræ*.
   - A. *Bagrina*: Bagrus, Chrysichthys, Clarotes, Macrones, Pseudobagrus, Liocassis, Bagroides, Bagrichthys, Rita, Acrochordonichthys, Akysis.
   - B. *Amiurina*: Amiurus, Hopladelus, Noturus.
   - C. *Pimelodina*: Platystoma, Sorubim, Hemisorubim, Platystomatichthys, Phractocephalus, Piramutana, Platynematichthys, Piratinga, Bagropsis, Sciades, Pimelodus, Pirinampus, Conorhynchus, Notoglanis, Callophysus, Lophiosilurus, Auchenoglanis.
   - D. *Ariina*: Arius, Galeichthys, Genidens, Paradiplomystax, Diplomystax, Ælurichthys, Hemipimelodus, Ketengus, Osteogeniosus, Batrachocephalus, Atopochilus.
   - E. *Bagariina*: Bagarius, Englyptosternum, Glyptosternum.
5. *Siluridæ Stenobranchiæ*.
   - A. *Doradina*: Ageniosus, Tetranematichthys, Euanemus, Auchenipterus, Glanidium, Centromochlus, Trachelyopterus, Cetopsis, Astrophysus, Doras, Synodontis.
   - B. *Rhinoglanina*: Rhinoglanis, Callomystax.
   - C. *Malapterurina*: Malapterurus.
6. *Siluridæ Proteropodes*.
   - A. *Hypostomatina*: Stygogenes, Arges, Brontes, Astroplebus, Callichthys, Chaetostomus, Plecostomus, Hypoptopoma, Loricaria, Acestra, Sisor, Erethistes, Exostoma, Pseudecheneis.
   - B. *Aspredinina*: Aspredo, Bunocephalus, Bunocephalichthys, Harttia.
7. *Siluridæ Opisthopteræ*.
   - A. *Nematogenyina*: Heptapterus, Nematogenys.
   - B. *Trichomycterina*: Trichomycterus, Eremophilus, Parіodon.
8. *Siluridæ Branchicolæ*: Stegophilus, Vandellia.

Family 2. *Scopelidæ*.—Body naked or scaly. Margin of the upper jaw formed by the intermaxillary only; opercular apparatus sometimes incompletely developed. Barbels none. Gill-opening very wide; pseudobranchiæ well developed. Air-bladder none. Adipose fin present. The eggs are enclosed in the sacs of the ovary, and excluded by oviducts. Pyloric appendages few in number or absent. Intestinal tract very short.

Genera: *Saurus, Bathysaurus, Bathypterois, Harpodon, Scopelus, Ipnops, Paralepis, Sudis, Plagyodus, Aulopus, Chlorophthalmus, Scopelosaurus, Odontostomus*, and *Nannobrachium*. Fossil: *Osmeroides, Hemisaurida, Parascopelus*, and *Anapterus*.

Family 3. *Cyprinidæ*.—Body generally covered with scales; head naked. Margin of the upper jaw formed by the intermaxillaries. Belly rounded, or, if trenchant, without ossifications. No adipose fin. Stomach without blind sac. Pyloric appendages none. Mouth toothless; lower pharyngeal bones well developed, falciform, subparallel to the branchial arches, provided with teeth, which are arranged in one, two, or three series. Air-bladder large, divided into an anterior and posterior portion by a constriction, or into a right or a left portion, enclosed in an osseous capsule. Ovarian sacs closed.

The family of "Carps" is the one most numerously represented in the fresh waters of the Old World and of North America. Numerous fossil remains are also found in Tertiary freshwater formations; the majority can be referred to existing genera: *Barbus, Thynnichthys, Gobio, Leuciscus, Tinca, Amblypharyngodon, Rhodeus, Cobitis, Acanthopsis*; only a few showing characters different from those of living genera: *Cyclurus, Hexapsephus, Mylocyprinus*.

There is much less diversity of forms and habits in this family than in the Siluroids; but the genera are sufficiently numerous to demand a further subdivision of the family into groups.

1. *Catostomina*: Catostomus, Moxostoma, Sclerognathus, Carpiodes.
2. *Cyprinina*: Cyprinus (Carp), Carassius, Catla, Cirrhina, Dangila, Osteochilus, Labeo, Barynotus, Tylognathus, Abrostomus, Discognathus, Crossochilus, Gymnostomus, Epalzeorhynchus, Capoeta, Barbus (Barbel), Thynnichthys, Barbichthys, Amblyrhynchichthys, Albulichthys, Oreinus, Schizothorax, Ptychobarbus, Gymnocypris, Schizopygopsis, Diptychus, Aulopyge, Gobio (Gudgeon), Ceratichthys, Bungia, Pimephales, Hyborhynchus, Campostoma, Hybognathus, Ericymba, Pseudorasbora, Cochlognathus, Exoglossum, Rhinichthys.
3. *Rhoteichthyina*: Rhoteichthys.
4. *Leptobarbina*: Leptobarbus.
5. *Rasborina*: Rasbora, Luciosoma, Nuria, Aphyocypris, Amblypharyngodon.
6. *Semiplotina*: Cyprinion, Semiplotus.
7. *Xenocypridina*: Xenocypris, Paracanthobrama, Mystacoleucus.
8. *Leuciscina*: Leuciscus (White-Fish, Roach, Chub, Dace, Rudd, Minnow), Myloleucus, Ctenopharyngodon, Mylopharodon, Paraphoxinus, Meda, Graodus, Tinca (Tench), Leucosomus, Chondrostoma, Orthodon, Acrochilus.
9. *Rhodeina*: Achilognathus, Rhodeus, Pseudoperilampus.
10. *Danionina*: Danio, Pteropsarion, Aspidoparia, Barilius, Bola, Schacra, Opsariichthys, Squaliobarbus, Ochetobius.
11. *Hypophthalmichthyina*: Hypophthalmichthys.
12. *Abramidina*: Abramis (Bream), Aspius, Alburnus (Bleak), Leucaspius, Rasborichthys, Elopichthys, Pelotrophus, Acanthobrama, Osteobrama, Chanodichthys, Smiliogaster, Culter, Pelecus, Eustira, Chela, Pseudolabuca, Cachius.
13. *Homalopterina*: Homaloptera, Psilorhynchus.
14. *Cobitidina* (Loaches): Misgurnus, Nemachilus, Cobitis, Lepidocephalichthys, Acanthopsis, Botia, Oreonectes, Lepidocephalus, Acanthophthalmus, Apua, Paramisgurnus.

Family 4. *Kneriidæ*.—Body scaly, head naked. Margin of the upper jaw formed by the intermaxillaries. Dorsal and anal fins short, the former belonging to the abdominal portion of the vertebral column. Teeth none, either in the mouth or pharynx. Barbels none. Stomach siphonal; no pyloric appendages. Pseudobranchiæ none. Branchiostegals three; air-bladder long, not divided. Ovaries closed.

One genus: *Kneria*.

Family 5. *Characinidæ*.—Body covered with scales, head naked; barbels none. Margin of the upper jaw formed by the intermaxillaries in the middle and by the maxillaries laterally. Generally a small adipose fin behind the dorsal. Pyloric appendages more or less numerous; air-bladder transversely divided into two portions, and communicating with the organ of hearing by means of the auditory ossicles. Pseudobranchiæ none.

1. *Erythrinina*: Macrodon, Erythrinus, Lebiasina, Nannostomus, Pyrrhulina, and Corynopoma.

2. *Curimatina*: Curimatus, Prochilodus, Cænotropus, Hemiodus, Saccodon, Parodon.
3. *Citharinina*: Citharinus.
4. *Anastomatina*: Leporinus, Anostomus, Rhytiodus.
5. *Nannocharacina*: Nannocharax.
6. *Tetragonopterina*: Alestes, Tetragonopterus, Chirodon, Megalobrycon, Gastropelecus, Piabucina, Scissor, Pseudochalceus, Aphyocharax, Chalceus, Brycon, Chalcinopsis, Bryconops, Creagrutus, Chalcinus, Piabuca, Paragoniates, Agoniates, Nannæthiops, and Bryconæthiops.
7. *Hydrocyonina*: Hydrocyon, Cynodon, Anacyrtus, Hystricolon, Salminus, Oligosarcus, Xiphorhamphus, Xiphostoma, and Sarcodaces.
8. *Distichodontina*: Distichodus.
9. *Ichthyborina*: Ichthyborus and Phago.
10. *Crenuchina*: Crenuchus and Xenocharax.
11. *Serrasalmonina*: Mylesinus, Serrasalmo, Myletes, and Catoprion.

Family 6. *Cyprinodontidæ.*—Head and body covered with scales; barbels none. Margin of the upper jaw formed by the intermaxillaries only. Teeth in both jaws; upper and lower pharyngeals with cardiform teeth. Adipose fin none; dorsal fin situated on the hinder half of the body. Stomach without blind sac; pyloric appendages none. Pseudobranchiæ none; air-bladder simple, without ossicula auditus.

1. *C. Carnivoræ*: Cyprinodon, Characodon, Fitzroyia, Haplochilus, Fundulus, Limnurgus, Lucania, Rivulus, Cynolebias, Orestias, Jenynsia, Gambusia, Pseudoxiphophorus, Belonesox, Anableps.
2. *C. Limnophagæ*: Pœcilia, Mollienesia, Platypœcilus, Girardinus. Fossil remains are referable to Cyprinodon and Pœcilia.

Family 7. *Heteropygii.*—Head naked; body covered with very small scales; barbels none. Margin of the upper jaw formed by the intermaxillaries. Villiform teeth in the jaws and on the palate. Adipose fin none. Dorsal fin belonging to the caudal portion of the vertebral column, opposite to the anal. Ventral fins rudimentary or absent. Vent situated before the pectorals. Stomach cæcal; pyloric appendages present. Pseudobranchiæ none; air-bladder deeply notched anteriorly.

Genera: *Amblyopsis* (Blind-Fish of the Mammoth Cave) and *Chologaster.*

Family 8. *Umbridæ.*—Head and body covered with scales; barbels none. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally. Adipose fin none; the dorsal fin belongs partly to the abdominal portion of the vertebral column. Stomach siphonal; pyloric appendages none; pseudobranchiæ glandular, hidden; air-bladder simple.

One genus: *Umbra.*

Family 9. *Scombresocidæ.*—Body covered with scales; a series of keeled scales along each side of the belly. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally. Lower pharyngeals united into a single bone. Dorsal fin opposite the anal, belonging to the caudal portion of the vertebral column. Adipose fin none. Air-bladder generally present, simple, sometimes cellular, without pneumatic duct. Pseudobranchiæ hidden, glandular. Stomach not distinct from the intestine, which is quite straight, without appendages.

Genera: *Belone* (Gar-Pike), *Scombresox*, *Hemirhamphus*, *Arrhamphus*, *Exocœtus* (Flying-Fish). Fossil: *Holosteus.*

Family 10. *Esocidæ.*—Body covered with scales; barbels none. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally. Adipose fin none; the dorsal fin belongs to the caudal portion of the vertebral column. Stomach without blind sac; pyloric appendages none. Pseudobranchiæ glandular, hidden; air-bladder simple; gill-opening very wide.

One genus only: *Esox* (Pike).

Family 11. *Galaxiidæ.*—Body naked; barbels none. Margin of the upper jaw chiefly formed by the intermaxillaries, which are short, and continued by a thick lip, behind which are the maxillaries. Belly rounded; adipose fin none; dorsal opposite to anal. Pyloric appendages in small number. Air-bladder large, simple; pseudobranchiæ none. The ova fall into the cavity of the abdomen before exclusion.

Genera: *Galaxias* and *Neochanna.*

Family 12. *Mormyridæ.*—Body and tail scaly; head scaleless; barbels none. The margin of the upper jaw is formed in the middle by the intermaxillaries, which coalesce into a single bone, and laterally by the maxillaries. Suboperculum and interoperculum present, the latter very small. On each side of the single parietal bone a cavity leading into the interior of the skull, and covered with a thin bony lamella. All the fins are well developed (*Mormyrus*); or caudal, anal, and ventral fins are absent (*Gymnarchus*). No adipose fin. Pseudobranchiæ none; gill-openings reduced to a short slit. Air-bladder simple. Two cæca pylorica behind the stomach.

Genera: *Mormyrus* and *Gymnarchus.*

Family 13. *Sternoptychidæ.*—Body naked, or with very thin deciduous scales; barbels none. Margin of the upper jaw formed by the maxillary and intermaxillary, both of which are toothed; opercular apparatus not completely developed. Gill-opening very wide; pseudobranchiæ present or absent; air-bladder simple, if present. Adipose fin present, but generally rudimentary. Series of phosphorescent bodies along the lower parts. The eggs are enclosed in the sacs of the ovarium, and excluded by oviducts.

Genera: *Sternoptyx*, *Argyropelecus*, *Polyipnus*, *Coccia*, *Maurolicus*, *Chauliodus*, *Gonostoma*, *Photichthys*, and *Diplophos.*

Family 14. *Stomiatidæ.*—Skin naked, or with exceedingly delicate scales; a hyoid barbel. Margin of the upper jaw formed by the intermaxillary and maxillary, which are both toothed; opercular apparatus but little developed. Gill-opening very wide; pseudobranchiæ none. The eggs are enclosed in the sacs of the ovarium, and excluded by oviducts.

Genera: *Astronesthes*, *Stomias*, *Echiostoma*, *Malacosteus*, and *Bathyophis.*

Family 15. *Salmonidæ.*—Body generally covered with scales; head naked; barbels none. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally. Belly rounded. A small adipose fin behind the dorsal. Pyloric appendages generally numerous, rarely absent. Air-bladder large, simple; pseudobranchiæ present. The ova fall into the cavity of the abdomen before exclusion.

Genera: *Salmo* (Salmon, Trout, Charr), *Oncorhynchus*, *Brachymystax*, *Luciotrutta*, *Plecoglossus*, *Osmerus* (Smelt), *Retropinna*, *Hypomesus*, *Thaleichthys*, *Mallotus* (Capelin), *Coregonus* (Gwyniad, Pollan), *Thymallus* (Grayling), *Salanx*, *Argentina*, *Microstoma*, *Bathylagus*. Fossil: *Osmeroides*, *Acrognathus*, and *Aulolepis.*

Family 16. *Percopsidæ.*—Body covered with ctenoid scales; head naked. Margin of the upper jaw formed by the intermaxillaries only; opercular apparatus complete. Barbels none. Gill-openings wide. Adipose fin present.

One genus only: *Percopsis.*

Family 17. *Haplochitonidæ.*—Body naked or scaly (cycloid). Margin of the upper jaw formed by the intermaxillary; opercular apparatus complete. Barbels none. Gill-opening wide; pseudobranchiæ. Air-bladder simple. Adipose fin present. Ovaries laminated; the eggs fall into the cavity of the abdomen, there being no oviduct. Pyloric appendages none.

Genera: *Haplochiton* and *Prototroctes.*

Family 18. *Gonorhynchidæ.*—Head and body entirely covered with spiny scales; mouth with barbels. Margin of the upper jaw formed by the intermaxillary, which, although short, is continued downwards as a thick lip, situated in front of the maxillary. Adipose fin none; the dorsal fin is opposite to the ventrals, and short, like the anal. Stomach simple, without blind sac; pyloric appendages in small number. Pseudobranchiæ; air-bladder absent. Gill-openings narrow.

One genus only: *Gonorhynchus.*

Family 19. *Hyodontidæ.*—Body covered with cycloid scales; head naked; barbels none. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally, the latter being articulated to the end of the former. Opercular apparatus complete. Adipose fin none; the dorsal fin belongs to the caudal portion of the vertebral column. Stomach horseshoe-shaped, without blind sac; intestine short; one pyloric appendage. Pseudobranchiæ none; air-bladder simple. Gill-openings wide. The ova fall into the abdominal cavity before exclusion.

One genus only: *Hyodon* (Moon-Eye).

Family 20. *Pantodontidæ.*—Body covered with large cycloid scales; sides of the head osseous. Margin of the upper jaw formed by the single intermaxillary mesially and by the maxillaries laterally. The dorsal fin belongs to the caudal portion of the vertebral column, is short, and opposite and similar to the anal. Gill-openings wide; gill-covers consisting of a præoperculum and operculum only. Branchiostegals numerous. Pseudobranchiæ none; air-bladder simple. Stomach without cæcal sac; one pyloric appendage. Sexual organs with a duct.

One genus: *Pantodon.*

Family 21. *Osteoglossidæ.*—Body covered with large hard scales, composed of pieces like mosaic. Head scaleless; its integuments almost entirely replaced by bone; lateral line composed of wide openings of the mucous duct. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally. The dorsal fin belongs to the caudal portion of the vertebral column, is opposite and very similar to the anal fin; both approximate to the rounded caudal (with which they are abnormally confluent). Gill-openings wide; pseudobranchiæ none; air-bladder simple or cellular. Stomach without cæcal sac; pyloric appendages two.

Genera: *Osteoglossum*, *Arapaima*, and *Heterotis.*

Family 22. *Clupeidæ.*—Body covered with scales; head naked; barbels none. Abdomen frequently compressed into a serrated edge. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally; maxillaries composed of at least three movable pieces. Opercular apparatus complete. Adipose fin none; dorsal not elongate; anal sometimes very long Stomach with a blind sac; pyloric appendages numerous. Gill-apparatus much developed, the gill-openings being generally very wide. Pseudobranchiæ generally present. Air-bladder more or less simple.

Genera: *Engraulis* (Anchovies), *Coilia*, *Chatoessus*, *Clupea* (Herring, Sprat, Shad, Mossbanker, Menhaden, Ale-Wife, Pilchard, Sardine), *Clupeoides*, *Pellonula*, *Clupeichthys*, *Pellona*, *Pristigaster*, *Albula*, *Elops*, *Megalops*, *Chanos*, *Dussumieria*, *Etrumeus*. Several of these genera have been found in Tertiary formations; other fossils are: *Thrissopater*, *Leptosomus*, *Opisthopteryx*, *Spaniodon*, *Halec*, *Platinx*, *Cœlogaster*, *Rhinellus*, *Scombroclupea*, *Crossognathus*, *Spathodactylus*, *Chirocentrites*, and *Hemitrichas*.

Family 23. *Bathythrisidæ*.—Allied to the herrings—*Bathythrissa*.

Family 24. *Chirocentridæ*.—Body covered with thin, deciduous scales; barbels none. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally, both bones being firmly united in juxtaposition. Opercular apparatus complete. Adipose fin none: the dorsal fin belongs to the caudal portion of the vertebral column. Stomach with a blind sac; intestine short, the mucous membrane forming a spiral fold; pyloric appendages none. Pseudobranchiæ none; air-bladder incompletely divided into cells; gill-opening wide.

One genus only: *Chirocentrus*.

Family 25. *Alepocephalidæ*.—Body with or without scales; head naked; barbels none. Margin of the upper jaw formed by the intermaxillaries and maxillaries, the former being placed along the upper anterior edge of the latter. Opercular apparatus complete. Adipose fin none; the dorsal fin belongs to the caudal portion of the vertebral column. Stomach curved, without blind sac; pyloric appendages in moderate number. Pseudobranchiæ; air-bladder absent. Gill-openings very wide.

Genera: *Alepocephalus*, *Bathytroctes*, *Platytroctes*, and *Xenodermichthys*.

Family 26. *Notopteridæ*.—Head and body scaly; barbels none. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally. Opercular apparatus incomplete. Tail prolonged, tapering. Adipose fin none. Dorsal short, belonging to the caudal portion of the vertebral column; anal very long. Stomach without blind sac; two pyloric appendages. Pseudobranchiæ none; air-bladder present, divided in the interior. The ova fall into the cavity of the abdomen before exclusion. On each side a parieto-mastoid cavity leading into the interior of the skull.

One genus only: *Notopterus*.

Family 27. *Halosauridæ*.—Body covered with cycloid scales; head scaly; barbels none. Margin of the upper jaw formed by the intermaxillaries mesially and by the maxillaries laterally. Opercular apparatus incomplete. Adipose fin none. The short dorsal belongs to the abdominal part of the vertebral column; anal very long. Stomach with a blind sac; intestine short; pyloric appendages in moderate number. Pseudobranchiæ none. Air-bladder large, simple; gill-openings wide. Ovaries closed.

One genus only: *Halosaurus*.

Family 28. *Hoplopleuridæ*.—Body generally with four series of subtriangular scutes, and with intermediate scale-like smaller ones. One (?) dorsal only; head long, with the jaws produced.

Extinct. Genera: *Dercetis*, *Leptotrachelus*, *Pelargorhynchus*, *Plinthophorus*, *Saurorhamphus*, *Eurypholis*, *Ischyrocephalus*.

Family 29. *Gymnotidæ*.—Head scaleless; barbels none. Body elongate, eel-shaped. Margin of the upper jaw formed in the middle by the intermaxillaries and laterally by the maxillaries. Dorsal fin absent or reduced to an adipose strip; caudal generally absent, the tail terminating in a point. Anal fin exceedingly long. Ventrals none. Extremity of the tapering tail capable of being reproduced. Vent situated at, or at a short distance behind, the throat. Humeral arch attached to the skull. Ribs well developed. Gill-openings rather narrow. Air-bladder present, double. Stomach with a cæcal sac and pyloric appendages. Ovaries with oviducts.

Genera: *Sternarchus*, *Ramphichthys*, *Sternopygus*, *Carapus*, *Gymnotus* (Electric Eel).

Family 30. *Symbranchidæ*.—Body elongate, naked or covered with minute scales; barbels none. Margin of the upper jaw formed by the intermaxillaries only, the well-developed maxillaries lying behind and parallel to them. Paired fins none. Vertical fins rudimentary, reduced to more or less distinct cutaneous folds. Vent situated at a great distance behind the head. Ribs present. Gill-openings confluent into one slit situated on the ventral surface. Air-bladder none. Stomach without cæcal sac or pyloric appendages. Ovaries with oviducts.

Genera: *Amphipnous*, *Monopterus*, *Symbranchus*, *Chilobranchus*.

Family 31. *Murænidæ* (Eels).—Body elongate, cylindrical or band-shaped, naked or with rudimentary scales. Vent situated at a great distance from the head. Ventral fins none. Vertical fins, if present, confluent, or separated by the projecting tip of the tail. Sides of the upper jaw formed by the tooth-bearing maxillaries, the fore part by the intermaxillary, which is more or less coalescent with the vomer and ethmoid. Humeral arch not attached to the skull. Stomach with a blind sac; no pyloric appendages. Organs of reproduction without efferent ducts.

Genera: *Nemichthys*, *Cyema*, *Saccopharynx*, *Synaphobranchus*, *Anguilla*, *Conger*, *Congromuræna*, *Murænesox*, *Nettastoma*, *Saurenchelys*, *Oxyconger*, *Hoplunnis*, *Myrus*, *Myrophis*, *Paramyrus*, *Chilorhinus*, *Murænichthys*, *Ophichthys*, *Moringua*, *Muræna*, *Enchelycore*.

Order V.—*Lophobranchii*.

The gills are not laminated, but composed of small rounded lobes attached to the branchial arches. Gill-cover reduced to a large simple plate. Air-bladder simple, without pneumatic duct. A dermal skeleton, composed of numerous pieces arranged in segments, replaces more or less soft integuments. Muscular system not much developed. Snout prolonged. Mouth terminal, small, toothless, formed as in Acanthopterygians.

Family 1. *Solenostomidæ*.—Gill-openings wide. Two dorsal fins, the rays of the anterior not articulated. All the other fins well developed.

One genus only: *Solenostoma*, which was preceded in the Tertiary epoch by *Solenorhynchus* (Monte Postale).

Family 2. *Syngnathidæ*.—Gill-openings reduced to a very small opening near the upper posterior angle of the gill-cover. One soft dorsal fin; no ventrals, and sometimes one or more of the other fins are also absent.

Pipe-Fishes and Seahorses. Fossil remains occur at Monte Bolca. Besides species of *Siphonostoma* and *Syngnathus* (*Pseudosyngnathus*), remains of an extinct genus, *Calamostoma*, allied to *Hippocampus*, but with a distinct caudal fin, have been found.

Genera: *Siphonostoma*, *Syngnathus*, *Doryichthys*, *Nerophis*, *Protocampus*, *Ichthyocampus*, *Nannocampus*, *Urocampus*, *Leptoichthys*, *Cœlonotus*, *Stigmatophora*, *Gastrotokeus*, *Solenognathus*, *Phyllopteryx*, *Hippocampus*.

Order VI.—*Plectognathi*.

Teleosteous fishes with rough scales, or with ossifications of the cutis in the form of scutes or spines; skin sometimes entirely naked. Skeleton incompletely ossified, with the vertebræ in small number. Gills pectinate; a narrow gill-opening in front of the pectoral fins. Mouth narrow; the bones of the upper jaw generally firmly united. A soft dorsal fin, belonging to the caudal portion of the vertebral column, opposite to the anal; sometimes elements of a spinous dorsal besides. Ventral fin none, or reduced to spines. Air-bladder without pneumatic duct.

Family 1. *Sclerodermi*.—Snout somewhat produced; jaws armed with distinct teeth in small number. Skin with scutes, or rough. The elements of a spinous dorsal and ventral fin generally present.

Genera: *Triacanthus*, *Balistes* (File-Fish), *Monacanthus*, *Anacanthus*, *Ostracion* (Coffer-Fish). Fossil: *Acanthoderma*, *Acanthopleurus*, *Glyptocephalus*.

Family 2. *Gymnodontes*.—Body more or less shortened. The bones of the upper and lower jaw are confluent, forming a beak with a trenchant edge, without teeth, with or without median suture. A soft dorsal, caudal, and anal are developed, approximate. No spinous dorsal. Pectoral fins; no ventrals.

Genera: *Triodon*, *Tetrodon* (Globe-Fish), *Diodon* (Sea-Hedgehog), *Orthagoriscus* (Sun-Fish)

Subclass III.—*Cyclostomata*.

Skeleton cartilaginous and notochordal, without ribs and without real jaws. Skull not separate from the vertebral column. No limbs. Gills in the form of fixed sacs, without branchial arches, six or seven in number on each side. One nasal aperture only. Heart without bulbus arteriosus. Mouth anterior, surrounded by a circular or subcircular lip, suctorial. Alimentary canal straight, simple, without cæcal appendages, pancreas, or spleen. Generative outlet peritoneal. Vertical fins rayed.

The Cyclostomes are most probably a very ancient type. Unfortunately the organs of these creatures are too soft to be preserved, with the exception of the horny denticles with which the mouth of some of them is armed.

Family 1. *Petromyzontidæ* (Lampreys).—Body eel-shaped, naked. Subject to a metamorphosis; in the perfect stage with a suctorial mouth armed with teeth, simple or multicuspid, horny, sitting on a soft papilla. Maxillary, mandibulary, lingual, and suctorial teeth may be distinguished. Eyes present (in mature animals). External nasal aperture in the middle of the upper side of the head. The nasal duct terminates without perforating the palate. Seven branchial sacs and apertures on each side behind the head; the inner branchial ducts terminate in a separate common tube. Intestine with a spiral valve. Eggs small. The larvæ without teeth, and with a single continuous vertical fin.

Genera: *Petromyzon*, *Mordacia*, and *Geotria*.

Family 2. *Myxinidæ*.—Body eel-shaped, naked. The single nasal aperture is above the mouth, quite at the extremity of the head, which is provided with four pairs of barbels. Mouth without lips. Nasal duct without cartilaginous rings, penetrating the palate. One median tooth on the palate, and two comb-like series of teeth on the tongue. Branchial apertures at a great distance from the head; the inner branchial ducts lead into the œsophagus. A series of mucous sacs along each side of the abdomen. Intestine without spiral valve. Eggs large, with a horny case provided with threads for adhesion.

Genera: *Myxine* and *Bdellostoma* (Hag-Fish).

Subclass IV.—*Leptocardii.*

Skeleton membrano-cartilaginous and notochordal, ribless. No brain. Pulsating sinuses in place of a heart. Blood colourless. Respiratory cavity confluent with the abdominal cavity; branchial clefts in great number, the water being expelled by an opening in front of the vent. Jaws none.

This subclass is represented by a single family (*Cirrostomi*) and by one or two genera (*Branchiostoma* and *Epigonichthys*); it is the lowest in the scale of fishes, and lacks so many characteristics, not only of this class, but of the vertebrata generally, that Haeckel, with good reason, separates it into a distinct class, that of *Acrania.* The various parts of its organization have been duly noticed in the former parts of this article. (A. C. G.)

ICHTHYOSAURUS (from ἰχθύς, a fish, and σαῦρος, a lizard), a genus of extinct reptiles, the species of which are the only known representatives of the order *Ichthyopterygia.* Upwards of thirty of these have been described, all of Mesozoic age, the genus so far as is certainly known appearing for the first time in the Liassic formation where it most abounds, continuing throughout the Oolitic, and disappearing before the close of the Cretaceous period. In Britain its remains have been found in greatest abundance in the Lias of Lyme Regis, although it occurs more or less commonly throughout the whole of that formation from the south of Dorsetshire through Somerset and Leicester to the Yorkshire coast. They are found in rocks of similar age in France and Germany; and Sir Edward Belcher obtained remains of a Liassic ichthyosaur from an island in 77° 16′ N. lat.,—one of many proofs that in Mesozoic times a comparatively warm climate must have prevailed within the Arctic Circle. Remains of true ichthyosaurs have not yet been found on the American continent, although Professor Marsh lately (1877) described portions of the skeleton of a saurian obtained from strata of Jurassic age in the Rocky Mountains which seems to have differed from Old World ichthyosaurs chiefly in the absence of teeth, the jaws being "entirely edentulous and destitute even of a dentary groove." For the reception of this form Professor Marsh proposes to institute a new order—*Sauranodonta*; but it has been suggested, on the other hand, that *Sauranodon* should rather be regarded as the type of a new family of the old order *Ichthyopterygia.*

Owing to the comparative abundance and excellent preservation of ichthyosaurian remains, the hard parts of those creatures have been studied under exceptionally favourable circumstances, and much has thus been learnt of their structure and, by inference therefrom, of their life history. They were large marine reptiles, measuring in some instances 30 feet in length, and somewhat resembling in appearance the dolphins of the present day. Like these they were air-breathers, and must therefore have come to the surface to breathe, although being cold-blooded they were no doubt able, like the aquatic saurians of our own period, to remain much longer under water than the warm-blooded *Cetacea.* The ichthyosaurian head was large, and was prolonged into a more or less elongated snout, certain species rivalling in this respect the gavial of the Ganges. The brain cavity, on the other hand, was remarkably small. The eyes were enormously large, the orbit in *Ichthyosaurus platyodon*—the largest known species—having been found to measure 14 inches in long diameter. This huge eyeball was protected by a ring of bony sclerotic plates similar to those found in rapacious birds and in turtles and lizards of the present day. The jaws, which in *Ichthyosaurus platyodon* have been known to measure 6 feet in length, were rendered still more formidable by their array of strong, conical, pointed teeth, numbering in some instances over one hundred and eighty, and placed not in distinct sockets, as in the crocodile, but in a common alveolar groove. These, as they became worn, were replaced by a succession of young teeth, which budded up at the base of the old. The neck in the ichthyosaurus was extremely short, and not marked by any constriction. The vertebræ resembled those of fishes in being deeply biconcave. The tail was long and tapering; in many specimens this organ has been found to be fractured at about a fourth of its length from the extremity, and, as the vertebræ of the same region seem to have been flattened vertically, Professor Owen regards it as probable that these reptiles were provided with a tegumentary caudal fin like that of the *Cetacea*, only vertical instead of horizontal; the sole evidence of the presence of such a horizontal fin in extinct whales would be the horizontally flattened condition of the last caudal vertebræ, should any of these chance to be preserved. Ichthyosaurians were provided with two pairs of limbs in the form of paddles, which externally must have borne considerable resemblance to the anterior limbs of dolphins and other *Cetacea.* They differed, however, very markedly from these in the possession of a bony apparatus, stretching, in the case of the front pair, from one shoulder joint to the other, on which the anterior paddles were supported. This "scapular arch," according to Professor Owen, resembled, "in the number, shape, and disposition of its bones," the same parts in the Australian *Ornithorhynchus*, a mammal which leads, as *Ichthyosaurus* did, an aquatic life, obtaining its food at the bottom of lakes and rivers, but having to rise frequently to the surface to breathe. The hind limbs were in almost all the species much smaller than the pair in front. The skeleton of each of the paddles consisted mainly of a large number—in some species exceeding a hundred—of small polygonal bones arranged in more than five closely packed longitudinal rows, the whole covered with skin, and forming a highly elastic organ of locomotion. The ichthyosaur was provided with slender ribs along the vertebral column from the anterior part of the neck to the tail; a sternum, however, was wanting, the abdominal walls being strengthened by the development of transverse arcuated bones. As no trace of horny scales or bony scutes has ever been detected in connexion with those reptilian remains, it may be assumed that these sea-saurians, as they have been called, were, like the *Cetacea* of the present day, covered with a smooth or wrinkled skin unprovided with any of those dermal appendages.

From a study of their bony structure it may be inferred that these huge aquatic reptiles inhabited the open sea, occasionally visiting the shores, where their powerful paddles enabled them to crawl on land, and where, like seals, they probably loved to bask in the sunshine. That they were predatory in their habits—the tyrants indeed of Mesozoic seas—might be inferred from our knowledge of their jaws and teeth; and this is amply confirmed by an examination of the half-digested contents of their stomachs.

Their food seems to have consisted chiefly of ganoid fishes and the smaller reptiles, and as the vertebræ and other remains of young ichthyosaurs have occasionally been found mixed with these, there is reason to believe that they, like many other marine animals, did not hesitate to devour the weaker members of their own species. In several instances tolerably complete skeletons of small ichthyosaurs have thus been found enclosed within the ribs of larger individuals of the same species, and their occurrence gave rise to the evidently erroneous conjecture that those reptiles might have been viviparous. The fact that the entombed specimens have in almost every case been found with the head turned towards the tail of the enclosing animal was supposed to favour this view; the discovery, however, of additional specimens may at any time deprive this argument of the little value it has, and recently Professor Merian described a specimen from the Upper Lias of Würtemberg in which the included ichthyosaur lay with its head towards that of the enveloping specimen. The nature of their food is indicated, not only by the occurrence, in what from its position must have been the stomach, of the half-digested remains of fishes and reptiles, but also by the presence of similar relics, and especially of the scales of fishes, in their fæces. The coprolites of the ichthyosaurians are oval bodies measuring usually from 2 to 4 inches in length, and exhibiting on their surface the impression of the spirally convoluted internal surface of the intestine. These coprolites consist chiefly of phosphate of lime, and occur in great abundance in certain Liassic beds, where, says Buckland, they look "like potatoes scattered on the ground."

The species of the genus *Ichthyosaurus* differ from each other chiefly in the proportion of certain parts of the body and of the teeth. Professor Huxley has divided them into two groups:—(1) those which have relatively short snouts and short paddles, with four carpalia, including therein such forms as *I. intermedius* and *I. communis*, the latter remarkable as having its anterior paddles three times the length of the pair behind; and (2) those with longer snouts, long paddles, and three carpalia, including such forms as *I. longirostris* and *I. tenuirostris*, which in the length of their snouts rival the gavial of the Ganges, and *I. platyodon*, in which the fore and hind limbs are of equal length.

ICONIUM (Greek Ἰκόνιον), an ancient city of Asia Minor, now, under the name of Cogni, Konieh, Koniyeh, Konijah, or Konia, the capital of the Turkish vilayet of Caramania, is situated 310 miles east from Smyrna, at the entrance to an extensive and elevated plain which forms the centre of Asia Minor. To the eastward this plain stretches beyond the horizon, but the city is enclosed on other sides by a semicircle of snow-covered mountains. It lies at the foot of Mount Taurus, and the country immediately around it, watered by streams from the surrounding mountains, is occupied by fruitful gardens and orchards, forming an oasis in the midst of wide-stretching barrenness and desolation. The numerous richly adorned mosques, chapels, shrines, and monuments attest the former importance of the city when in the zenith of its power and prosperity, and lend additional brightness and picturesqueness to its appearance as seen from a distance; but on closer inspection the splendour is seen to be so intermixed with squalor and decay as to degenerate into tawdriness. Ancient walls about 2 miles in circumference surround the older part of the town, but one half of the inhabited portion is outside their boundaries. These walls were built by the Seljuk sultans in the 13th century of large square blocks of stone which have evidently formed part of more ancient edifices; and they are flanked by square towers richly adorned with cornices, demi-lions couchant, eagles with outspread wings, and Arabic inscriptions. The gateways are ornamented with alto-rilievos representing figures in procession. Great part of the space inside the walls is occupied by crumbling ruins of houses, and by dilapidated mosques half-buried in rubbish and overgrown by weeds. Of the ancient Greek city there are now no remains, but Greek inscriptions are to be found in the ancient walls erected by the Turkish conquerors, and bas-reliefs and other relics have been dug up at various periods. Modern Konieh lies to the south-west of the old town, half of it being outside the walls. The houses are one-storied, unplastered, and built mostly of sun-dried bricks and wood. Among the numerous monuments of saints and sheiks is the famous green monument of Mevlana-Djelâl-eddin-Rûmi, the poet and founder of the spinning dervishes, large numbers of whom have taken up their quarters in the surrounding gardens. The most beautiful building of the city is the court mosque, with a lofty and finely tapering minaret glittering with porcelain. Of the old residence castle situated on the hill within the boundaries there are now only a few remains, great part of it having been used in building the Konak or palace of the pasha. Adjoining the ruins of the castle there is an old Byzantine chapel dedicated to St Thecla. Below the castle, and forming part of the western wall of the town, there is another fortress in a pretty good state of preservation, and for many years used as a state prison. The bazaar has a miserable appearance, and the principal goods exposed for sale are English and Swiss cottons and Nuremberg wares, the oppressive regulations of the Turkish Government in regard to the importation of salt having rendered the rearing of sheep wholly unprofitable, and thus entirely destroyed the native cloth-weaving industry. The number of dwelling-houses is about 7000, of which 150 are Armenian; and the population numbers in all probability between 40,000 and 50,000.

Iconium was situated on the military road between Antioch of Pisidia and Derbe. By Strabo (xii. 6, 1) it is spoken of as a small town (πολίχνιον), but by Pliny (*H. N.*, v. 25) as a very celebrated city. Xenophon (*Anab.*, i. 2, 19) mentions it as the nearest town to Phrygia; but Cicero (*Ad Div.*, iii. 6–8; xv. 4) calls it the capital of Lycaonia; while Ammianus Marcellinus (xiv. 2) reckons it as belonging to Pisidia. In the time of Pliny its territory formed a tetrarchy which embraced fourteen cities, many of them of considerable size. The apostle Paul visited Iconium on his first missionary tour from Antioch, and founded a Christian community there, but on account of the hostility of the Jews he deemed it expedient to retire to Lystra. Subsequently he twice visited the city; and it is the scene of the apocryphal story of Paul and Thecla, mentioned by many of the early fathers. About this time it became a Roman *colonia*, its Roman name being *Claudia* or *Claudiconium*. A Christian synod met at Iconium in 235. Under the rule of the Byzantine emperors the city continued to flourish, but in 708 it was conquered by the Arabs and incorporated in the caliphate. Having been conquered by the Seljuk Turks in 1074, Kilidj Arslan I. in 1097 made it his residence, and the capital of a kingdom whose rulers were named sultans of Iconium, and which may be regarded as the cradle of the Ottoman power. On May 18, 1190, Frederick Barbarossa, after a victory over the Turks on the 7th, captured the town, but failed to storm the castle. From 1244 the sultans were alternately deposed and reinstated by the khans of the Mongols, until the dismemberment of the sultanate on the death of Masoud II. in 1294, when their territories were added to Caramania, which in 1392 acknowledged the sovereignty of the Porte, and in 1486 was incorporated with the Ottoman empire. On 30th December 1832 the city was the scene of a victory over the Turks by Ibrahim Pasha. See Kinneir, *Travels in Asia Minor*; Hamilton, *Researches in Asia Minor*; Leake, *Geography of Asia Minor*; Chesney, *Euphrates Expedition*; Texier, *Asie Mineure*; and E. Sherling in the Berlin *Zeitschrift für allgemeine Erdkunde* for 1864.

ICONOCLASTS. See Image Worship.

ICTERUS, a bird so called by classical authors, and supposed by Pliny to be the same as the *Galgulus*, which nearly all writers agree in considering to be what we now know as the Golden Oriole (*Oriolus galbula*).[1] At any

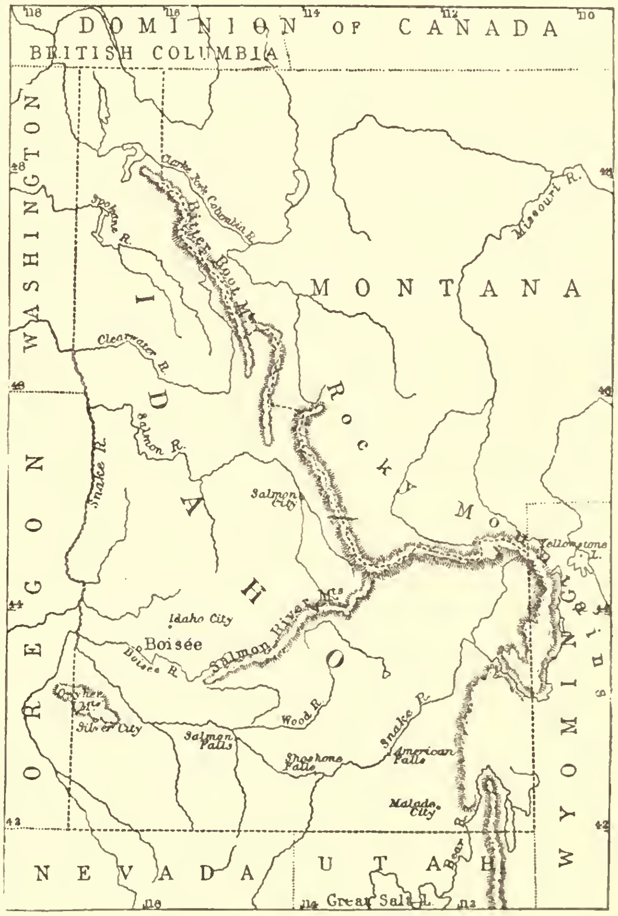
[1] The number of names by which this species was known in ancient times—*Chloris* or *Chlorion*, *Galbula* (akin to *Galgulus*), *Parra*, and

rate it signified one in the plumage of which yellow or green predominated, and hence Brisson did not take an unhappy liberty when he applied it in a scientific sense to some birds of the New World of which the same could be said. These are now held to constitute a distinct Family, *Icteridæ*, intermediate it would seem between the BUNTINGS (vol. iv. p. 525) and STARLINGS (*q. v.*); and, while many of them bear the vulgar name of Troopials (the English equivalent of the French *Troupiales*, first used by Brisson), others are known as the American GRACKLES (vol. xi. p. 26). The typical species of *Icterus* is the *Oriolus icterus* of Linnæus, the *Icterus vulgaris* of Daudin and modern ornithologists, an inhabitant of northern Brazil, Guiana, Venezuela, occasionally it is said visiting some of the Antilles and of the United States, but without much apparent proof. Thirty-three species of the genus *Icterus* alone, and more than seventy others belonging to upwards of a score of genera, are recognized by Messrs Sclater and Salvin (*Nomenclator*, pp. 35–39) as belonging to the Neotropical Region, though a few of them emigrate to the northward in summer. It would of course be impossible here to dwell upon them, but *Cassicus* and *Ostinops* may perhaps be named as the most remarkable. They are nearly all gregarious birds, many of them with loud and in most cases, where they have been observed, with melodious notes, rendering them favourites in captivity, for they readily learn to whistle simple tunes, which are admirably reproduced by their clear voice. Some have a plumage wholly black, others are richly clad, as is the well-known Baltimore Oriole, Golden Robin, or Hangnest of the United States, *Icterus baltimore*, whose brightly contrasted black and orange have conferred upon it the name it most commonly bears in North America, those colours being, says Catesby (*Birds of Carolina*, i. p. 48), the tinctures of the armorial bearings of the Calverts, Lords Baltimore, the original grantees of Maryland, but probably more correctly those of their liveries. The most divergent form of *Icteridæ* seems to be that known in the United States as the Meadow-Lark, *Sturnella magna* or *S. ludoviciana*, a bird which in aspect and habits has considerable resemblance to the Larks of the Old World, *Alaudidæ*, to which, however, it has no near affinity, while *Dolichonyx oryzivorus*, the Rice-bird, with its very Bunting-like bill, is not much less aberrant. (A. N.)

IDAHO, a north-western territory of the United States, was originally a part of Oregon, from which it was separated in 1863. It lies on the Pacific slope, with the exception of a small portion in its south-eastern corner, which is drained into the Great Salt Lake of Utah. It is bounded on the N. by British Columbia and N.E. by Montana; on the E. by Wyoming; on the S. by Utah and Nevada; and on the W. by Oregon and Washington. The boundaries are the meridians (111° and 117° W. long.) and the 42d and 49th parallels of N. lat., except that in the N.E. the Bitterroot range separates the territory from Montana, and the Snake river forms part of the western limit. The area of the territory is imperfectly known, but may be set down approximately at 86,300 square miles. The mean elevation is about 4700 feet. The lowest point, which is on Snake river, at the mouth of the Clearwater, is about 1000 feet above the sea, while the highest mountains rise nearly to 10,000 feet. The surface is very diversified; the northern portion is largely mountainous, with several fine broad valleys. In the southern portion a large area within the great bend of the Snake river is occupied by an immense plain of basalt. South of the Snake the country is an alternation of broad valleys and narrow abrupt mountain ranges.

The principal mountains are the Bitterroot and Salmon River chains, with their spurs and subordinate ranges. They attain a height of from 8000 to nearly 10,000 feet. The Snake River plain lies south of these mountains, extending east and west nearly across the territory. This is a field of basalt, seamed and crevassed, with little vegetation, and that consisting principally of *Artemisia*. The soil here is a shifting sand; and there is little surface water, as the streams sink and flow underneath.

The principal river is the Snake, the south fork of the Columbia. It is a rapid stream with numerous falls, three of which, the American, Shoshone, and Salmon or Fishing, are very considerable. It is navigable only in its lower course. Several of the branches of the Snake, the Salmon, Clearwater, and Spokane, are large streams, but are not navigable, and are of value only for irrigation and mining purposes.



Map of Idaho.

The climate, like that of other portions of the north-western United States, is characterized by great aridity of atmosphere and slight rainfall. In the south the aridity is such that large areas are almost desert; but in the mountainous regions of the north the rainfall is much greater, and agricultural operations can be carried on to some extent without irrigation. The northern part, being principally mountainous, is covered with forests of conifers, chiefly species of pine, spruce, fir, and tamarack. In the open valleys the vegetation consists mainly of the various kinds of grasses known collectively as "bunch grass." On the Snake River plains there is little vegetable growth

Vireo—may be readily explained by its being a very common and conspicuous bird, as well as one which varied in plumage according to age and sex (*cf.* ORIOLE). Owing to its general colour, *Chloris* was in time transferred to the GREENFINCH (vol. xi. p. 165), while the names *Galbula*, *Parra*, and *Vireo* have since been utilized by ornithologists (*cf.* JACAMAR and JACANA).

except *Artemisia*, while the country south and east of the Snake is covered with this and with grasses, with a little scattered timber (*Coniferæ* and aspens) on the mountains. A rough estimate gives as the area covered by forest 40,000 square miles, by useful grasses 25,000 square miles, and by *Artemisia* 21,300 square miles.

Though the bison formerly ranged over this whole region, it is now practically extinct. The moose is still occasionally seen, and, rarely the Rocky Mountain goat (*Aploceras montanus*). The wapiti, the mountain sheep (*Ovis montana*), and various species of deer are still abundant in the mountains, while the antelope or pronghorn abounds in the plains. Grizzly, black, and cinnamon bears, the American panther, the wild cat, and the wolverine are not unfrequently met with in the unsettled regions. Among the smaller quadrupeds, the prairie dog and gopher are abundant in the valleys and on the plains. Birds of many species are plentiful, especially in the mountain regions. Of reptiles, several species of rattlesnakes and lizards, including horned toads (*Phrynosoma*), are characteristic of the arid plains, where they are numerous.

The southern portion of this territory has been the scene of comparatively recent volcanic action, which has covered enormous areas with basalt. The mountains of this portion are mainly of the Silurian and Carboniferous ages. The ranges of the northern portion are known to be mainly Eozoic; but the geology of that section has yet to be investigated.

The administration of the territory is in the hands of a governor, secretary, and chief justice, all appointed by the president of the United States, and a treasurer, comptroller, and superintendent of public instruction, who, as well as the members of the two houses of the legislature, are elected by the people. The territory is represented in Congress by a delegate, also elective. The population in 1880 was 32,946, distributed thus in the several counties :—

County.	Population.	County.	Population.
Ada	4674	Nez Percé	4483
Alturas	1693	Oneida	6952
Bear Lake	3242	Owyhee	1427
Boisé	3213	Shoshone	469
Cassia	1315	Washington	877
Idaho	2371		
Kootenai [1]		Total	32,946
Lemhi	2230		

The principal settlements are Malade, Boisé (the capital of the territory), Idaho, Buenavista, and Silver City.

The agricultural, grazing, and mining interests of Idaho are but commencing their development. In the valleys of the southern portion the Mormons are raising abundant crops of cereals, with the aid of irrigation. In the valleys of the lower Snake, the Boisé, Clearwater, Salmon, and Spokane rivers, wheat, oats, rye, and other grains are cultivated to some extent. Large portions of the territory are well adapted for grazing, and this is now being turned to account.

The mineral wealth has not yet, owing to difficulty of transportation, been developed to any great extent; but it is known to be important. Gold and silver are found, the former both in vein and in placer deposits. The principal vein deposits now being worked are in the Salmon River and Owyhee mountains. Placers have been worked in nearly every county of the territory, and have paid well. During the year 1880 many new and rich deposits have been discovered in the Wood River district, in the Salmon River mountains, and there has been a considerable influx of mining population.

The Utah and Northern Railroad crosses the south-eastern portion of the territory, from Utah to Montana.

The total number of Indians in Idaho is about 6000, consisting of the tribes known as the Nez Percé, Bannack, Shoshone, Cœur d'Alène, Spokane, Pend' Oreille, and Kootenai. They are under the control of the Government, and most are settled on reservations. (H. G.*)

IDIOCY. See INSANITY.

IDLE, a town of the West Riding of Yorkshire, in the parish of Calverley, is pleasantly situated on an eminence near the river Aire, on the Great Northern Railway, 9 miles north-west of Leeds and 3 north of Bradford. The staple manufacture is woollen cloth; there are also worsted mills, and a cotton-warp factory. There are several stone and slate quarries in the neighbourhood. The church of the Holy Trinity, erected in 1830 in the Later English style, is a handsome structure with embattled tower crowned with pinnacles; and there are national and other schools, an oddfellows' hall, a mechanics' institute, and a church institute. The population (including Windhill, which is a separate vicarage) in 1861 was 9155, and in 1871 it had reached 12,036.

IDOLATRY. The word εἰδωλολατρεία (*idololatria*, afterwards shortened occasionally to εἰδολατρεία, *idolatria*) occurs in all four times in the New Testament, viz., in 1 Cor. x. 14, Gal. v. 20, 1 Pet. iv. 3, Col. iii. 5. In the last of these passages it is used, obviously in a typical sense, to describe the sin of covetousness or "mammon-worship." In the other places it is employed in its natural sense, but with the utmost generality, to indicate all the rites and practices of those special forms of Paganism with which Christianity first came into collision. It can only be understood by reference to the LXX., where εἴδωλον (like the word "idol" in A.V.) occasionally translates indifferently no fewer than sixteen words by which in the Old Testament the objects of what the later Jews called "strange worship" (עֲבוֹדָה זָרָה) are denoted (see Trommius, *Concordantiæ*). In the widest acceptation of the word, idolatry in any form is absolutely forbidden in the second commandment, which runs "Thou shalt not make unto thee a graven image; [and] to no visible shape in heaven above, or in the earth beneath, or in the water under the earth, shalt thou bow down or render service" (see DECALOGUE, vol. vii. p. 15). For some account of the various interesting questions connected with the many practical departures from this law which are recorded in the history of the Israelites the reader is referred to the article JEWS; those differences as to the interpretation of the prohibition which have so seriously divided Christendom are discussed under the head of IMAGE WORSHIP.

In the ancient church, idolatry was naturally reckoned among those magna crimina or great crimes against the first and second commandments which involved the highest ecclesiastical censures. Not only were those who had gone openly to heathen temples and partaken in the sacrifices (sacrificati) or burnt incense (thurificati) held guilty of this crime; the same charge, in various degrees, was incurred by the libellatici, whose renunciation of idolatry had been private merely, or who otherwise had used unworthy means to evade persecution, by those also who had feigned themselves mad to avoid sacrificing, by all promoters and encouragers of idolatrous rites, and by idol makers, incense sellers, and architects or builders of structures connected with idol worship. Idolatry was made a crime against the state by the laws of Constantius (*Cod. Theod.*, xvi. 10. 4, 6) forbidding all sacrifices on pain of death, and still more by the statutes of Theodosius (*Cod. Theod.*, xvi. 10. 12) enacted in 392, in which sacrifice and divination were declared treasonable and punishable with death; the use of lights, incense, garlands, and libations was to involve the forfeiture of house and land where they were used; and all who entered heathen temples were to be fined. See Bingham, *Antiqq.*, bk. xvi. c. 4.

[1] Unorganized, and attached to Nez Percé county.

IDRIA, a mining town in Austria, in the duchy of Carniola and circle of Loitsch, situated in a narrow Alpine valley on the river Idrizza, 28 miles north-north-east of Trieste. It is the seat of a circle court and of an office of mines, the building used for which is the old castle of Gewerkenegg or Gewerkenburg, built in 1527 by the miners during the lordship of the Venetian republic. The town also possesses a handsome church, a high school, a mining school, and a theatre. Linen weaving, lace making, and gin distilling employ a considerable number of the inhabitants, but the origin and prosperity of the town are due to the rich mines of quicksilver which were accidentally discovered in 1497. Since 1580 they have been under the management of the Government. The mercurial ore lies in a bed of clay slate, and is found both mingled with schist and in the form of cinnabar. A special excellence of the ore is the greatness of the yield of pure metal compared with the amount of the refuse. The mine is reached by a shaft 150 fathoms deep, and the descent is accomplished partly by means of ladders and partly by steps cut out of the solid rock. The number of miners employed is about five hundred; they wear a peculiar uniform. Formerly the mines were wrought by state prisoners, but notwithstanding the unhealthiness of the employment it is now largely sought after on account of the high wages offered to the workmen, as well as the pension allowed them when disabled, and the provision that is made for their widows and orphans. In 1870 improved ovens for smelting the ore were erected. The yearly yield of the mines is about 290 tons. The population of Idria in 1869 was 3813.

IDRISI. See EDRISI.

IDUMEA (Ἰδουμαία) is the Greek form of the Hebrew Edom (אֱדֹם), a district south of the Holy Land. The name Edom is restricted in the Bible to the mountain country south-east of the Dead Sea, and to the chain of Mount Hor near Petra. The word means "red," and the title was no doubt derived from the red colour of the cliffs of Nubian sandstone, which form the greater part of this chain. The coast or desert of Edom was bounded by the desert of Zin (the present *'Arabah*) on the W., by the desert of Paran on the S.W., and extended as far as Ezion-geber and Eloth, at the head of the Gulf of Akabah. It is identified with Mount Seir, the possession of Esau (Gen. xxxii. 3). In later times, however, we find that the term Idumea receives a considerable extension, embracing all the pastoral country south of Judæa, and extending even within the borders of Philistia. Bethsura (*Beit Sûr*), Acrabattine (Acrabbim), and Hebron are in 1 Macc. iv. and v. alluded to as within or near its limits.

By Josephus the term Idumea is used with this more extended meaning, embracing an area of 3000 square miles. It answers to the Biblical term Negeb ("dry") applied to the south country, where the formation is a soft chalk, and which is inhabited by nomadic pastoral tribes. Josephus divides the Idumean district into minor divisions, viz., (1) Gobalitis ("mountains"), the original Seir or Edom; (2) Amalekitis ("the land of Amalek"), west of the former; (3) Acrabattine ("the scorpion land"), the ancient Acrabbim south-west of the Dead Sea. The frontier towns on the north were Tekoa, Bethsura, and Bethgubrin (*Beit jibrîn*), and among the more important places within the district were Hebron, Petra, Arad, Malatha (*Tell el Milh*), Beersheba, Rehoboth, Elusa (*Khalasah*), Eboda (*'Abdeh*), &c. Josephus speaks of Upper Idumea, apparently the district round Hebron, and enumerates Begabris (*Beit jibrîn*) and Caphar Topha (*Tuffûh*, near Hebron) among its towns.

In the Talmud Eleutheropolis (*Beit jibrîn*) is placed in Idumea (*Midrash Yalkut*, Gen. xxxiii., and *Bereshith Rabba*, ch. vi.). Jerome defines Idumea as extending from Eleutheropolis to Petra and Eloth. The south boundary of the Holy Land, as defined in the Talmud, included Idumea, the reason being that the Idumeans had embraced Judaism about 140 B.C. (Joseph., *Ant.*, xiii. 9, 1). Strabo (lib. xvi.) speaks of the Edomites as of Nabathean or Arab origin. Pliny (*H. N.*, v. 12) makes the country extend southwards to the Serbonian bog (near the present Port Said). Ptolemy (v. 15), in the middle of the 2d century, restricts the name to a district west of Jordan, including Elusa (*Khalasah*) and Gemmaruris (probably *Jemrûrah* in the Hebron hills). The original Edom is called by this geographer Arabia Petræa.

The aboriginal inhabitants of Idumea were the Horim or "cave dwellers" expelled by Esau. Mount Seir is said to have been named after one of their chiefs (Gen. xxxvi. 20, Deut. ii. 12). Jerome speaks of the natives of this country as still dwelling in caves, and in common with the Talmudic writers attributes to them the great caverns at Eleutheropolis. The inhabitants appear to have been always nomadic and pastoral, they were mingled with the Jews (tribe of Simeon) and with the Hittites. At the time of the great siege of Jerusalem the Idumeans fought in concert with the Jews (Jos., *B. J.*, vi. 8, 2), and the Romans applied the name Idumea very loosely to the whole of southern Palestine, including even Jerusalem. At the present day the habit of living in caverns is very marked in this district, the rock being soft and easily excavated. The soil is generally a soft white marl, producing a rich herbage in spring, and supporting numerous flocks. (C. R. C.)

IFFLAND, AUGUST WILHELM (1759-1814), a German actor and dramatic author, was born in Hanover on the 19th of April 1759. His father was registrar at the war office of Hanover, and intended that his son should be a clergyman. Young Iffland, however, preferred the stage to theology, and at the age of eighteen went to Gotha in order to prepare himself for a theatrical career. At that time the greatest actor in Germany was Eckhof, a man of undoubted genius, for whom Lessing repeatedly expressed the warmest admiration in his *Hamburgische Dramaturgie*. Iffland was fortunate enough to receive instruction from him in Gotha, and under his guidance made such rapid progress that he was able in 1779 to accept an engagement at the theatre in Mannheim, then the most famous of the German theatres. He soon stood high in his profession, and extended his reputation by frequently appearing at the leading theatres in different parts of the country. In 1796 he settled in Berlin, where he became director of the national theatre of Prussia; and in 1811 he was made general director of all representations before royalty. On the 22d of September 1814 he died. His plays are almost entirely destitute of imagination; but they display a thorough mastery of the technical necessities of the stage, and a remarkable power of devising effective situations. His best characters are simple and natural, fond of domestic life, but too much given to the utterance of sentimental commonplace. His best known plays are *Die Jäger*, *Dienstpflicht*, *Die Advocaten*, *Die Mündel*, and *Die Hagestolzen*, all of which are still occasionally represented. Iffland was a dramatic critic as well as a dramatic author, and German actors place high value on the reasonings and hints respecting their art which are to be found in his *Almanach für das Theater*. As an actor he fell far short of his master, Eckhof, whose style was marked by spontaneity and passion, while Iffland's acting always bore traces of elaborate study. Hence he failed in great tragical parts; but he was unexcelled in his day in the skill with which he interpreted dramatic conceptions representing the course of ordinary middle class life. Within these limits he was almost equally distinguished in his capacity for rendering comic and pathetic effects. In 1798-1802 Iffland issued his *Dramatic Works* (with an autobiography) in 16 volumes, to which, in 1807–9, he added 2 volumes of *New Dramatic Works.* Two selections from his writings were afterwards published, the one in 10, the other in 11 volumes.

See K. Duncker, *Iffland in seinen Schriften als Künstler, Lehrer, und Director der berliner Bühne*; and Koffka, *Iffland und Dalberg.*

IGLAU, or Jihlava, one of the oldest towns of Moravia, and second only to Brünn in respect of size and population, is situated about 50 miles west-north-west of that city, and on the right bank of the Iglawa, close to the Bohemian frontier, in 49° 25′ N. lat. and 15° 34′ E. long. Iglau is the capital of a circle of the same name, the seat of the judicial authorities, and the military headquarters of the district. It consists of the town proper and the suburbs of Frauen, Pirnitzer, and Spital. Among the principal buildings are the churches of St James, St Ignatius, St John, and St Paul, the town-hall, a gymnasium, a high school, a military seminary, civil and criminal courts, several hospitals, and the barracks formed from a monastery abolished by order of the emperor Joseph II. There is also a fine cemetery, containing some remarkable monuments. The industrial establishments comprise cloth and linen weaving, paper, earthenware, and glass factories; potash, vinegar, and dye works; tanneries, iron foundries, a large brewery, and an extensive cigar factory, employing over 2000 hands. Fairs are periodically held in the town; and the trade in timber, cereals, and linen and woollen goods is generally brisk. The population in 1870 amounted to about 20,200, most of whom were Germans or of German extraction.

At a very early date Iglau enjoyed exceptional privileges, and they were confirmed by King Wenceslaus III. in the year 1250. The town-hall contains a collection of municipal and mining laws dating as far back as 1389. At Iglau, on July 5, 1436, the treaty was made with the Hussites, by which Sigismund was acknowledged King of Bohemia. A granite column near the town marks the spot where Ferdinand I., in 1527, swore fidelity to the Bohemian states. During the Thirty Years' War Iglau was twice captured by the Swedes. In 1742 it fell into the hands of the Prussians, and in December 1805 the Bavarians under Wrede were defeated near the town by the archduke Ferdinand d'Este.

IGLESIAS, a town of Sardinia, capital of a district in the province of Cagliari, is beautifully situated amongst limestone hills about 3 miles from the west coast, and at the terminus of a railway line from Cagliari, 34 miles west-north-west from that town. It is the seat of the suffragan bishop of Cagliari, and possesses a cathedral, an episcopal palace, four convents, a Jesuit college, and the ruins of old fortifications. The town is abundantly supplied with water from various springs. The surrounding country is highly productive, and there is an active trade in wine, oil, fruits, cheese, corn, and other agricultural products. Lead and zinc are obtained in the neighbourhood. The population of the town in 1871 was 6630.

IGLÓ, formerly Neudorf, a mining town of North Hungary, in the county of Szepes or Zips, is pleasantly situated on the Hernád, and on the Kaschau-Oderberg line of railway, about 5 miles south of Löcse (Leutschau), in 48° 56′ N. lat. and 20° 33′ E. long. Among the few public buildings are Lutheran and Roman Catholic churches, a gymnasium, a teachers' seminary, a circuit court, and the usual Government offices. There are, moreover, factories for the manufacture of stoneware, fuller's earth, linen, and paper; also sawmills, steam flour mills, and iron foundries. In the vicinity are extensive iron and copper mines and stone quarries. The inhabitants of the town and neighbourhood are chiefly employed in mining, bee-keeping, flax-growing, agriculture, and trade. The population (including that of Great and Little Igló-Hnilecz) amounts to 6691, mostly German by nationality and Lutheran by creed. Igló was formerly the capital of the sixteen privileged Zips towns, and its origin may be traced to Saxon colonists of the 12th century.

IGNATIUS, St. See Apostolic Fathers, vol. ii. p. 196.

IGNATIUS DE LOYOLA, St. See Loyola.

IGNORANTINES (*Frères Ignorantins*), as the Brethren of the Christian Schools (*Frères des Écoles Chrétiennes*) are commonly though improperly called, are a religious fraternity founded at Rheims in 1679, and formally organized in 1683, by the priest Jean-Baptiste de La Salle, for the purpose of affording a free education, especially in religion, to the children of the poor. The name Ignorantine was given either on account of the low class of the pupils, or from a clause in the rules of the order forbidding its members to learn or teach Latin. Other popular names applied to the order are *Frères de Saint-Yon*, from the house at Rouen, which was their headquarters from 1705 till 1770, *Frères à quatre bras*, from their hanging sleeves, and *Frères Fouetteurs*, from their former use of the whip (*fouet*) in punishments. The brethren, although not allowed by their rules to enter holy orders, take the usual vows of chastity, poverty, and obedience. They are distinguished by a peculiar coarse black dress, consisting of a cassock, a hooded cloak with hanging sleeves, and a broad-brimmed hat. The order, approved by Pope Benedict XIII. in 1725, rapidly spread over France, and although expelled after the Revolution of 1789, was recalled by Napoleon in 1803, and formally recognized by the French Government in 1808. Since then its members have penetrated into nearly every country of Europe, and into America, Asia, and Africa. In France alone they number more than 1300 schools for young and old, attended by upwards of 300,000 pupils, taught by some 8000 masters. See *Histoire du Vénérable J.-B. de la Salle*, by A. Ravelet, 2d ed., Paris, 1874.

IGUALADA, a town of Spain, in the province of Barcelona, is situated on the left bank of the Noya, in a rich agricultural and vinebearing country, 32 miles north-west of Barcelona. It consists of an old and a new town, the former dilapidated and dirty, with narrow and irregular streets and the remains of a fortress and ramparts, while the latter possesses regular and spacious streets and many fine houses. Among the public buildings are an old Gothic church, a town-hall, two conventual buildings, a clerical college, a hospital, and military barracks. The former commercial prosperity of Igualada has now much declined, but its industries are still considerable, and comprise cotton spinning, cotton and woollen weaving, and the manufacture of firearms, leather, hats, and brandy. There is also some trade in corn. Population in 1877, 11,882.

IGUANA (*Iguanidæ*), a family of lizards belonging to the suborder *Pachyglossæ* or "thick-tongued," and comprising 56 genera and 236 species. With a single undoubted exception, all the genera of this extensive family belong to the New World, being specially characteristic of the Neotropical region, where they occur as far south as Patagonia, while extending northward into the warmer parts of the Nearctic region as far as California and British Columbia. The single non-American genus—*Brachylophus*—occurs in the Fiji Islands. The iguanas are characterized by the peculiar form of their teeth, these being round at the root and blade-like, with serrated edges towards the tip, resembling in this respect the gigantic extinct reptile iguanodon. The typical forms belonging to this family are distinguished by the large dewlap or pouch situated beneath the head and neck, and by the crest, composed of slender elongated scales, which extends in gradually diminishing height from the nape of the neck to the extremity of the tail. The latter organ is very long, slender, and compressed, while its vertebræ, in common with those of certain other lizards, possess thin unossified septa traversing their centres. It is owing to the weakness thus produced in their vertebral column that, when caught by the tail, they are able to part so readily with the portion seized. The tongue is generally short and not deeply divided at its extremity, nor is its base retracted into a sheath; it is always moist and covered with a glutinous secretion. The prevailing colour of the iguanas is green; and, as the majority of them are arboreal in their habits, such colouring may be generally regarded as protective. Those on the other hand which reside on the ground have much duller, although as a rule equally protective hues; thus Darwin observed on the shore at Bahia a terrestrial member of this family, which from its mottled appearance could hardly be distinguished from the surrounding surface. Iguanas, however, possess to an extent only exceeded by the chameleon the power of changing their colours, their brilliant green becoming transformed in an instant, under the influence of fear or irritation, into more sombre hues and even into black. They differ greatly in size, from a few inches to several feet in length. One of the largest and most widely distributed is the common iguana (*Iguana tuberculata*), which occurs in South America and the West Indies. It attains a length of 5 feet, and is of a greenish

Iguana.

colour occasionally mixed with brown, while the tail is surrounded with alternate rings of those colours. Its food consists of vegetable substances, which it obtains from the forest trees among whose branches it lives and in the hollows of which it deposits its eggs. These are of an oblong shape, about an inch and a half in length, and are said by travellers to be very pleasant eating, especially when taken raw, as they usually are, and mixed with farina. They are timid, defenceless animals, depending for safety on the comparative inaccessibility of their arboreal haunts and their protective colouring, which is rendered even more effective by their remaining still on the approach of danger. Otherwise they exhibit few signs of animal intelligence. "The iguana," says Bates (*The Naturalist on the Amazon*), "is one of the stupidest animals I ever met. The one I caught dropped helplessly from a tree just ahead of me; it turned round for a moment to have an idiotic stare at the intruder, and then set off running along the path. I ran after it and it then stopped as a timid dog would do, crouching down and permitting me to seize it by the neck and carry it off." Along with several other species the common iguana is much sought after in tropical America; the natives esteem its flesh a delicacy, and capture it by slipping a noose round its neck as it sits in fancied security on the branch of a tree. Although chiefly arboreal, many of the iguanas take readily to the water; and there is at least one species, *Oreocephalus cristatus*, which leads for the most part an aquatic life. These marine lizards occur only in the Galapagos Islands, where they are never seen more than 20 yards inland, while they may often be observed in companies several hundreds of yards from the shore, swimming with great facility by means of their flattened tails. Their feet are all more or less webbed, but in swimming they are said to keep these organs motionless by their sides. Their food consists of marine vegetation, to obtain which they dive beneath the water, where they are able to remain, without coming to the surface to breathe, for a very considerable time. Though they are thus the most aquatic of lizards, Mr Darwin, who studied their habits during his visit to those islands, states that when frightened they will not enter the water. Driven along a narrow ledge of rock to the edge of the sea, they preferred capture to escape by swimming, while if thrown into the water they immediately returned to the point from which they started. A land species belonging to the allied genus *Trachycephalus* also occurs in the Galapagos, which differs from most of its kind in forming burrows in the ground.

IGUANODON, a genus of extinct Dinosaurian reptiles, the remains of which have been found in greatest abundance in the Wealden, a delta formation of the south-east of England. They also occur, though more sparingly, in the Lower Greensand, where lately (1879) Professor Prestwich announced the discovery in the "Kimmeridge Clay" of what are as yet the earliest known remains of these reptiles. Although no complete skeleton of the iguanodon has been found, such bones of it as have been obtained prove it to have been one of the largest terrestrial animals known. Thus its femur in one instance measured from 4 to 5 feet in length, with a circumference of 22 inches at its narrowest part. These and other measurements led Dr Mantell—the original discoverer of *Iguanodon*—and others to conclude that it probably attained a length of from 50 to 60 feet. Its front limbs appear to have been small, while the hind pair attained enormous development, and from the structure of the latter, which may be regarded as intermediate between those of existing reptiles and of birds, the iguanodon is supposed to have either habitually or occasionally walked on its hind legs like a bird. This supposition is rendered all the more probable by the discovery in the same strata of gigantic three-toed footsteps in pairs such as might have been formed by the iguanodon had it walked in this bipedal manner. The teeth of these animals formed one of their most marked characteristics,—bearing a striking resemblance to the teeth of existing iguanas in their blade-like form and serrated edges, but differing from these as well as from those of all other known reptiles in internal structure. Like existing iguanas they were probably herbivorous, using their teeth for cutting and tearing their tough vegetable food; unlike these, however, they appear to have used their teeth also for the purpose of mastication. This is shown by the deeply worn condition in many cases of the crowns of their teeth, which, from being sharp and incisor-like, gradually assumed a molar-like form. As the old teeth were thus reduced by "tear and wear," they were gradually replaced by a fresh dental crop. The front portion of the jaws was destitute of teeth, the upper part being beak-like, while the lower was hollowed out like the same region in the parrot.

Professor Owen regards this as an arrangement to facilitate the protrusion of what was probably a long prehensile tongue—an organ which the iguanodon may be supposed to have employed in stripping the foliage from the trees. There is no fossil evidence to show that it possessed either scutes, scales, or any other form of dermal armour.

IGUVIUM. See Eugubine Tables and Gubbio.

ILCHESTER, formerly Ivelchester, a market-town of Somersetshire, is situated in the valley of the river Ivel or Yeo, 33 miles south-south-west of Bath, and 5 miles north-north-east of Yeovil railway station. It is connected by a stone bridge with the village of Northover on the other side of the river. The principal buildings are the parish church of St Mary, an old edifice in the Early English style, with a small octagonal tower, and the town-hall. It possesses almshouses, founded in 1426, and national schools. There are no manufactures or trade, and the importance of the town belongs wholly to the past. Under the Romans it was a military station, and bore the name of *Ischalis*. Anciently it was a place of considerable extent, and was defended by walls and a deep moat. Traces of these fortifications are still to be found, and numerous Roman remains have been discovered at different periods. During a rebellion against William Rufus in 1088, the town was successfully defended against Robert Mowbray, one of the leaders of the insurgents. Before the Reform Act of 1832, when it was disfranchised, Ilchester returned two members to parliament. The county jail was there until 1846. The population of the town in 1871 was 751.

ÎLE-DE-FRANCE, an old district of France, forming a kind of island, bounded by the Marne, the Seine, the Oise, the Aisne, and the Ourcq. Until the end of the Carlovingian dynasty it was included in the domains of the crown. The government of Île-de-France, named after this district, now embraces the department of the Seine, together with the greater part of Seine-et-Oise, Seine-et Marne, Oise, and Aisne, and a small part of Loiret and Nièvre. It was bounded on the N. by Picardy, on the W. by Normandy, on the S. by Orléannais and Nivernais, and on the E. by Champagne. Its capital was Paris.

ILFRACOMBE, a market-town, seaport, and watering-place of Devonshire, is picturesquely situated on the Bristol Channel, and at the terminus of a branch of the London and South-Western Railway, 11 miles north by west of Barnstaple, and 50 miles north-west by west of Exeter. The parish is under the government of a local board of health, established in 1857. The old town, built on the cliffs above the harbour, consists of a principal street about a mile in length, with smaller streets branching off from it. Behind the old town many fine villas and marine residences rise in beautiful terraces commanding picturesque and magnificent views. The heights or torrs overspread with foliage form a sort of semicircle round the town, stretching westwards to a considerable distance; and it is sheltered from the sea by the Capstone Rock. Hillsborough Rock, on the east side of the harbour, with a height of about 500 feet, has near its summit some remains supposed to be of Celtic origin. On Lantern Rock, at the west side of the harbour, a lighthouse has been erected. For access to the bathing ground, which is confined to a few small coves at the foot of the rocks, three tunnels have been cut through the solid rock. Inland the country presents a beautiful variety of hill and dale, clothed with woods and possessing a rich and luxuriant vegetation. The principal public buildings are the parish church, dating from the 12th century, and recently restored, and St Philip and St James's Church, recently erected at a cost of over £10,000, the town-hall erected in 1860, the market-house of the same date, the baths, and the assembly rooms. Waterworks were completed in 1866 at a cost of £7000. The harbour, formed wholly of a natural basin, admits vessels of more than 200 tons burden, and there is a pier 850 feet in length. Herring fishing is prosecuted, but the shipping trade has considerably declined. The population of the parish, which in 1861 was 3851, was 4721 in 1871.

The name of the town is differently spelt in old documents, the variations being Ilfordscombe, Alfredscombe, Alfrincombe, Ilfarcombe, and Ilfridcombe. In the latter part of the 13th century it obtained a grant for holding a fair and market, and in the reign of Edward III. it was a place of such importance as to supply him with six ships and ninety-six men for his armament against Calais. During the Parliamentary war, being garrisoned for the Roundheads, it was in 1644 captured by the Royalists, but in 1646 it fell into the hands of Fairfa

ILHAVO, a town of Portugal, province of Beira and district of Alveiro, is situated on the Atlantic Ocean, 8 miles south-west of Alveiro and 34 north-west of Coimbra. It is inhabited chiefly by fishermen, but has a celebrated manufactory of glass and porcelain, the Vista-Alegre, at which the art of glass-cutting has reached a high degree of perfection. Salt is largely exported. The population is about 6000.

ILI, one of the principal rivers of Central Asia, in what is now the Russian province of Semiryetchensk. The head-stream, called the Tekes (French form, Tekesse), rises at a height of 11,600 feet in the Ulabas mountains, which lie to the E. of Lake Issyk-kul, about 79° 50′ E. long. and 42° 40′ N. lat. At first it flows eastward and north-eastward through a mountainous gorge which gradually widens into a valley of considerable breadth between the Tian-Shan range on the south and the Kara-Tau and the Temur-lik or Nan-Shan on the north. Meeting the Kunges (French form, Koungesse) from the east, the river takes a westerly direction; and under the name of Ili it continues to hold westward for about 300 miles, to the neighbourhood of the military post of Ili or Ilijsk in 77° 5′ E. long. The valley between 79° 30′ and 82° E. long. is about 50 miles wide, and the portion above the town of Kuldja (Old Kuldja) is fertile and populous, Tarantchi villages following each other in rapid succession, and the pastures being well stocked with sheep and cattle and horses. At Ilijsk the river turns north-west, and at length, after traversing a district of desert and marsh, it falls by at least seven mouths into the Balkhash Lake, the first bifurcation of the delta taking place about 115 miles up the river. From Old Kuldja to New Kuldja, according to Captain Fischer (1871), the Ili is navigable for only two and a half months at most, and even then considerable difficulty is occasioned by the shoals and banks. From New Kuldja to Ilijsk (280 miles) navigation is easy when the water is high, and practicable even at its lowest condition. The section from Ilijsk to Lake Balkhash (about 240 miles) was explored in 1856 at the instance of Mr Kutznezoff, who had a boat built on the lake and towed up stream; he found a passable channel all the way, but no practical use has since been made of it. Except in the deltaic portion, the river has a rapid current and the water is turbid. At Ilijsk there is a ferry on the road from Kopal to Vyernoe. The principal tributaries of the Ili are the Kash, the Belluluko, and the Kur-Tcharyn. A vast number of streams flow towards it from the mountains on both sides, but the great proportion of them are used up by the irrigation canals, and never reach their natural goal. The wealth of coal in the valley is said to be great, and the Chinese worked gold and silver with profit. Fort Ili or Ilijsk, a modern Russian establishment, must not be confounded with Ili, the old capital of the Chinese province of the same name. The latter, otherwise known as Hoi-yuan-tchen, New Kuldja (Gulja), or Mantchu Kuldja, was formerly a city of 70,000 inhabitants, but now lies completely deserted. Old Kuldja, Tatar Kuldja, or Nin Yuan is now the principal town of the district. See Kuldja.

ILLINOIS

(Compiled according to Census of 1880 and latest surveys.)

See Baer and Helmersen, *Beiträge zur Kenntniss des Russ. Reiches*, xx.; Semenow in Petermann's *Mittheilungen*, 1858; *Slovar Ross. Imp.*; Radloff, "Das Ili-Thal und seine Bewohner," in Petermann's *Mittheilungen*, 1866; Hellwald, *Die Russen in Centralasien*; Vambery, "The Tekes Valley," in *Ocean Highways*, vol. i.; Sewerzow, *Erforschung des Thian-Shan-Gebirgssystem* (1875); A. W. Dilke, "On the Valley of the Ili," in *Proc. Roy. Geog. Soc.*, 1874.

ILIOS, or ILIUM. See TROY.

ILKESTON, a market-town of Derbyshire, is situated on a hill commanding fine views of the Erewash valley, and on the Erewash branch line of the Midland Railway, 8 miles west by north of Nottingham, and 9 east-north-east of Derby. The town is under the government of a local board of health, and has a county court. The principal buildings are the parish church of St Mary's in the Norman and Early English style, with lofty pinnacled tower; the town-hall erected in 1868; and the mechanic's institute. National schools have been recently erected. The manufactures of the town are principally hosiery and lace, and various kinds of stoneware. Coal and iron are wrought in the neighbourhood. An alkaline mineral spring, resembling the seltzer water of Germany, was discovered in 1830, and baths were then erected, which were afterwards extended. The waters are used both externally and internally, and are efficacious in rheumatism, gout, spinal affections, liver complaints, and kindred ailments. The principal constituents of the water are carbonic acid, sulphuric acid, muriatic acid, lime, magnesia, and soda. The town, which is very ancient, obtained a grant for a market and fair in 1251. It was formerly the seat of the assizes, which were transferred to Nottingham on account of the plague. The population of the parish in 1861 was 8374, and of the town 3330, and the population of the parish and local board district in 1871 was 9662.

ILLE-ET-VILAINE, a maritime department of France, formed out of part of the old province of Brittany, is situated on the north-west coast, between 47° 38′ and 48° 37′ N. lat. and 1° and 2° 14′ W. long. It is bounded on the N. by the sea and the department of Manche, on the E. by Mayenne, on the S. by Loire-Inférieure, and on the W. by Morbihan and Côtes-du-Nord. It takes its name from its two principal rivers, the Ille and the Vilaine. The former joins the Vilaine at Rennes after a course of 18 miles through the department, and the latter, which rises in Mayenne, flows past the towns of Vitré, Rennes, and Redon. The stream is tidal up to the port of Redon, and is navigable for barges as far as Rennes. The Vilaine receives the Meu and the Seiche, which are both navigable. There are two other navigable streams, the Airon and the Rance. The Ille-et-Rance canal connects the town of Rennes with those of Dinan and St Malo. The department forms one vast plateau, broken by ranges of low hills, which decline on the one side to the English Channel and on the other to the Bay of Biscay. The sea-coast line is partly rocky and partly marshy, the marshy portions being in many places defended against the encroachments of the sea by artificial dams. There are also morasses in many parts of the interior, with a number of stagnant lakes, a circumstance which renders the atmosphere very humid. The sky is seldom bright, for the south-west winds, while they keep the temperature mild, also bring frequent showers, and in spring and autumn thick fogs prevail. The soil is thin and not very fertile, but lately has been improved by the use of artificial manure. The only truly fruitful portion is that round Dol. About two-thirds of the soil is under culture, one-ninth in meadows, one-fifteenth in wood, and one-sixth waste. Cereals of all kinds are grown, but the principal are wheat, rye, and barley. Potatoes, flour, and hemp are also largely grown, and tobacco is cultivated to some extent. Apples and pears are the principal fruit, and the cider of the canton of Dol has a high reputation. The vine is cultivated in the southern districts. Cheese, said to equal Gruyère, is made in considerable quantities, and the butter of Rennes has a reputation equal to that of the best in France. Large numbers of horses and cattle are raised. The horses belong to the small hardy Breton breed, and are much in demand as post and artillery horses. Notwithstanding the extent of heath land very few sheep are kept. The principal manufactures are leather, sea-salt, glass, paper, and linen. Iron ore is obtained in considerable quantities, and there are also lead and zinc mines, as well as slate quarries. The population is of Celtic origin, and the dialect is a mixture of Celtic and French. Ille-et-Vilaine is divided into the arrondissements of Fougères, St Malo, Montfort, Redon, Rennes, and Vitré, with 43 cantons and 350 communes. The chief town is Rennes, and the principal seaport St Malo. The department has an area of 2597 square miles. The population in 1872 was 589,532, and in 1876 it had reached 602,712.

ILLINOIS

ILLINOIS, the twenty-first in the order of admission and the fourth in rank of population of the States of the American Union, is one of the group of States formed out of the "North-West Territory." Its boundaries, beginning at the point where the Wabash river joins the Ohio, pass thence north by that river, by the west line of Indiana, and by Lake Michigan to 42° 30′ N. lat., thence west to the Mississippi river, thence south by that river to its confluence with the Ohio river, and thence, by that, north-easterly to the mouth of the Wabash. It has an area of 55,414 square miles, extending with varying width from 42° 30′ to 36° 59′ N. lat. Plate V

Surface and Soil.—Illinois is a great plain, with its highest section in the north, on Lake Michigan; thence it imperceptibly declines to the south-west, in which direction its principal rivers flow to the Mississippi. A small tract in the north-west, which includes the lead mines, is hilly and broken, and there are bluffs along the Mississippi, some of which rise 300 to 400 feet. A ridge extends across the south end of the State, constituting the fruit district of the region, called "Egypt" on account of its never-failing fertility. On this ridge or swell of clay land are grown all the varieties of berries, grapes, plums, peaches, apples, and all kinds of vegetables in great profusion, which find prompt sale in Chicago and the northern counties by reason of reaching market at early dates in the season. Excepting along the rivers, and where there has been extensive tree planting, the greater part of the State consists of a vast level or slightly undulating treeless prairies. Much of this has been reclaimed from swamp land by systematic drainage, and is found to be the strongest and most productive soil of the State. To the eye the surface of the State is as level as that of an ocean in calm. The general slope from the watershed rarely exceeds 1 foot to the mile, and the fall of the Illinois river in a course of 300 miles to the south-west, is, for most of the distance, but 1 inch to the mile. The origin of the prairies is still a matter of speculation, but there is an opinion that in a former geological age the whole State was the bed of a vast shallow freshwater lake. The prairie soil is a black fine humus mould, formed of the decayed vegetation, and underlain at varying depths by clay. The soil is of great fertility, and much of it seemingly inexhaustible. Over these prairies for hundreds of miles the plough never touches stone, pebble, or even sand. A luxuriant native grass formerly sustained herds of buffalo, and from the still unbroken prairie surface are annually mown thousands of tons of the wild grass for hay, which is as nutritious and brings as high a price in market as "tame hay." All the cereals, roots, fruits, grasses, and vegetables of the temperate zone are grown in Illinois, and some of the semi-tropical productions, as cotton and amber cane. Because of the richness of the soil, cultivators still plough very shallow, and neglect manuring, or even rotation of crops, in the larger portion of the State. It is usual to plant maize for ten or twenty years in succession, only changing the crop to wheat, oats, barley, buckwheat, or rye when the market prices of these cereals promise larger profits than maize. Upon any sign of exhaustion, the productiveness may be restored by deeper ploughing, grassing, fallowing, and applying barnyard manure. In half a century there has never been a bad failure of crops; twice or thrice there has been insufficient rain, and as often too much, and once a frost in summer; but the injury in no one year was so great or so widespread as to produce general distress among farmers.

Minerals.—Coal is found in nearly all parts of the State; it is bituminous, a small proportion being cannel. The beds vary from 3½ to 8 feet in thickness. The Coal-measures are part of the general formation extending from beyond the Mississippi river in Missouri, across Illinois and parts of Indiana and Ohio, and into Kentucky. It is estimated that three-fourths of the surface area of the State are underlain by beds of coal. There are twelve separate and well-defined beds of from 4 to 8 feet in thickness. The State is supplied with coal for consumption, not only from the mines of Illinois, but also from those of Indiana and Ohio by rail, and with anthracite from Pennsylvania by lake. The coal mined in the State is between 3,500,000 and 4,000,000 tons annually. Near Galena, in the north-west part of the State, are lead mines which have been worked for half a century, and which at one time made Galena the most prosperous city in the State. Salt springs are found in the south-east counties. Stone suitable for building is found in various parts of the State. An inexhaustible field of limestone, called "Lemont marble," is found near Chicago, and has been largely used in rebuilding that city.

State Lands.—The lands in the State were thus classified in the years 1878 and 1880:—in the former year there were 25,639,304 acres of improved and 8,635,953 of unimproved lands (total, 34,275,257), while in the latter year the numbers were 26,174,566 and 8,204,505 (total, 34,379,071 acres). The city and town lots numbered 365,344 improved and 486,731 unimproved in 1878, and 374,664 improved and 484,932 unimproved in 1880. The railroads hold 13,253 acres of land and 3028 city and town lots.

The improved lands were under cultivation in 1878 and 1880, as follows:—

	1878.	1880.
	Acres.	Acres.
Wheat	2,118,000	2,702,380
Maize	7,062,502	7,592,152
Oats	1,582,387	1,703,843
Meadows	2,102,990	2,267,945
Other field products	698,116	567,890
Enclosed pasture	4,034,551	4,242,713
Orchards	271,565	293,593
Woodland	3,982,807	3,708,567

Agricultural Products.—The great crops of Illinois are maize or Indian corn, wheat, and hay; and much attention is also given to the raising of live stock. The State produces more wheat than any other State in the Union. The farms number about 247,000. We give full agricultural returns for 1879, and those for 1880 so far as completed to December of that year:—

	Acres.	Average per Acre. Bushels.	Bushels Produced.	Total Value.
Wheat.				
1879	2,440,800	18¾	45,417,661	$39,930,639
1880	3,256,350	17½	56,508,309	46,497,160
Maize.				
1879	7,918,881	38	305,913,377	97,483,052
1880	Returns not	complete	d.	
Oats.				
1879	1,631,139	33½	54,664,569	12,059,162
1880	1,749,391	35	62,709,062	12,858,247
Hay.			Tons.	
1879	2,332,278	...	2,578,736	16,428,012
1880	2,259,857	...	3,486,584	22,589,691

The following table gives returns for 1879:—

	Acres.	Quantity.	Value.
Rye	235,073	4,238,824 bush.	$1,991,401
Barley	...	578,911 ,,	265,951
Pasture	4,193,884	...	12,319,620
Orchards	290,646	...	2,497,687
Potatoes	90,351	7,125,932 ,,	3,506,758
Sorghum	14,949	1,524,705 galls.	579,257
Flax seed	...	990,447 bush.	1,296,758
Hogs sold	...	1,984,194	16,640,061
Fat cattle sold	...	...	16,751,450
Fat sheep sold	...	...	513,884

Railways.—In 1850 Congress granted to the State, to aid in the construction of a railway from Cairo to Galena and Chicago, alternate sections of land along the route; the State transferred the grant of land to the Illinois Central Railroad Company, a corporation composed mainly of English capitalists, conspicuous among whom was Richard Cobden. These capitalists furnished the money and constructed the road, and they and their successors still own the property. The railway lies wholly within the State, though it works other lines extending south to New Orleans and west to the Missouri river. Its completion gave that impetus to the construction of railways to Chicago and across the State which has contributed so largely to the rapid development of the resources of Illinois. The State is now admirably supplied with railways, their extent reaching 6849 miles. They cross every county in the State; indeed, they are so numerous and so interlaced that there are few if any localities more than 10 miles from a railway, while a large proportion of the shipping points have the benefit of more than one route by which to ship and receive merchandise. The great trunk lines leading west from the Atlantic and from Canada have their termini at Chicago, or at some other point in Illinois, while those leading from the States west of the Mississippi also terminate in Illinois, or crossing the State run further east. The system of railway government somewhat resembles that of England. A railway commission, appointed by the State, exercises a general supervision, and enforces the penalties for violations of law. The receipts of the forty-six railways doing business in Illinois amounted in 1879–80 to $138,659,155; the working expenses to $73,089,185; and the net income to $61,093,612.

Inland Navigation.—In addition to the railway traffic, there is much business done by steamboats at Cairo, East St Louis, Alton, Quincy, Rock Island, and other points on the Ohio and Mississippi rivers, though transportation by river has declined much of late years. The Illinois and Michigan canal is 93 miles long, and connects Lake Michigan at Chicago with the Illinois river, at the head of the navigation of that river. This canal has cost $17,000,000, but is now too small for the service needed. The Illinois river is formed by the union of the Kankakee and Des Plaines rivers, which junction occurs 45 miles south-west of Chicago. It receives, besides the rivers named, the waters of the Fox, Sangamon, and Vermilion rivers, and of some smaller streams. Its general direction is south-west to the Mississippi, into which it falls. The State has expended much money improving the navigation by locks and dams, and this improvement when completed, with the enlargement of the canal to the capacity of steamboat navigation, will be one of the most extensive works of interior water communication in the world, being over 400 miles long, and connecting the waters of the Atlantic, through the St Lawrence river and the lakes, and through the Mississippi river, with the Gulf of Mexico. Rock river rises in Wisconsin, flows rapidly to the south-west through Illinois, and joins the Mississippi near Rock Island. On this river manufacturing establishments are rapidly increasing, the water power being regarded as equal to any in the country. The other rivers are the Kaskaskia, Embarras, Little Wabash, Big Muddy, and Chicago river, the last-named an inlet from Lake Michigan, furnishing a commodious harbour, 8 miles long, in which an average of 400 vessels find shelter during the winter season. The extent of the commerce on the lake is shown by the custom-house returns. During 1880 the steam vessels arriving at Chicago had a total burthen of 2,141,879 tons, the sailing vessels 2,456,337 tons; the clearances showed about the same figures.

Manufactures.—The statistics of manufactures for 1870 give as results 13,597 establishments, employing 82,979 operatives. Since that date the increase in manufactures throughout the State has been general, embracing all branches of manufacturing industry. The following are the statistics for Cook county (including Chicago) in 1880:—number of establishments, 3752; capital, $80,693,102; average number of hands, 113,507; wages paid, $37,615,381; value of material used, $180,807,706; value of products, $253,405,695. These figures for Cook county alone in 1880 exceed in several particulars those for the whole State in 1870; and the increase in the State during the ten years may be regarded as proportionate to that in Cook county. The abundance of coal, the proximity to the Lake Superior iron and copper mines, the unlimited means of transportation, the supply of lumber, the cheapness of food, the superior water power in various parts of the State, have all tended to make Illinois a large and convenient seat of manufactures. The iron and steel establishments of the State rank with the largest in the country. On Rock Island, in the Mississippi river, the U. S. Government has an arsenal for the manufacture of ordnance. The establishment is the most extensive in the United States, and the buildings and workshops cover nearly the entire island.

Administration.—The territory embraced in the present State of Illinois was ceded in 1765 by France to Great Britain; then it became a possession of the colony of Virginia; in 1787 it was made a county in the North-West Territory; from 1800 to 1809 it was a county in the territory of Indiana; in 1809 it was erected into a territory; and in December 1818 was admitted into the Union as a State. On its admission to the Union a constitution providing a form of government was adopted; in 1848 this was superseded by another, and this again was set aside in 1870 by the third and present constitution, which provides the ordinary State government of three departments, executive, legislative, and judicial. The executive, consisting of a governor and other officers, are elected every four years; the legislature, or general assembly, consists of a senate of 51 members, elected by as many districts; the term of senators is four years, one half, or as near as may be, retiring every two years. The house of representatives consists of 153 members, 3 elected in each senatorial district every two years. In electing representatives, the voter may give his three votes for one, two, or three candidates. This cumulative voting is peculiar to the constitution of Illinois; it has become popular. The judiciary consists of one supreme court of seven judges, several district appellate courts of limited jurisdiction, circuit courts in such number as may be needed, and one county court, including probate jurisdiction, in each county. Each county and each township has its own local government. Every male citizen resident one year in the State may vote. This constitution when adopted was regarded as a great improvement and advance in State government, and many of its provisions have since been adopted by other States. The sessions of the legislature are held at Springfield, which since 1836 has been the capital of the State.

Revenue, Debts, Taxation.—In 1836–38 the State was seduced into a scheme of internal improvements. The population was then less than half a million, but the debt created was $14,000,000, to construct railways and a canal. In three years the scheme was abandoned, and the State in July 1841 suspended payment of interest. In 1845 the legislature levied a tax to pay the current interest; in 1848 an irrepealable tax was levied to pay the principal; all the overdue and unpaid interest was funded in interest-bearing bonds. Credit was restored, and in December 1880 the State was free of all debt. Taxation is imposed by a rate levied on all real and personal property, according to a previous valuation, made by local assessors, revised by county boards, and again revised and equalized by a State board. The total assessment or valuation of the property in the State for taxation averages not more than one-fourth of the value at which the property can be sold. The constitution limits the rate of taxation (except to pay debts) by counties to 75 cents on each $100 of the official valuation. The same valuation governs all taxation, the maximum rate being fixed by law. In like manner all municipal corporations are (since 1870) prohibited from incurring any debt, for any purpose, exceeding, with previous debts, 5 per cent. on the official valuation of the property within their territorial jurisdiction. An annual tax is required in each municipality to pay the interest and a portion of the principal of all existing debts. Under these stringent requirements, municipal debts in Illinois are gradually decreasing. The State, without becoming responsible for municipal debts, acts as trustee, and through its officers collects and disburses the taxes to pay principal and interest of these local debts. The latter were contracted mainly in aid of railroads, and bore an average rate of 9 per cent. interest.

The gross taxation for all purposes, including schools, for 1878 and 1879 was as follows:—

	1878.	1879.
State taxes	$3,614,855	$2,712,626
County taxes	5,557,446	4,730,095
City taxes	7,576,882	6,182,420
Town taxes and others	10,941,658	9,327,959
Totals	$27,690,841	$22,953,100

The valuation of all the property in the State for taxable purposes, for the year 1880, was $786,616,394. The rate of tax levied for State purposes, and to pay cost of assessment and collection, is 36 cents on each $100 of the property valuation given, which, as above stated, is about one-fourth of the real value. In 1880 lands (except railroad lands) were valued at $390,594,627, and city and town lots at $182,808,928; total lands and lots, $573,403,555.

The State is in receipt of a permanent revenue from the Illinois Central Railroad Company. In consideration of the cession of land, in 1850, by the State, the company contracted to pay into the State treasury half-yearly 7 per cent. of the gross annual earnings of the line. This was to be in lieu of all other taxes on the property of the company. This contract is now a source of large revenue to the State. Up to November 1, 1855, the payment to the State was $29,752; the payment in 1880 was $368,349. The total payments to the State, at the close of 1880, amounted to $8,307,217.

Education and Charities.—The public school system is liberally supported in Illinois. The permanent school fund yields about $60,000, to which the State adds $1,000,000 annually, and this is distributed among the counties. Many counties and districts have invested school funds. The aggregate of these local funds is $5,500,000, the interest of which is applied to support schools. In addition each school district levies such taxes as may be needed for its schools, and may borrow money to build schoolhouses. In

1878 the receipts of revenue for schools amounted to $9,634,727, the expenditure to $7,526,109. The number of children in the State (1878) of the school age, six to twenty-one years, was 1,102,021; of these 706,733 were enrolled as attending the public schools, and 41,406 as attending private and parochial schools; total attending schools, 748,139. The whole number of school districts in the State was 11,714; male teachers 9475, female teachers 12,817, teachers in private schools 1017—total teachers 23,309. Salaries of male teachers range from $15 to $225 per month, of female teachers from $10 to $115 per month. Five months in each year is the minimum term of the public schools, ten months the general term. Except the income from invested funds, school revenues are obtained from direct taxation. The State has established two normal universities, providing the buildings and grounds,—one at Normal, M'Lean county, the other at Carbondale, Jackson county. There is an industrial university at Champaign, maintained and liberally endowed by the State. There are also several other universities and colleges, including medical and theological, in various parts of the State. All schools supported in whole or in part by public money must be non-sectarian in their instruction and government.

Under the general supervision of a board of charities, the State maintains four hospitals for the insane, at Jacksonville, Elgin, Anna, and Kankakee; an institution for educating the blind, and one for educating the deaf and dumb, both at Jacksonville; an asylum for imbecile children; an eye and ear infirmary; a home for soldiers' orphans; and a correctional or reformatory school for boys. All these institutions are provided with spacious grounds and extensive buildings. The annual expenditure for the maintenance of these charities is about $1,000,000. This does not include the cost of buildings and grounds, on which over $5,000,000 have been expended. Several other asylums for the insane are maintained by local authorities.

The population of Illinois, which now comprises 102 counties, was as follows at the dates given:—

1800	2,458	1850	851,470
1810	12,282	1860	1,711,951
1820	55,162	1870	2,539,891
1830	157,445	1880	3,080,824
1840	476,183		

The following cities had a population in 1880 exceeding 5000:—

Chicago	503,304	Decatur	9,449
Peoria	29,315	Cairo	9,017
Quincy	27,275	Elgin	8,606
Springfield	19,746	Galena	8,205
Bloomington	17,184	Streator	8,088
Joliet	16,145	Ottawa	8,010
Rockford	13,136	Danville	7,751
Aurora	11,825	Moline	7,740
Rock Island	11,660	La Salle	7,250
Galesburg	11,446	Pekin	6,508
Jacksonville	10,927	Mattoon	6,106
Belleville	10,682	Kankakee	6,027
East St Louis	10,054	Sterling	5,841
Freeport	10,016	Princeton	5,440
Alton	9,500	Monmouth	5,004

The density of the population in 1880 was 55·6 persons per square mile. (J. W. S.—J. ME.)

ILLUMINATI, or "Enlightened," is a title which at different times has been given to, or assumed by, various sects or orders of mystics, on the ground of the superior knowledge of God and of divine things which they claimed. Among these may be mentioned that of the Spanish "Alombrados" or "Alumbrados," which arose about the year 1520, and which before its final disappearance about a century later afforded numerous victims to the Inquisition, especially at Cordova. Ignatius Loyola, while a student at Salamanca (1527), was tried by an ecclesiastical commission for alleged sympathy with its views, but was acquitted with an admonition. Under the name of Illuminés a similar sect appeared in Picardy in 1623, and afterwards entered into close relations with the Guérinets or followers of Pierre Guérin; but by its antinomianism it soon provoked repressive measures, to which it finally succumbed in 1635. The history of another sect of Illuminés, which appeared in the south of France about 1722, is very obscure, but it is said to have subsisted until 1794. The title of Illuminati has often been popularly bestowed also on Rosicrucians, Martinists, and Swedenborgians; but one of the most recent as well as most important applications of this elastic word has been to denote a secret society, or semi-political semi-religious order, which made some stir in Germany, especially in the southern and Catholic portions of it, from 1776 to 1784. It was founded on May 1, 1776, by Adam Weishaupt, professor of canon law at Ingolstadt, and an ex-Jesuit, and set before it as its general purpose the discouragement of tyranny, superstition, and ignorance, and the furtherance of the cause of reason, freedom, and virtue. The name originally assumed for the order was the Society of the Perfectibilists (Gesellschaft der Perfectibilisten). Politically its tendencies were republican, and in religion it was free-thinking, having a distinct aversion to Christian ritual and Christian dogmas alike. The entire subserviency of its members (who on admission were pledged to blind obedience to the orders of their superiors) was secured by a strict system of secret confessions and monthly reports, checked by mutual espionage. Beginning with a narrow circle of disciples carefully chosen from among his own students, Weishaupt gradually extended his propaganda from Ingolstadt to Eichstädt, Freising, Munich, and elsewhere, special attention being given to the enlistment of young men of wealth, rank, and social importance. As the order increased in numbers its organization naturally became more complicated, and was ultimately considerably influenced by the intimate relations which were established with masonic lodges at Munich and Freising in 1780. About the same time an important impulse was given to its prosperity in middle and northern Germany by the ambition and energy of a newly acquired member, Baron Adolf von Knigge, who had his headquarters at Frankfort-on-the-Main. It was to him that the society was indebted for the extremely elaborate constitution (never, however, actually realized) according to which the entire membership was divided into three great classes, in the first of which were to be included the "novices," the "minervals," and the "lesser illuminati," while the second consisted of "freemasons" ("ordinary," "Scotch," and "Scotch knights"), and the third or "mystery class" was subdivided into the two grades of priests and regents and of magus and king. Each member of the order had given him a special name, generally classical, by which alone he was referred to in official communications; all correspondence was conducted in cipher; to increase the mystification, towns and provinces were invested with new and altogether arbitrary designations. At its period of greatest development the order included in its operations a very wide area, extending from Italy to Denmark, and from Warsaw to Paris; at no time, however, do its numbers appear to have exceeded two thousand. Its aims and method, which, as plainly appears in portions of Goethe's *Wilhelm Meister*, were somewhat in accordance with the taste of the period, met with more or less sympathy and approval from Goethe himself and from Herder,[1] from the grand-dukes Ernest II. of Gotha and Karl August of Weimar, as well as from other persons of influence and repute (Bode, Nicolai). A rupture which

[1] Perthes, *Das Deutsche Staatsleben vor der Revolution*, p. 262.

took place between Weishaupt and Knigge in 1784 greatly accelerated the public expression of a counter feeling of suspicion and dislike which had been slowly gathering strength, and in 1785 the Bavarian Government issued an edict which proved fatal to the order. Many of its members were imprisoned or compelled to leave their homes; Weishaupt himself was deprived of his chair and banished the kingdom.

See *Grosse Absichten des Ordens der Illuminaten* (with Appendices, Munich, 1786); and Weishaupt's *Vollständige Geschichte der Verfolgung der Illuminaten* (1787), and *Kurze Rechtfertigung meiner Absichten* (1787).

ILLUMINATION is a term which has long been used to signify the embellishment of written or printed text or design with colours, and especially with gold, more rarely also with silver. The lustre of the former metal may probably have led to the adoption of the word in this sense. The Latin verb *illuminare*, with the meaning of "to decorate," occurs as early as the 8th century; and in the first portion of the *Roman de la Rose*, composed before 1260, *enluminer* is found with a similar meaning, while Dante (*Purgat.*, xi. 79) alludes to this kind of painting and its French designation as "quell' arte, che alluminar è chiamata in Parisi." In Early English we find the forms *enlomyne, luminen, limnen*, whence *limn*. Of synonymous use with these terms we find in the Middle Ages the words *miniare* and *miniatura*, from *minium*, a red pigment, in early use for decorating MSS. Miniature employed in connexion with the art of illumination now, however, generally signifies a picture or portrait as distinguished from mere ornament or ornate letters.

The research into the past which has characterized the present century has extended to the art of illumination, and, following the lead of D'Agincourt, Mabillon, and others, has by the examination of mediæval decorated manuscripts thrown a vast amount of light upon the arts of the past. In spite of iconoclasm in the East, the burning of Arabic MSS. in Spain, and the destruction and dissipation of libraries which unhappily accompanied the Reformation, a considerable number of beautiful and elaborate volumes have come down to us where larger and more exposed works of art have perished. They therefore supply many a lacuna in art history. Conformably to the unity which pervaded all art work in the Middle Ages, a close correspondence in style has been recognized between the ornamentation of MSS. of different periods and contemporaneous architecture and other arts. The architect, the decorator, the glass-stainer, and other artists have consequently learned, and with great profit, to search their pages for ornamental motives, details, and colouring, in thorough harmony with ancient styles, which no other source supplies so copiously. Invaluable materials too for the history of costume are found in the miniatures with which they abound.

The earliest writing of which monuments exist, the Egyptian, was often enhanced by the use of colour. In the ritual papyri, directions, &c., are written in red to distinguish them from the main text, just as was subsequently done in mediæval liturgical MSS.—a practice from which the term *rubric* is derived. A few scattered passages in Latin classic authors (notably Ovid, Seneca, Varro, Martial, Pliny the Elder, J. Capitolinus) prove the occasional use of rubrication and of pictorial embellishment of MSS. among the Romans. The earliest decorated MSS., at least of European execution, which have reached us date from the 4th and 5th centuries of our era, and are of extreme rarity. Of these one of the most celebrated is the *Virgil* written in elegant capitals preserved in the Vatican, in which the adornment is limited to rectangular pictures (miniatures) painted in the antique manner seen in the Pompeian frescos, the body colour laid on with a free brush and without black outlines. It may be taken as the type of a class of MSS. of which very few specimens are extant. A different type of early calligraphy, which was much esteemed, is found in the *Codex Argenteus*, now at Upsala, written about 360, containing Ulfila's Mœso-Gothic version of part of the Scriptures. It is written in gold and silver letters on vellum stained a red purple. The art of thus staining vellum, perhaps with the murex, was afterwards lost, and in the 8th and 9th centuries was imitated by painting the vellum.

After the 2d century art rapidly declined in the West, owing to the corruption and anarchy of the empire. It found a home, however, at Constantinople, where intercourse with Persia resulted in a style which blends Oriental magnificence with Western vigour and variety, and is destined, as we are about to see, to exercise a dominant influence upon the art of Europe for many centuries. This style, known as the Byzantine, is distinguished by very characteristic details, and by its lavish use of gold, especially in backgrounds. Meanwhile Christianity had been planted in remote Ireland, which proved such favourable soil that the isle was already at the beginning of the 6th century renowned for its learning and sanctity, and was the seat of numerous monasteries and seminaries, where a native style of art was developed, wholly distinct from anything else which the world has seen. Its principal features are spirals, extremely ingenious plaits, and interlacements of attenuated lacertine animals and birds of conventional form. The human figure is sometimes introduced, but becomes objectionable, through the ignorance of drawing and of anatomy usually characteristic of semi-civilized attempts to portray the higher organisms. The work is further distinguished by a degree of minuteness, intricacy, and precision baffling to the modern draughtsman. It is seen in its highest perfection in the *Book of Kells*, preserved in the library of Trinity College, Dublin, and in the Lindisfarne Gospels in the British Museum. This style, known as the Celtic or Anglo-Celtic, was transplanted by Irish missionaries to Lindisfarne, Bobbio, St Gall, Würzburg, Luxeuil, and other places, where volumes displaying this peculiar ornamentation are still treasured. The influence of Anglo-Celtic art is very apparent in the subsequent "Carlovingian style" which arose in France and Germany under the fostering care of Charlemagne, and of Alcuin, whom he had invited to France to direct the progress of learning and the arts. The gospels found upon the knees of the great emperor when his tomb at Aix-la-Chapelle was opened, the gospels of St Servin de Toulouse, those of St Medard de Soissons, the Bible of San Calisto monastery at Rome, and the Harleian *Codex aureus* of the British Museum are justly renowned examples of this majestic and magnificent style, in which the pages glow with gold and purple, and the Roman acanthus, Celtic interlacements, and Byzantine details combine in harmonious variety. A text written wholly or partially in gold ink is another characteristic of the epoch. About this period too are found those gigantic initials which from containing figures relating to the text have been called in France *Historiées*. A new style had also arisen in England, in which the debased Roman acanthus was largely developed. This conventional foliage is here seen skilfully combined with gold bars, which surround the page, and form a border at the commencement of books, &c. This style has been called the *Opus Anglicum*. It often displays a masterly freedom and spirit, and a peculiar "fluttering outline," which also characterizes the spirited pen-drawings frequently found in MSS. of the period. The finest specimens of this style, among which are the benedictional of St Ethelwold, belonging to the duke of Devonshire, and a couple of volumes in the public library, Rouen, were probably executed at Hyde Abbey, Winchester.

The apprehensions of the year 1000 as the end of the world tended greatly to paralyse art. As these fears died away, however, the Romanesque style of architecture was being developed, especially in the Rhine-lands. This was favoured by numerous Greek artists who, deprived of their livelihood by Eastern iconoclasm, had migrated westwards, and deeply impressed the Byzantine character upon the architecture of central and western Europe. Simultaneously there arose a bold sweeping style of ornament, characterized by fine rounded curves and Byzantine details, but also by a tendency to naturalism, and, in books, by large initials. The Byzantine gold backgrounds were still a glowing feature, which indeed continued through the whole subsequent progress of illumination. From the 11th century gold leaf was applied to the vellum upon a substratum of fine plaster, and could be so highly burnished as to exhibit the rich lustre of a polished lamina of the solid metal. As skill in drawing increased, nature was more copied, and towards the 14th century natural foliage, conventionally treated, constitutes the main portion of the ornament. The oak, the vine, and especially the ivy, are frequent, springing in free spirited curves from decorated initials, or extending into a border round the whole or part of the page. The initials decrease in size whilst they gain in excellence of execution, and illumination, considered as decorative design, is generally considered to have reached its highest perfection about this period. The pictures of sacred subjects gradually lose Byzantine rigidity and assume dramatic expression, pose, and grouping. And towards the 15th century the blue or gold background begins to be abandoned for natural scenery and accessories. Towards the commencement of the 15th century illumination was liberally fostered by John, duke of Berri, brother of Charles V. His magnificence in this branch of art awoke the emulation of Philip the Bold, duke of Burgundy, and of the duke of Bedford, the regent of France, in the same direction. For the last-named was painted the celebrated *Bedford Hours*, now in the British Museum, part of the workmanship of which has been ascribed to Jan, Hubert, and Margaretta van Eyck. As perfect mastery of drawing and facility of realistic execution were gained, illumination as a decorative art became debased in design. Borders of gold or richly coloured grounds, over which are scattered exquisitely painted flowers, fruit, and insects, surround pages of text or miniatures wrought with supreme manual dexterity, but not unfrequently of meretricious composition. In juxtaposition with this rich and copious ornamentation (the primary end of the book), the text, already less black and massive than in preceding centuries, too often dwindles into insignificance. The *Hours of Anne of Brittany*, preserved at the Louvre, is one of the most celebrated specimens of 16th century illumination of this style.

The character of Italian illumination differs considerably from that which marked the art in central or northern Europe. It had arisen by slow degrees from the devastation which Italy had suffered in the early centuries of the Christian era. The scriptoria of Ravenna, Siena, Florence, Bologna, Perugia, Ferrara, in the 13th and 14th centuries, produced illuminated volumes worthy of their growing schools of painting, and were especially celebrated for the elaboration of large choral books.

The Renaissance, with its revival and enrichment of classical forms, was fully reflected in the illuminator's art, which was largely employed in smaller volumes for secular subjects, and was patronized by the Italian princely families, and finally reached its culmination in the hands of such artists as Girolamo dei Libri, whose drawing is very accurate, and attains a microscopic delicacy of stippling, and his pupil Giulio Clovio, who in his composition makes large use of the human figure, and with an imitation of Michelangelo's manner combines unrivalled minuteness of execution. Long after the invention of printing the popes and doges retained official illuminators in their service; and some of the most elaborate and costly volumes were executed subsequently to the introduction of the press. The typographical multiplication of books, however, proved fatal to the art. The early productions of the press, indeed, had blank spaces left for initials and miniatures, which were painted in by hand, often very roughly. These were soon replaced by printed designs intended to be gilt and coloured, which reflected the character of contemporaneous art, as far as the technical difficulties of the yet imperfect press allowed. The custom of adorning sumptuous volumes with engraved initials and other ornament has continued to the present time, with an increasing tendency to naturalism.

The visitor to the public libraries and museums of Moscow and St Petersburg will have there admired the rich display of Slavonic illuminated MSS. of peculiar style, intricate design, careful execution, and frequently fine colour. The leading features of Russian art were derived from Byzantium, but, as Russian archæologists maintain, were blended with a native element, and a true national style arose in the 12th and continued to the 16th century, when the influence of the Renaissance began to be felt.

The fecund art of Constantinople was also the parent of another style—the Arabian or Mahometan—which, however, contains a previously existing Oriental element. The style began to develop in the 7th century. It is geometrical or constructive in character, the use of symbolism or representations of animals or plants being forbidden in the sect of Omar. Inscriptions in cufic characters are often happily used as a decorative feature; rich colouring of red blue and gold prevails. The Turkish and Moresque styles are modifications of the Arabian. Illumination was carried in this style to the highest degree of splendour. Casiri's *Bibliotheca Arabico-Hispana Escurialensis* conveys some idea of the former magnificence of the Moorish libraries in Spain.

In India illumination, though of great antiquity, does not present those transitions of style which mark the development of western art. Like Indian art generally, its special characteristics are profusion, richness, harmony, repose, and perhaps monotony, with very extensive employment of flowers. Persian art was derived from India. It reflects the Persian love of flowers and symbolism, and the treatment is more free and natural than in India. It seems to have reached its highest perfection about the 15th and 16th centuries of our era, but is still continued. The execution of a magnificent MS. of the *Thousand and One Nights* was undertaken under the auspices of the present shah. The absence of any attempt to shade or give relief to the design is, it should here be mentioned, a characteristic of all Oriental design.

During the earlier part of the Middle Ages the art of illumination was in Europe mostly practised in the scriptorium or apartment devoted to the elaboration of MSS. which was attached to each monastery. In later times the art was practised by lay artists. Illuminators as well as patrons of illumination were occasionally found among the highest ranks; Saint Dunstan and King René may be instanced. And some distinguished painters were also illuminators. All Western MSS. of fine quality were executed upon vellum. Materials were mostly prepared with great care by the artists themselves, or under their direction, and as a rule are found to have well stood the test of time.

The price given in recent years for MS. volumes valuable for their beauty or antiquity often reaches many hundreds of pounds sterling. A folio Vulgate of the 9th century was purchased by the British Museum in 1836 for £750. The *Bedford Hours*, acquired with other MSS. for the same establishment, has been valued at over £2000. At the Didot sale in Paris a MS. executed in the highest style of French art fetched above £3000.

Bibliography.—Among a large number of works on the subject the following may here be mentioned:—C. G. Schwarzius, *De ornamentis librorum*, Leipsic, 1756; N. Humphreys, *Illuminated Books of the Middle Ages*; Silvestre and Champollion, *Universal Palæography*; Westwood, *Palæographia Sacra Pictoria*; Madden, *Illuminated Ornaments*; Tymms, *The Art of Illuminating*; Bastard, *Peintures des Manuscrits*; Westwood, *Facsimiles of Anglo-Saxon and Irish MSS.* Information upon Eastern styles, with coloured plates, will be found in Racinet, *Polychromatic Ornament*, and O. Jones, *Grammar of Ornament*, and upon Russian art in V. Boutowsky's *Histoire de l'Ornement Russe, d'après les Manuscrits*, Paris, 1870. For the technical part of the subject, see Theophilus, *De diversis artibus*, several editions, with translation and notes; *Original Treatises from the 12th to 18th Centuries on the Arts of Miniature, &c.*, edited, with translation and notes, by Mrs Merrifield; Bradley, *Manual of Illumination*; Shaw, *Art of Illumination.* (H. B. W.)

ILLYRIA is the name applied to the country that lies to the east of the Adriatic Sea. The usual Greek name is Illyris, though the older writers generally use the expression οἱ Ἰλλύριοι. The common name in Latin is Illyricum. The term Illyria is occasionally used in both languages, and has become the recognized name in English. The boundaries of the country thus known varied very much at different periods, and can be described only along with its history. For a short time, in the 4th and 3d centuries B.C., there was some slight government under monarchs whose power was acknowledged by the whole country; but in general the land was either a province of some conquering race or the abode of isolated tribes with little or no common feelings or aims.

The origin and character of its oldest inhabitants are involved in the obscurity that still shrouds the ethnology and early history of all south-eastern Europe. The Greeks acknowledged some affinity of race between themselves and the Illyrians in the legend that Cadmus retired from Thebes with his wife Harmonia and settled in Illyria, where he became the father of Illyrius, the eponymous ancestor of the whole race. In harmony with this myth, the general consensus of modern investigation tends to the view that at an early period the whole of Europe south of the Danube, together with the centre and west of Asia Minor, were peopled by kindred races, some of whose names are preserved to us as Leleges, Thracians, Pelasgi, Illyrians, &c. If we divide the Indo-European tribes that peopled Europe into two great families, the northern and the southern, we shall find that the Thraco-Illyrian tribes must be distinguished from the Slavonic tribes who dwelt immediately north of them, and who are closely akin to the Lithuanian and other tribes of the northern family. On the other hand, it would not be easy to draw any line of demarcation at this early time between the Illyrians and their neighbours on the west, south, and east. Separation of nationalities was produced afterwards by growing civilization, which developed distinct national characters and well-defined countries.

At this early period then we may say that the Danube, as the boundary between the northern and the southern family, was the limit of the Illyrian tribes towards the north. In other directions they shaded off into kindred tribes of similar manners and language. Various causes led to a very unequal development of civilization among these tribes. Intercourse with stranger races like the Phœnicians, and amalgamation with kindred immigrant races, such as the Ionians and Dorians, raised some of these tribes rapidly to the highest stage of civilization. But these new races were attracted by the more favourable conditions of the Greek peninsula, and few of them found their way to the northern countries. Some traces of early Ionian settlers in Illyria are found (see Curtius, *Die Ionier vor der ionischen Wanderung*, p. 46); but they do not seem to have permanently affected the character of the natives. As Greece became civilized, it sent forth its own colonists to occupy most of the favourable sites along the Mediterranean coasts. But, whereas Thrace with its rich mines had a line of Hellenic colonies along its southern shore, very few were planted in Illyria. According to Strabo, the shore was full of fine harbours, and the coast land was very fertile; but he adds that the people were barbarous and warlike. On this account it was that Greek colonization never spread on the Illyrian coast. Dyrrachium or Epidamnus was almost the only Greek colony, and its history for centuries showed one continuous conflict with the barbarous natives, which prevented its growth. Macedonia again found a family of Greek refugees who established themselves as petty chiefs, and gradually spread their power, with civilization and settled rule, over the whole country. Nothing of the kind happened to Illyria; the chiefs who rose at times to power were always apparently as barbarous as their followers. In these unpropitious circumstances, the Illyrian tribes remained in their primitive barbarous condition later than almost any of their neighbours, and when many of the surrounding states had become civilized, Illyria was divided from them by the line separating barbarism from civilization. Naturally their characteristics resembled closely those of the ruder Thracian tribes, and both are described by the Greek historians as tattooing their bodies and offering human victims to their gods. Their women seem to have had a high position socially, and to have even exercised political power. Queens are mentioned more than once as their rulers. This reminds us of the German tribes, whose women also were much respected; and we know that among the Greeks women were much freer and more respected in the older time before Oriental influence had affected native customs. It is said that chastity was not held in much account by the women of Illyria; but it must be remembered that people whose women are kept more secluded are very apt to ascribe such a character to the freer life of other races.

The Illyrians are said by Herodotus (ix. 43) to have attacked the temple of Delphi. Brasidas with his small army of Spartans was assaulted by them on his adventurous march (424 B.C.) across Thessaly and Macedonia to attack the Athenian colonies in Thrace. The earlier history of the Macedonian kings is one constant struggle against the Illyrian tribes. The migrations of the Gauls at the beginning of the 4th century disturbed the country between the Danube and the Adriatic. The Scordisci and other Gallic tribes settled there, and forced the Illyrians towards the south. The necessities of defence seem to have united the Illyrians under a chief Bardylis (about 383 B.C.) and his son Clitus. Bardylis nearly succeeded in destroying the rising kingdom of Macedonia; King Amyntas was defeated, and a few years later Perdiccas was defeated and slain. But the great Philip crushed them completely, and annexed part of their country. During the next century we hear of them as pirates. Issuing from the secluded harbours of the coast, they ravaged the shores of Italy and Greece, and preyed on the commerce of the Adriatic. The Greeks applied to Rome for help. Hellenism had proved too weak to civilize the northern races; it was left to the stronger organization of Rome to absorb them. Teuta, the Illyrian queen, at first scorned the Roman demands for redress, and even murdered the ambassadors; but the two Illyrian wars (229 and 219 B.C.) ended in the submission of the Illyrians, a considerable part of their frontier being annexed by the conquerors. In 168 B.C. Gentius, the Illyrian king, provoked the third Illyrian war, the result of which was the annexation of the whole country by the Romans. Frequent rebellions occurred, but at last the natives accepted the Roman civilization. During the empire, the country was one of the best recruiting grounds for the Roman legions; and in troubled times many Illyrian soldiers fought their way up from the ranks to the imperial purple. Claudius, Aurelian, Probus, Diocletian, and Maximian were all sons of Illyrian peasants.

In the time of the republic Illyricum comprised the country between the Liburnians, a kindred race, on the north and Epirus on the south. Under the empire the importance of the country made its name spread over all the surrounding districts. In the 2d century after Christ, the Illyricus Limes included Noricum, Pannonia, Mœsia, Dacia, and Thrace. Constantine added Greece, Epirus, and Macedonia, taking from it Thrace and part of Mœsia, and made it one of the four divisions of the Roman empire governed by a "præfectus prætorio." When the empire was divided, Illyricum was halved. Illyris Barbara or Romana, including Noricum, Pannonia, &c., was annexed to the Western empire; while Illyris Græca, including Macedonia, Epirus, and Greece, formed part of the Eastern empire. The Via Egnatia, the great line of road which connected Rome with Constantinople and the East, led across Illyricum from Dyrrachium to Thessalonica.

In the wreck of the Roman empire Illyria suffered severely. In the 4th century the Goths ravaged it repeatedly, but these, the most civilized of the barbarian invaders of Rome, with their warlike aristocracy, passed on, and were succeeded by wilder tribes. Slavs, as also Huns and other nomadic races from the East, in succession devastated the country. An agricultural population could no longer maintain itself, and all the elements of civilization disappeared. Justinian (527–565) tried in vain to defend the country by a series of forts; his armies were defeated time after time, and at last he allowed the Huns to make settlements south of the Danube. Rome gave up the defence of civilization against the inroads of barbarism, and bribed the barbarians to be quiet. Still the Via Egnatia was defended, as the artery of communication and the highway of commerce between Constantinople and the west. The open country, however, even south of the great road, was abandoned to the Slavs and Huns. The older Illyrians partly united with these races, partly went farther south, encroaching on the Greek people, and the name of one of their tribes, Albani, is preserved in the modern name of their descendants, the Albanians.

Heraclius (610–641 A.D.) settled Slavonic peoples all along the coast of Illyria as far south as Dyrrachium. The states which were thus created were of great importance in the Dark Ages. The republic of Narenta vied for a time with that of Venice; and the commerce of Ragusa was so rich that it has given its name to all wealthy merchant vessels or "argosies." The name of Illyria had by this time disappeared from history; and the country was now divided between these powerful merchant cities and the states of Bosnia, Croatia, Servia, Rascia, and Dalmatia. In literature the name was preserved, and the scene of Shakespeare's comedy *Twelfth Night* is laid in Illyria. Politically the name was revived in the beginning of this century, when the small kingdom of Illyria to the north of the Adriatic was constituted at the peace of Vienna, 1809. In 1849 the territorial distribution of the Austrian empire was remodelled, and Illyria again disappeared. (W. M. RA.)

ILORI, or ILORIN (the Alourie of the Landers' expedition), an important town of the Yoruban territory of Western Africa, situated about 60 or 70 miles south of the Niger, and about 160 miles north-north-east of Lagos. The wall has a circuit of 12 miles, but is badly kept in repair. Along the south-eastern side flows a small stream which joins the Asa, a tributary of the Niger. The inhabitants are Yorubas, Fellatah (Pullo), Houssas, Gambarees, Bornuese, and Nufes or Papas. Most of them speak Yoruban. An extensive native trade is carried on at Ilorin, the Houssa caravans importing manufactured goods of various sorts, not only from Central Africa, but even from the coasts of the Mediterranean. The trade from the Guinea coast on the other hand is confined to brandy, guns, and powder. The variety of local industries is very considerable: Rohlfs mentions beautiful leather goods, carved wooden vessels, finely plaited mats, embroidered work, pottery of various kinds, shoes of yellow and red leather, and, what was unique in his experience of Negro tribes, the manufacture of cheese. The population is estimated at from 60,000 to 70,000, exclusive of the resident traders from foreign parts. There are a number of mosques in the town, and the Mahometans are the dominant power, but the lower classes maintain their pagan customs. About 1820 Ilori declared itself independent of Yoruba, and assisted in the destruction of Oyo.

See R. F. Burton, *Abeokuta and the Cameroons Mountains*, Lond., 1863; G. Rohlfs, *Quer durch Afrika*, Leipsic, 1874.

IMAGE WORSHIP. In the present article the word "image" will be employed to denote any artificial representation, whether pictorial or sculptural, of any person or thing, real or imaginary, which is used as a direct adjunct of religious services. This definition of the word shuts out from present consideration, though at some points by an almost imperceptible boundary, the worship of all merely natural symbols, whether animate or inanimate, conventional or the reverse. Thus, for example, every form of animal worship is excluded by it, and also the cultus connected with memorial stones of which traces so unmistakable are found in the Old Testament and in almost every other ancient literature (the λίθοι λιπαροί or ἀληλιμμένοι, βαίτυλοι, *lapides uncti*, *batyli*, of classical writers). So far as images (εἰκόνες, *imagines*) are merely more or less perfect productions of pictorial or plastic art, they fall to be treated under PAINTING, SCULPTURE, MOSAIC, &c.; so far as they have been regarded as aids to devotion and spiritual instruction, or made the objects of religious veneration, the history of their introduction and of the various aspects under which they have been viewed forms a large and not unimportant chapter in the history of religion in general and of the Christian church in particular. Only the outlines of that history can be indicated here.

Most religions of which the history has been traced give distinct indications of a primitive period in which "idols" were unknown. Thus in India "the worship of idols is a secondary formation, a later degradation of the more primitive worship of ideal gods" (M. Müller). In the Vedic hymns it is the appearances of nature themselves that are worshipped as symbols of unseen deity; and the present image worship of the Hindus is most probably Post-Buddhistic in its origin. The testimonies of the Greek historians (Herod., i. 131; Strabo, p. 732; Diog. Laer., *De Vit. Phil.*, procem. 6) as to the absence of religious images from the worship of the ancient Persians is confirmed by all the more recent direct investigations into the primitive life of that branch of the Aryan race. There is the same concurrence of testimony as regards the ancient Greeks;[1] the powers of nature were in the first instance

[1] See Schoemann, *Griech. Alterthümer*, ii. 197 *sqq*

worshipped through natural symbols,—such as serpents, trees, meteoric stones,—and in some cases temples occurred which contained no visible symbol at all. Even in the Homeric poems, the allusions to images of the gods are but few: where an image is mentioned (as in *Il.* vi. 301), it is evident that it was of the rudest description, and but little indebted to human art. The same remark applies to the cultus of ancient Rome. It was carried on without the use of images until the comparatively late period at which the state entered into relations with Etruria, Magna Græcia, and Sicily.[1] The date of the oldest statue in Rome, that of Diana on the Aventine, can be given with considerable precision as between 577 and 534 B.C. As regards the ancient Germans also, we have the testimony of Tacitus that down to his time at least their gods were still invisible and had neither temples nor images.[2] And, whatever be our construction of the primitive history of the Semitic races, there can be little doubt, so far as the Jews at least are concerned, of the correctness of their own impression that "idolatry," in the strict etymological sense of that word, was not the most primitive form of religion practised among them.

The decalogue contains a direct precept against the making of any "graven image" (*pesel* or *pasil*), for religious uses at least (Ex. xx. 4, 5; Deut. v. 8, 9; with which compare Deut. iv. 15–18). The "graven images" contemplated in the passage last cited are images of men, quadrupeds, birds, reptiles, and fishes; and the manner in which the prohibition is made is fitted to suggest that all these "likenesses" had made their appearance and already become objects of religious veneration prior to its promulgation. Nothing certain, however, is known as to the "strange gods" alluded to in Gen. xxxv. 4 as having been buried by Jacob under the oak at Shechem; nor can much be said with regard to the "teraphim" which are first mentioned as having been worshipped in one of the branches of the family of Terah (Gen. xxxi. 19), but are often subsequently referred to as having been used in the time of the judges (Judg. xvii. 5; *cf.* xviii. 30), and at various stages throughout the history both of the northern and of the southern kingdom (Hos. iii. 4; Zech. x. 2; 2 Kings xxiii. 24). Sometimes they must have been but small; but from other passages it may be inferred that they may have been, occasionally at least, of human form and size (1 Sam. xix. 13, 16). Much obscurity attaches also to the calf worship of which an instance occurred in the wilderness (Ex. xxxii. 4), and which was a prominent feature in the religion of the northern kingdom from the days of Jeroboam to the end; it is a disputed question whether the cult was of Egyptian or of purely Semitic origin. The difficulty in Lev. xvii. 7, and perhaps also in Deut. xxxii. 17, Ps. cvi. 37, is by some interpreters explained by a reference to the Egyptian goat worship (Mendes); if so, these passages contain no allusion to image worship. The various forms of the Baal cultus so often referred to in the Old Testament were no doubt Semitic; there are no explicit references to any images, however, in this connexion; and in point of fact (see BAAL) that deity was generally represented in his "high-places," not by images, but by obelisks or pillars. That the plastic arts, even in a religious connexion, were not wholly discouraged among the Jews, appears from what we read, not only about the brazen serpent in the wilderness, but also about the existence in tabernacle and temple of such figures as cherubs (Ex. xxv. 18–20; xxvi. 1; xxxvi. 35; 1 Kings vi. 23, 32, 35) executed in various materials, lions, oxen, lotus flowers, and pomegranates (*cf.* Ex. xxxi. 4, 5). The graphic descriptions of the process of idol-making, both "graven images" and "molten images" in Isa. xl. and xliv. (with which may be compared Wisd. xv.; see also the reference in Isa. xxx. 22 to molten images overlaid with a precious metal) show that the exercise of those arts was far from being confined, at the periods to which these passages relate, within the limits fixed by the second commandment. After the captivity, however, there developed itself among the Jews a steadily growing tendency to interpret the language of the law with the most stringent literality; and at the time of the Roman occupation the masses, under Pharisaic influences, showed a sensitiveness on the subject of images which in certain recorded instances led to very striking results. Thus, the existence of trophies in the theatre at Jerusalem was violently objected to; Vitellius found it necessary to avoid Judæa in his march from Antioch to Petra, lest the Holy Land should be defiled by the presence of the Roman eagles; at the outbreak of the Jewish war the house of Antipas at Tiberias was destroyed because it was adorned with sculptures (Joseph., *Ant.*, xv. 8. 1, 2; xviii. 3. 1; *Vit.*, 12). This aversion to every exercise of the imitative arts, as regards living things at least, passed over from Judaism to Mahometanism.[3]

As regards the attitude towards religious images assumed by the primitive Christian church, several questions have often been treated as one which cannot too carefully be kept quite apart. There can be no doubt, for example, that the early Christians were absolutely unanimous in utterly condemning all heathen image-worship and the various customs, many of them obviously immoral, with which it was associated; it is needless to multiply citations from the fathers in proof of so undisputed a fact. A form of iconolatry specially deprecated in the New Testament was the then prevalent adoration of the images of the reigning emperors (see Rev. xv. 2). It is also tolerably certain that, if for no other reasons besides the fewness, obscurity, and poverty of the early converts to Christianity, the works of art seen in their meeting houses cannot possibly at first have been numerous. Along with these reasons would certainly cooperate towards the exclusion of visible aids to devotion, not only the church's vivid recollection of what Christ had been, and its living sense of His continued real though unseen presence, but also, during the first years, its constant expectation of His second advent as imminent. In point of fact it was a common accusation brought against the Christians by their enemies that they had "no altars, no temples, no known images" (Min. Fel., *Oct.*, c. 10), that "they set up no image or form of any god" (see Arnob., *Adv. Gent.*, vi. 1; similarly Celsus); and this charge was never denied. At a comparatively early date indeed we read of various Gnostic sects calling in the fine arts to aid their worship; thus Irenæus (*Hær* i. 25, 6), speaking of the followers of Marcellina, says that "they possess images, some of them painted, and others formed from different kinds of material; and they maintain that a likeness of Christ was made by Pilate at that time when Jesus lived among men. They crown these images, and set them up along with the images of the philosophers of the world; that is to say, with the images of Pythagoras and Plato and Aristotle and the rest. They have also other modes of honouring these images after the same manner as the Gentiles" (*cf.* Aug., *De Hær.*, c. 7). It is

[1] See Preller, *Röm. Mythologie*, p. 10, &c. The statement of Plutarch (*Numa*, 8), that for 170 years after the foundation of the city images were unknown, recurs in many later writers.

[2] The statements of Tacitus on this head, as well as those of later historians are discussed very fully in Grimm's *Deutsche Mythologie*, i. p. 93 *sqq.*

[3] On the pre-Islamitic polytheism of Arabia, and the extent to which it consisted in the worship of living animals or their images, see a suggestive paper by Prof. W. Robertson Smith on "Animal Worship and Animal Tribes among the Arabs and in the Old Testament" in the *Journal of Philology*, vol. ix. p. 75–100 (1880).

also well known that the emperor Alexander Severus found a place for several Scripture characters and even for Christ in his lararium (Lamprid., *Vit. Alex. Sev.*, c. 29). But there is no evidence that such a use of images extended itself at that early period to orthodox Christian circles; and the presumption is all the other way. The first unmistakable indication of the actual public use of the painter's art for directly religious ends does not occur indeed until the year 306 A.D., when the synod of Elvira, Spain, decreed (can. 36) that "pictures ought not to be in a church, lest that which is worshipped and adored be painted on walls."[1] The scope of this prohibition has been very differently viewed by interpreters,—some thinking that all that is forbidden is any attempt at delineating the divine; others considering that the synod contemplated frescos only and not pictures, which could be more readily hidden from profanation in times of persecution; others taking the canon in the broadest sense as directed against the exhibition in churches of pictures of sacred subjects. In any case, and particularly if the last theory be adopted, it is evident that the use of sacred pictures in public worship was not at the beginning of the 4th century a thing wholly unknown within the orthodox church in Spain; and the presumption is that in other places, about the same period, the custom was looked upon with a more tolerant eye. Indications of the existence of allied forms of sacred Christian art prior to this period are not wholly wanting. It seems possible to trace some of the older and ruder frescos in the catacombs back to a very early century; and it is certain that Bible manuscripts were often copiously illuminated and illustrated even before the middle of the 4th century. An often-quoted passage from Tertullian (*De Pudic.*, c. 10, *cf.* c. 7) shows that in his day the communion cup was wont to bear a representation of the Good Shepherd. Clement of Alexandria (*Pædag.*, iii. 11) mentions the dove, fish, ship, lyre, anchor, as suitable devices for Christian signet rings.

During the 4th and following centuries the tendency to enlist the fine arts in the service of religion and the church may be said to have steadily advanced; not, however, so far as appears, with the formal sanction of any regular ecclesiastical authority, and certainly not without strong protests raised by more than one powerful voice. From a passage in the writings of Gregory of Nyssa (*Orat. de Laudibus Theodori Martyris*, c. 2) it is easy to see how the stories of recent martyrs would offer themselves as tempting subjects for the painter, and at the same time be considered to have received from him their best and most permanent expression; that this feeling was very widespread is shown in many places by Paulinus of Nola (*ob.* 431), from whom we gather that not only martyrdoms, and Bible histories, but also symbols of the Trinity were in his day freely represented pictorially. Augustine (*De Cons. Ev.*, i. 10) speaks less approvingly of those who look for Christ and His apostles "on painted walls" rather than in His written word. How far the Christian feeling of the 4th and 5th centuries was from being thoroughly settled in favour of the employment of the fine arts is instructively shown by such a case as that of Eusebius of Cæsarea, who in reply to a request of Constantia, sister of Constantine, for a picture of Christ, wrote that it was unlawful to possess images pretending to represent the Saviour either in His divine or in His human nature, and added that to avoid the reproach of idolatry he had actually taken away from a lady friend the pictures of Paul and of Christ which she had.[2] Similarly Epiphanius in a letter to John, bishop of Jerusalem, tells how in a church at Anablatha near Bethel he had found a curtain painted with the image "of Christ or of some other saint," which he had torn down and ordered to be used for the burial of some pauper. The passage, however, reveals, not only what Epiphanius thought on the subject, but also the fact that such pictures must have been becoming frequent. Nilus, the disciple and defender of Chrysostom, permitted the symbol of the cross in churches and also pictorial delineations of Old and New Testament history, but deprecated other symbols, pictures of martyrs, and most of all the representation of Christ. In the time of Gregory the Great the Western Church at last obtained something like an authoritative declaration on the vexed question about images, but in a sense not quite the same as that of the synod of Elvira: Serenus of Marseilles, on account of what he considered to be flagrant abuses, had ordered the removal and destruction of all sacred images within his diocese; this vigorous action called forth several letters from Pope Gregory (viii. 2, 111; ix. 4, 11), in which he utterly disapproved of that violent course, and, for the first time clearly drawing the distinction which has ever since been authoritative for the Roman Church, pointed out that "it is one thing to worship a picture and another to learn from the language of a picture what that is which ought to be worshipped. What those who can read learn by means of writing, that do the uneducated learn by looking at a picture. . . . That, therefore, ought not to have been destroyed which had been placed in the churches, not for worship, but solely for instructing the minds of the ignorant." Here it may be mentioned with regard to the symbol of the cross, that its public use dates from the time of Constantine, though, according to many Christian archæologists it had, prior to that date, a very important place in the so-called "disciplina arcani." The introduction of the crucifix was decidedly later, and originally the favourite combination was that of the figure of a lamb lying at the foot of the cross; the Trullan council in 692 by its 82d canon enjoined that this symbol should be discontinued, and that where Christ was shown in connexion with His cross He should be represented in His human nature.

It was not until the 8th century that the religious and theological questions which seem naturally to connect themselves with image worship were at last distinctly raised in the Eastern Church in their entirety, and argued in what from some points of view might fairly be called an exhaustive manner. The controversy began with the edict by which Leo the Isaurian, in the tenth year of his reign (726), sought to deliver the church from what he called "the idolatry of image worship." The text of that edict is not extant, but it seems to have been directed exclusively against such "idolatrous" homage as appeared to be involved in the established custom of prostration before them. The use of the strong word "idolatrous" at once led to a keen controversy, in which it was urged by the theologians that a "relative worship" (προσκύνησις σχετική) might, without idolatry, be given to the image of Christ. Among those who took this ground was the famous John of Damascus, who retorted upon the iconoclastic emperor with charges of Judaizing and even of Manichæan leanings. Leo, unconvinced, but finding that his first edict had been wholly ineffectual, four years later (730) issued a second decree, of a more sweeping character than the first, inasmuch as all the holy images were ordered to be removed, and all recalcitrant bishops summarily ejected from their posts. This proceeding called forth further arguments from the theologian of Damascus, through whose influence the iconoclasts were anathematized in such churches as were not too directly and entirely under the political influence of Constantinople. At the same time (730) Pope Gregory

[1] Placuit picturas in ecclesia esse non debere, ne quod colitur et adoratur in parietibus depingatur. See Hefele, *Conciliengesch.*, i. 170.

[2] The letter, which is most probably, though not certainly, genuine, appears in the *Acta* of the second council of Nice.

II. addressed to the emperor two important controversial letters in favour of images. They are preserved in the *Acta* of the second council of Nice. Apart from their direct historical importance, they are of considerable interest as literary and theological curiosities. To the objection which had of course been urged from the decalogue, he replied that the prohibition there was directed simply against the idolatry of Canaan, and could not have been intended in a sense inconsistent with the fact that Moses had been commanded to make cherubim and the like. Christ Himself was an image, the image of God. The charge that the iconoduli prayed to stones, walls, and pictures was easily met; and the further difficulty that six œcumenical councils had met and separated, but enjoined nothing about images, it was held, told distinctly against the iconoclasts, for the same councils had equally failed to urge upon men the duty of taking their necessary food. Heedless of Gregory's remonstrances, the emperor continued, during the remaining twelve years of his life, to carry on the struggle with but little effect; the religious use of images was too intimately interwoven, not only with the church life, but also with the domestic habits of his people, to yield even to the most determined efforts of an arbitrary despotism. In 741 Leo was succeeded by Constantine Copronymus (741–775), who fully shared the iconoclastic views of his father, and in 754 convoked a council, attended by three hundred and thirty-eight bishops, but never recognized as œcumenical, which under his influence declared all reverencers of images to be men who had lapsed into idolatry; decreed that "Christ in His glorified humanity, though not incorporeal, was yet exalted above all the limits and defects of a sensuous nature, too exalted therefore to be figured by human art in an earthly material after the analogy of any other human body"; and pronounced anathema on all who attempted to express by visible colours the form of the Logos in His incarnation, and on all who delineated dumb and lifeless pictures of the saints, which could never serve any profitable end. All images whatsoever of sacred persons or things were ordered to be ejected from Christian churches; and to set them up either in public or in private buildings was forbidden under the gravest ecclesiastical penalties. The stringency of these decrees was justified by arguments drawn from reason and Scripture, as well as by appeals to such names as those of Gregory, Chrysostom, Athanasius, Epiphanius, and Eusebius. The attempt to enforce the decisions of the council as imperial laws was in many instances marked by oppressiveness and cruelty, and the general feeling of the community, fostered diligently by a numerous class of its most energetic and pious members, the monks, continued unchanged in its aversion to iconoclasm; and, although at the end of his reign Constantine succeeded in imposing upon every citizen of Constantinople an oath never again to worship an image, there can be little doubt that in a vast number of households secret leanings to image worship had been intensified rather than weakened by repressive measures. During the early part of the brief reign (775–779) of Leo IV. Chazarus, the stringency of the law was somewhat relaxed, until it was discovered that the empress (Irene) was herself a secret iconolater, when she was brought into disgrace, and numbers of her accomplices were seized and imprisoned. On the death of Leo, Irene became regent for her infant son Constantine, and, as was to be expected, used the power which she now possessed in favour of the cause she had long had at heart. With the assistance of the monks, after an abortive attempt to hold a synod at Constantinople in 786, there met at Nice in 787 a general council (the seventh œcumenical), the proceedings of which are of considerable historical importance. It was there decided that, not only the figure of the cross, but also other holy images (Christ, the Virgin Mary, angels, and saints), whether painted or executed in mosaic or other material, might be set up in churches, placed on holy vessels and vestments, on walls and panels, in houses and by highways, and were to be honoured with ἀσπασμός and προσκύνησις, though not with λατρεία, which is given to the divine nature alone. The decrees, which were signed by all present, were afterwards solemnly ratified at a final session (the eighth) held in Constantinople, and thus, after a struggle of sixty-one years, the worship of images asserted in the Greek Church that ascendency which, with only one brief interruption of a few years, it has ever since maintained.

The decisions of this Eastern council were in full harmony with the personal views and practices of the popes, who, however, were compelled to show considerable moderation in the attitude they assumed. The Latin Church also, as is shown by the writings of Agobard of Lyons and Claudius of Turin, contained strongly iconoclastic elements, which, if full scope had been given them, might conceivably have altered very considerably the current of Western opinion. On political as well as on religious grounds, however, it was felt to be inexpedient to push matters on either side to extremes; very important therefore at this juncture was the step taken by the emperor Charlemagne in the publication of his *De Impio Imaginum Cultu Libri IV.*, commonly called the *Libri Carolini*, in which, condemning alike the fanaticism of iconoclasts and the superstition of iconoduli, he maintained the right of images to exist for purposes of commemoration and ornament (propter memoriam rerum gestarum et ornamentum). At the synod of Frankfort-on-the-Main, held in 794, his general position was maintained, and adoration of images (*adoratio et servitus imaginum*) was wholly condemned. Great injustice was done, however, to the fathers of the second Nicene council when they were accused of maintaining that the same worship ought to be given to images of saints as to the Holy Trinity,—a doctrine which they had been at special pains to repudiate. The settlement which had been obtained in 787 did not subsist entirely undisturbed even in the Eastern Church. In 815, two years after Leo the Armenian had ascended the throne, a council convoked by him at Constantinople formally abolished the decrees of Nice, and again banished the images from the churches. The new controversy, with which the name of Theodore of the Studium is still more prominently associated than was that of John of Damascus with its previous phase, went on with vicissitudes very similar to those which had formerly occurred during the reign of Leo and his successors Michael (820–830) and Theophilus (830–842). At length, during the regency of the empress Theodora, the decrees of Nice were reaffirmed by a synod at Constantinople, and the banished images were triumphantly and finally reintroduced into the metropolitan church on the day which on the first Sunday in Lent is still celebrated throughout the Greek Church as a great festival under the name of ἑορτή or πανήγυρις τῆς ὀρθοδοξίας. One incident in this second iconoclastic controversy had been the mission of an embassy by Michael Balbus to Louis the Pious in 825. The reply was given through the synod of Paris, held in that year: in open disagreement with the opinions of Pope Hadrian I., the relatively neutral ground taken up at the synod of Frankfort was maintained.

Down to the close of this period the "images" spoken of in ecclesiastical controversy are almost entirely pictures or mosaics,—the religious use of sculptures, and particularly of statues (ἀγάλματα, ἀνδριάντες, στῆλαι), being little known, and, so far as known, disapproved. This distinction does not indeed appear in the actual decrees of the council of Nice; but it is clearly drawn in the statements of the patriarch Germanus and by Stephen Bostrenus, as quoted in the proceedings (*Act.* ii.). Such remains of Christian antiquity as the statue of Hippolytus, recently dug up at Ostia, and usually assigned to a date not later than the 5th century, as also the sitting figure of St Peter, dating from the same period, now seen in St Peter's, Rome, have no immediate connexion with the subject of this article. The same remark applies to the still earlier statue at Paneas referred to by Eusebius (*H. E.*, vii. 18), said to have been raised in honour of Christ by the woman mentioned in Matt. ix. 20; if it was really intended to represent Christ at all and not rather the emperor Hadrian, it was, at all events, obviously no object of special veneration. About the 9th century, however, "graven images" seem to have become more common. Thus in the treatise *De Imaginibus* (c. 31) of Agobard of Lyons (*ob.* 840), there is an obvious controversial allusion to molten or moulded statues of angels or holy men. With the gradual introduction of the architecture commonly known as Gothic, there came in a great advance in plastic art. The new cathedrals gave scope for and even demanded a wealth of decoration formerly unknown, until it seemed as if, not only the entire Biblical history, but all the *Acta Sanctorum*, were to be artistically told in wood and stone. The earliest extant sculptures in stone or stucco cannot be carried farther back than the 11th century. But the discussion of their date and character belongs to the artistic rather than to the religious side of the subject.[1]

At the period of the Reformation it was unanimously felt by the reforming party that, with the invocation of saints and the practice of reverencing their relics, the adoration of images ought also as matter of course to cease. The leaders of the movement were not all, however, perfectly agreed on the question as to whether these might not in some circumstances be retained in churches. Luther, it is well known, had no sympathy with the iconoclastic outbreaks which history mentions as having taken place with some frequency at this period; he classed images in themselves as among the "adiaphora," and condemned only their cultus; so also the "Confessio Tetrapolitana" leaves Christians free to have them or not, if only due regard be had to what is expedient and edifying. The "Heidelberg Catechism," on the other hand, emphatically declares that images are not to be tolerated at all in churches. This position, which is that of all the reformed churches, has an obvious connexion with their view as to the division of the decalogue, they following Origen on this question while the Lutherans adhere to the Philonic arrangement (see DECALOGUE).

At the council of Trent (session xxv.) the Church of Rome finally formulated the doctrine on the subject of images which is still of authority within its communion. That doctrine is avowedly based on the decrees of the second council of Nice. It is declared that images of Christ, the Virgin Mary, and other saints are to be set up and retained, especially in churches, and that "due" honour and veneration are to be accorded them by kissing and prostration. Warnings are appended, however, against their superstitious abuse somewhat in the spirit of Gregory the Great's letter and of the decision of the Frankfort synod.

The Greek Church continues tenaciously to adhere to the decrees of the second Nicene council, and has not yielded to any of the artistic impulses which have elsewhere made themselves so powerfully felt. The sacred pictures which abound everywhere, and are treated with extraordinary reverence and affection, are for the most part very defective æsthetically. Indeed the preference seems to be given to those executed in rude archaic style, and even now the painter of pictures intended for religious uses must bear in mind the monk's famous criticism on Titian. Nude or incompletely draped figures are forbidden, and only half lengths are permitted "ut omnis stultæ cogitationis occasio tollatur." No representation of the Godhead or of the Trinity is attempted. Although it is in the records of a Constantinopolitan council that the earliest extant notice of the crucifix occurs, that symbol is not now used in the East.

[1] Such works as Lubke's *Kunstgeschichte* may be consulted in this connexion; also Didron's *Iconographie* and Jameson's *Sacred and Legendary Art*.

The literature of the subject is immense. The most important monographs are—from the Catholic point of view, Maimbourg, *Histoire de l'Hérésie des Iconoclastes* (Paris, 1679–82); from the Protestant, Daillé, *De Imaginibus* (Leyden, 1642), and Spanheim, *Historia Imaginum restituta* (Leyden, 1686). For the acts of the councils, Labbé or Mansi must be consulted; the learned compilation of Goldast, *Imperialia decreta de cultu imaginum in utroque imperio promulgata collecta et illustrata* (Frankfort, 1608), will also be found useful. Compare Schlosser, *Gesch. der bilderstürmenden Kaiser* (Frankfort, 1812). The sections relating to image worship in the great work of Chemnitz (*Examen Conc. Trid.*, pars 4) are characterized by learning and moderation. The whole subject is treated, of course, in all the church histories; with most fulness and insight in that of Neander. The iconoclastic controversy is dealt with also in the histories of Gibbon and Milman. Copious archæological details are also given in Augusti's *Denkwürdigkeiten*, vol. xii. (Leipsic, 1831). (J. S. BL.)

IMÁM is the name given to the priest who leads the prayers of a Mahometan congregation, and is exactly equivalent to Antistes. In the Koran, chap. ii. v. 118, it is said of Abraham, "Verily, I will set thee as an imám (high priest or model) for men." In Turkey the imám, besides his function as a minister, performs the rites of circumcision, marriage, and burial. He is distinguished only by avoiding gay colours in his dress and wearing a white turban. In Persia the imám is also called a mujtahid; he has no secular duties. The title has been always borne by the caliphs or successors of Mahomet, the earlier ones having, like the Prophet himself, conducted the services in person, and addressed the people in a *khutbah* or homily on the great weekly gathering on Fridays. The title thus came to signify head of the faith, and as such is claimed and used by the present sultans of the Osmanli dynasty in Turkey, the last of the legitimate caliphs, El Mutawakkel, having in 1517 A.D. ceded his prerogatives to Selim I., the first Ottoman sultan, and his heirs. The caliphate (see CALIPH) is also called *El Imámah*, the imamate. The Shiah sect hold that the office of imám was specially assigned by Mahomet to Ali ibn Abi Tálib, his cousin and son-in-law, and passed from him to his legitimate male issue by Fatima Mahomet's daughter. The first imám then was Ali; the next two were Ali's sons Hasan and Husein (see HASAN); then came Ali Zein el 'Ábidîn, son of Husein. His son Zeid founded the sect called the Zeidîyeh, who recognized him as imám. This sect split into two subdivisions, one of which declared that the imám ought to be designated by his predecessor, the other that the imamate was elective, but must be confined to the descendants of Fatima. The twelve imáms generally received by the Shiahs do not, however, include Zeid, but are the following:—(1) Ali ibn Abi Tálib; (2) El Hasan his son; (3) El Husein, Ali's other son; (4) Ali Zein el 'Abidîn, son of Husein; (5) Mohammed el Bakir, son of Zein el Ábidîn; (6) Jaafer es Sádik, son of El Bakir; (7) Musá el Kadhim, son of Jaafer; (8) Ali er Ridhá, son of Musa; (9) Mohammed et Takí, son of Er Ridhá; (10) Ali el Hádí, son of Et Takí; (11) Hasan el Askarí, son of El Hádi. Here the chain of succession breaks off, the twelfth imám being Mohammed el Mehdi, surnamed Abu Kasim, who was predicted by the Prophet, and who is yet to come. The title imám is also applied to the founders of the four great orthodox sects of Mahometans.

IMBROS, or IMVRO, an island in the Ægean Sea, lying west of the southern end of the Thracian Chersonese, about 14 miles from the mouth of the Dardanelles. To the north-west, at a distance of 17 miles, lies the island of Samothraki; and about the same distance to the south-east is Lemnos. The area of Imbros is estimated at 105 square miles, and its population, which is mainly of Greek origin, is about 10,000. With its bare mountain ridges and sides it has no small similarity to Attica. Hagios Ilias, or St Elias, is the highest summit, 1859 feet above the sea-level. According to Franz von Loher about a third of the island could be turned into a very garden by an industrious and skilful race; but at present not more than one-tenth is under cultivation. Wheat, barley, and oats are grown, as well as a dye-plant locally called bouia. A German company is working lignite in the island. The only stream of importance has surrendered its ancient name of Ilissus for the simple appellation of *μεγάλος ποταμός* or Big River. The valley through which it flows is the only considerable tract of arable land in the island, and contains the four villages of Theodoro, Kastro, Gliki, and Panagia. Kastro, which lies on the coast, is the site of the ancient town which bore the same name with the island; but the only remains of antiquity are part of the mole, portions of the town-wall, and a number of tombstones. A hill above the town presents with its summit so great a likeness to a mediæval castle that it has frequently been described as such. The archæological investigations of Conze have brought to light a few inscriptions of secondary interest, which mainly serve to confirm the Attic character of Imbrian civilization. Attic and Trojan coins are not unfrequent; and traces are found of the worship of the Cabiri, Cybele, and Zeus Hypsiotes. Imbros plays no great part in history; though the name occurs as early as the *Iliad* and the Homeric *Hymns*. Herodotus mentions its subjugation to the Persians by Otanes. In later times it was distinctly recognized as an Athenian colony. The numerous watch-towers and diminutive strongholds observed throughout the island would indicate that it had its share in the busy warlike existence of the Middle Ages. Along with Samothraki, Lemnos, and Hagiostrati, Imbros belongs administratively to the Vilayet of the Islands, or Jesair bahr i Safid of Asiatic Turkey. It is the seat of a metropolitan of the Greek Church, with the title of exarch of the Ægean.

See Richter, *Wallfahrten nach dem Morgenlande*, Berlin, 1822; Mustoxides, Υπομνηματα ιστορικα περι της νησου Ιμβρου, Constantinople, 1845; Louis Lacroix, *Les îles de la Grèce*, 1853; Blau and Schlottmann, in *Berichten der Königl. preuss. Akad. der Wissensch.*, 1855; Conze, *Reise auf den Inseln des Thrakischen Meeres*, Hanover, 1860; Von Loher, *Griechische Küstenfahrten*, Bielefeld, 1876.

IMERITIA, a district in Transcaucasia, extends from the left bank of the Tzhenys-tzkalys to the range of hills that separate it from Georgia on the east, and is bounded on the south by Akhalzikh. Anciently a part of Colchis, and included in Lazia during the Roman empire, Imeritia was nominally under the dominion of the Greek emperors. In the early part of the 6th century it became the theatre of wars between Justinian and Chosroes, and was devastated by subsequent hostile incursions, reviving only on becoming united to Georgia. It flourished until the reign of Queen Thamar, but after her death (1212) the country became impoverished through strife and internal dissensions. Reunited to Georgia, it became known in 1259 as Imier, whence Imeritia (1469). In 1621 was made the earliest appeal to Russia for aid; in 1650 the first Russian envoys were received at Koutais, the capital; and in 1769 a Russian force expelled the Turks. In 1804 the monarch declared himself a vassal of Russia, and in 1810 the little kingdom was definitively annexed to that empire. Imeritia, Mingrelia, and Gouria, provinces not officially recognized as distinct, are now included in the Russian government of Koutais. See GEORGIA.

IMMACULATE CONCEPTION. The dogma of the immaculate conception of the Virgin Mary, as held by the Church of Rome, is to the effect that "the most blessed Virgin was, in view of the merits of Jesus Christ the Saviour of the human race, by the singular grace and favour of Almighty God, from the first moment of her conception in the womb of her mother, preserved free from all taint of original sin." The "pious opinion" that the mother of Christ had during her life been preserved from sin in a way in which no other human being ever had been may be traced back to a comparatively early period: indeed, without it her cultus (for some account of the growth of which see MARY) as it had developed itself long before the 9th century, would have been impossible. The actual history of an explicit doctrine of her immaculate conception, however, so far as has hitherto been discovered, may be said to begin, in the year 1140,[1] with the letter of remonstrance which Bernard of Clairvaux wrote to the canons of the cathedral at Lyons (*Ep.* 174), who, without consulting the Roman see, had recently introduced into their church a festival in celebration of that doctrine. Bernard argued vigorously against this on the ground of its novelty, its unscripturalness (Ps. li. 5), and its absurdity:—"On the same principle," said he, "you would be obliged to hold that the conception of her ancestors, in an ascending line, was also a holy one, since otherwise she could not have descended from them worthily, and there would then be festivals without number." How the recipients, who, it is stated, claimed to have learned their peculiar rite from a document communicated by the Virgin herself, were affected by this letter, is not recorded. Among controversial treatises which appeared shortly afterwards are mentioned those of Potho of Prüm and the Abbot de la Celle against the doctrine, and that of the English monk Nicolas in its favour. In the 13th century all the leading theologians, such as Alexander Halensis (p. iii., qu. 10, membr. 2), Albertus Magnus (*Comm. in Sent.*, iii. 3), Bonaventura (*Comm. in Sent.*, iii. 3. 1, 2), and Thomas Aquinas (*Summa*, p. iii., qu. 27, art. 1–3), took the view of St Bernard, their contribution to the theology of the subject consisting in an accurate definition of the moment at which the Virgin's sanctification in the womb must be held to have taken place. During the same century the feast of the Conception became very popular, and in 1263 it was accepted by a general chapter of the Franciscans at Pisa, without reference, however, to the question of immaculacy. Of great importance to the subsequent history of the dogma was the appearance in the theological world, towards the beginning of the 14th century, of Duns Scotus, the "subtle doctor" of the Franciscans, who, as in so many other points, so also in this, came into conflict with the still more illustrious "Doctor Angelicus," the Dominican Aquinas. In one part of his *Commentary* on the *Sentences* of Peter of Lombardy (lib. iii., dist. 3, qu. 1, sec. 9) he declares for the thinkableness and even probability of Mary's having been preserved intact from original sin; in a later passage (dist. 18, qu. 1, sec. 13) the doctrine is categorically stated. It was upon this disputed point that the long and bitter controversy between the two great mendicant orders chiefly turned. In 1389, the Spanish Dominican Joannes de Montesono having maintained in a disputation at Paris that the view of the Scotists was unscriptural and heretical, the university, without committing itself on the main point, condemned his violent theses, and this condemnation was concurred in by the Avignon pope, Clement VII. The members of the entire

[1] The allegation that it was taught by Anselm of Canterbury is based partly upon a spurious tract attributed to him and partly on unauthentic legend. His actual opinion is explicitly enough stated in the treatise *Cur Deus Homo*, c. 18:—"Virgo tamen ipsa, unde assumptus est, est in iniquitatibus concepta, et in peccatis concepit eam mater ejus."

Dominican order, for their refusal to acquiesce, were for several years excluded from the privileges of the university. In the beginning of the 15th century the famous chancellor, John Gerson, accepted the new dogma, and applied in its favour the well-known doctrine of development. At the council of Basel (in the 36th session, held September 17, 1439) it was defined and declared that the doctrine was consistent with faith, reason, and Scripture, and therefore to be approved and embraced; the contrary doctrine was not condemned, but it was forbidden to preach or to teach it. The university of Paris now made subscription to the doctrine of the Immaculate Conception a condition for its degrees, and various other universities entered into a solemn compact to use every exertion for its spread, but the controversy was far from having been brought to a close even by the action of Pope Sixtus IV., who in 1483 published a bull threatening with excommunication any one who should accuse of heresy either the advocates or the impugners of the doctrine, the point having not yet been decided by the apostolical see. In its fifth session (1546) the council of Trent, after formulating its decree on the subject of original sin, sought to effect a compromise between Dominicans and Franciscans by appending a declaration that it did not intend that this doctrine should be applied to the blessed and immaculate Virgin Mary, but that the constitutions of Sixtus IV. were still to be observed. In the beginning of the 17th century the field of battle was transferred to Spain, where, under the predominant influence of the Franciscans and Jesuits, medals were struck, pictures painted, statues erected, and persecutions set on foot in honour of the Virgin "sin pecado concebida"; and embassies were sent to Rome, both by Philip III. and by Philip IV., to obtain more explicit recognition of the popular doctrine. The popes continued for a long time, however, to maintain their attitude of reserve. Paul V. (1617) forbade all public dispute on the subject, and Gregory XV. (1622) extended the prohibition even to private discussions, except in the case of Dominicans "*inter se.*" But gradually the papal sympathies became more pronounced under Jesuit influences; Clement IX. gave the feast of the Conception an octave; Clement XI., in 1708, made it a festival "de præcepto" for all Christendom; while Benedict XIV. endeavoured to reconcile St Bernard with the more modern tendencies of Roman Catholic theology, by insisting upon subtle distinctions between the "conceptio activa" and the "conceptio passiva" of Mary. In the pontificate of Gregory XVI. several prelates received papal permission to describe her conception as immaculate; and in 1849 Pius IX. was induced to address to his bishops from Gaeta an encyclical, inviting them to state how far the dogmatic definition of the dogma would meet their wishes and the wishes of those under their charge. A large majority declared themselves strongly in favour of the proposal, and the ultimate result was that in December 8, 1854, the pope, in presence of a numerous concourse of cardinals, patriarchs, archbishops, and bishops assembled in St Peter's, Rome, solemnly promulgated the bull "Ineffabilis Deus," by which the doctrine of the Immaculate Conception finally became for the Roman communion an article of faith, the denial of which is accounted to be heresy.[1]

The feast of the Immaculate Conception is observed in the Roman Church on December 8. In the Greek Church there is a festival in honour of the conception of St Anne (the mother of Mary), for which December 9 was fixed by a constitution of the emperor Emanuel Comnenus in the 12th century. Her deliverance from the reproach of sterility is what is celebrated; there is no reference to anything analogous to the Roman doctrine. It may be remarked that strong expressions as to the absolute purity of Mary are found in the Koran (iii. 37), and still more in later Mahometan writings; but the Christian doctrine of sin is so utterly foreign to Islam that no precise theological construction of these expressions is possible.

[1] The words are "Auctoritate Domini Nostri Jesu Christi, beatorum Apostolorum Petri et Pauli, ac Nostra, declaramus, pronuntiamus et definimus, doctrinam, quæ tenet Beatissimam Virginem Mariam in primo instanti suæ Conceptionis fuisse singulari Omnipotentis Dei gratia et privilegio, intuitu meritorum Christi Jesu, Salvatoris humani generis, ab omni originalis culpæ labe præservatam immunem, esse a Deo revelatam, atque idcirco ab omnibus fidelibus firmiter constanterque credendam.

IMMERMANN, Karl Lebrecht (1796-1840), dramatist and novelist, was born April 24th, 1796, at Magdeburg. From the gymnasium of his native city he passed in 1813 to study law at the university of Halle, but his career there was interrupted by the commotions consequent upon Napoleon's escape from Elba. Immermann was prevented by illness from taking part in the earlier campaign, but he served in the Prussian army in 1815, was present at Ligny and Waterloo, and marched into Paris with Blücher. He went back to Halle to finish his studies, and held official positions at Oschersleben, Münster, and Magdeburg successively, before he became judge of a district on the Rhine, near Düsseldorf. The attention which his writings had already excited won him a warm welcome from the artistic circle which then made Düsseldorf famous, and there he spent the rest of his life, dividing his time amongst his judicial duties, his unsuccessful attempt to raise the theatre there to a permanent classic level of art and refinement, and a platonic literary friendship with the countess of Ahlefeldt. The last, begun at Münster and terminated only at his marriage with a granddaughter of the chancellor Niemeyer in 1839, exercised a marked influence over his genius. Immermann died at Düsseldorf, August 25, 1840. His dramas are perhaps better suited for the study than for the stage. Though sometimes rough and forbidding, they are marked by considerable insight into character; the comedies are by no means destitute of comic force. Signs of a close study of Shakespeare are abundant. In his semi-humorous romances Immermann is at his best, and it is by those that he will be chiefly remembered.

His chief works are the following: the tragedies—*Vale of Ronceval*, *Edwin*, *Petrarca*, 1822; *King Periander*, 1823; *Cardenio and Celinde*, 1826; *Frederick II.*, 1828; and *Ghismonda*, 1839; and the comedies—*Princes of Syracuse*, 1821; *Eye of Love*, 1824; *Disguises*, 1828; *School of the Pious*, 1829. Besides these he wrote the mythical play, *Merlin*, 1831; the trilogy of *Alexis*, 1832; the dramatic poem, *The Tragedy in the Tyrol*, 1827; and the romances—*Tulifäntchen*, 1827, *Die Epigonen*, 1836 (perhaps his best work), and *Münchhausen, a Story in Arabesques*, 1839. He published two volumes of poems (1822 and 1832), and began *Tristan and Isolde*, 1842. His miscellaneous writings include a translation of *Ivanhoe*; *On the Mad Ajax of Sophocles*, 1826; *Miscellen*, 1830; *The Hermit's Window*, 1822; *Journal of a Traveller*, 1833; *Memorabilien* (unfinished), 1840; and *Theaterbriefe*, 1851. The collected works were published in 14 vols. in 1835-43. See Putlitz's *Karl Immermann, sein Leben und seine Werke*, 1870.

IMMORTELLE, or Everlasting. The immortelle plant belongs to the division *Tubuliflorœ* of the natural family *Compositœ*, and is scientifically known as *Gnaphalium* (*Helichrysum*) *orientale* of Linnæus. It is a native of North Africa, Crete, and the parts of Asia bordering on the Mediterranean; and it is cultivated in many parts of Europe. It first became known in Europe about the year 1629, and has been cultivated since 1815. In common with several other plants of the same group, known as "everlastings," the immortelle plant possesses a large involucre of dry scale-like or scarious bracts, which preserve their appearance when dried, provided the plant be gathered in proper condition. The chief supplies of *Helichrysum orientale* come from Lower Provence, where it is cultivated in large quantities on the ground sloping to the Mediterranean, in positions well exposed to the sun, and usually in plots surrounded by dry stone walls. The finest flowers are grown on the slopes of Bandols and Ciotat, where the plant begins to flower in June. It requires a light sandy or stony soil, and is very readily injured by rain or heavy dews. It can be propagated in quantity by means of offsets from the older stems. The flowering stems are gathered in June, when the bracts are fully developed, all the fully-expanded and immature flowers being pulled off and rejected. After being dried, they are sent to Paris in boxes containing 100 bundles, with the flowers placed outwards and the stems in the centre. The immortelle is sold by weight or by the bundle, the price varying from 1½d. to 3d. per bundle, according to size, or from 12s. to 18s. per hundredweight, according to quality. A well-managed plantation is productive for eight or ten years. The plant is tufted in its growth, each plant producing 60 or 70 stems, while each stem produces an average of 20 flowers. About 400 such stems weigh a kilogramme. A hectare of ground will produce 40,000 plants, bearing from 2,400,000 to 2,800,000 stems, and weighing from 5½ to 6½ tons, or from 2 to 3 tons per acre. The colour of the bracts is a deep yellow. The natural flowers are commonly used for garlands for the dead, or plants dyed black are mixed with the yellow ones. The plant is also dyed green or orange-red, and thus employed for bouquets or other ornamental purposes.

The following is a list of the more important everlasting flowers:—*Acroclinium roseum*; *Ammobium alatum*; *Gnaphalium orientale* and other species; *Helichrysum bracteatum*, *macranthum*, and *compositum*, from Australia, and *H. vestitum*, from the Cape of Good Hope; *Helipterum canescens* and *Sandforti*, from South Africa; *Rhodanthe Manglesii*, *maculata*, and *atrosanguinea*, from Swan River; *Waitzia nitida* and *nivea*, from Swan River; and *Xeranthemum annuum*. Frequently these everlastings are mixed with bleached grasses, as *Lagurus ovatus*, *Briza maxima*, *Bromus brizæformis*, or with the leaves of the Cape silver tree (*Leucadendron argenteum*), to form bouquets or ornamental groups.

IMOLA, the ancient *Forum Cornelii*, a town of Italy, capital of a circle in the province of Bologna, is situated in a fruitful and charming plain on the old Æmilian way, near the river Santerno (ancient *Vatrenus*), 21 miles south-east of Bologna and 46 north-west of Rimini, on the railway connecting those towns. It is the seat of a bishop and of a subprefecture. The town is surrounded by walls flanked with towers, and its streets are spacious and lined with arcades. It possesses a cathedral with an octagonal tower, an old castle, a gymnasium, a technical school, a school of music, a public library, orphanages for boys and girls, a hospital, and a corn exchange. The manufacture of wine is the principal industry, but a special kind of cream of tartar is also made, and there is considerable trade in corn, hemp, flax, rice, and silk. The population of the town in 1871 was 9355 and of the commune 28,398. In 1876 the population of the commune was 28,678.

The ancient *Forum Cornelii* is said to have derived its name from its founder the dictator Sulla. According to Cicero, it was occupied by Octavian during the civil war which followed the death of Cæsar, and Martial mentions it in the third book of his epigrams as the place where he was at that time residing. The modern name of the town is, according to Paulus Diaconus, derived from that of the old citadel. The town, after its destruction in 538 by Narses, general of the emperor Justinian I., was rebuilt by the Lombards, after which it remained under the lordship of Bologna till the end of the 13th century. In 1272 it was taken possession of by the Pagani, and in 1292 by the Alidosii, from whom it was seized in 1472 by Duke Philip Maria Visconti of Milan. Under the pontificate of Alexander VI. it was incorporated with the States of the Church. In 1708 it was captured by the imperialists, and in 1797 by the French.

IMPEACHMENT, an exceptional, and now rare, form of procedure against criminals in England, in which the House of Commons are the prosecutors and the House of Lords the judges. It differs from procedure by bill of attainder, which follows the ordinary forms of legislation in both Houses, and takes effect in an Act of Parliament. In impeachment the form of procedure is strictly judicial. When the House of Commons has accepted a motion for impeachment, the mover is ordered to proceed to the bar of the House of Lords, and there impeach the accused "in the name of the House of Commons, and of all the Commons of the United Kingdom." The charges are formulated in articles, to each of which the accused may deliver a written answer. The prosecution must confine itself to the charges contained in the articles, though further articles may be adhibited from time to time. The Commons appoint managers to conduct the prosecution, but the whole House in committee attends the trial. The defendant may appear by counsel. The president of the House of Lords is the lord high steward, in the case of peers impeached for high treason; in other cases the lord chancellor. The hearing takes place as in an ordinary trial, the defence being allowed to call witnesses if necessary, and the prosecution having a right of reply. At the end of the case the president "puts to each peer, beginning with the junior baron, the questions upon the first article, whether the accused be guilty of the crimes charged therein. Each peer in succession rises in his place when the question is put, and standing uncovered, and laying his right hand upon his breast, answers, 'Guilty' or 'Not guilty,' as the case may be, 'upon my honour.' Each article is proceeded with separately in the same manner, the lord high steward giving his own opinion the last" (May's *Parliamentary Practice*, c. xxiii.). Should the accused be found guilty, judgment follows if the Commons move for it, but not otherwise. The Commons thus retain the power of pardon in their own hands, and this right they have in several cases expressly claimed by resolution, declaring that it is not parliamentary for their lordships to give judgment "until the same be first demanded by this House." An impeachment, unlike other parliamentary proceedings, is not interrupted by prorogation, nor even by dissolution. Proceedings in the House of Commons preliminary to an impeachment are subject to the ordinary rules, and in the Warren Hastings case an Act was passed to prevent the preliminary proceedings from discontinuance by prorogation and dissolution. A royal pardon cannot be pleaded in bar of an impeachment. The point was raised in the case of the earl of Danby in 1679, and the rule was finally settled by the Act of Settlement. Persons found guilty on impeachment may be reprieved or pardoned like other convicts. Impeachment will lie against all kinds of crimes and misdemeanours, and against offenders of all ranks. In the case of Simon de Beresford, tried before the House of Lords 4 Edward III., the House declared "that the judgment be not drawn into example or consequence in time to come, whereby the said peers may be charged hereafter to judge others than their peers," from which Blackstone and others have inferred that "a commoner cannot be impeached before the Lords for any capital offence, but only for high misdemeanours." In the case of Fitzharris in 1681, the House of Commons in answer to a resolution of the Lords suspending the impeachment, declared it to be their undoubted right "to impeach any peer or commoner for treason or any other crime or misdemeanour." And the House of Lords has in practice recognized the right of the Commons to impeach whomsoever they will. The procedure has, however, been reserved for great political offenders whom the ordinary powers of the law might fail to reach. It has now fallen into desuetude. The last impeachments were those of Warren Hastings (1788–95) and Lord Melville (1805), but an unsuccessful attempt was made by Mr Austey to impeach Lord Palmerston in 1848. The earliest recorded instances of impeachment are those of Lord Latimer in 1376, and of Pole, earl of Suffolk, in 1386. From the time of Edward IV. to Elizabeth it fell into disuse, "partly," says Hallam, "from the loss of that control which the Commons had obtained under Richard II. and the Lancastrian kings, and partly from the preference the Tudor princes had given to bills of attainder or pains and penalties when they wished to turn the arm of parliament against an obnoxious subject." Revived in the reign of James I., it became an instrument of parliamentary resistance to the crown, and it was not unfrequently resorted to in the first three reigns after the Revolution.

In the constitution of the United States the procedure of impeachment is an almost exact copy of that described above. The House of Representatives are the accusers, and appoint managers to conduct the prosecution at the bar of the senate. The vote of the senate is taken by putting the question separately to each member, and a majority of two-thirds is required for a conviction. In the separate States it partakes of the same quasi-political character—neither the prosecutors nor the judges being the same as in ordinary criminal offences. The most noted instances of impeachment in the United States are those of Associate Justice Chase in 1804, of President Andrew Johnson in 1868, and of Judge Barnard, New York, in 1872. The object of impeachment is the removal of public officers for malversation in office, which is followed sometimes by disqualification for any future appointment.

INCENSE[1] is the perfume (fumigation) arising from certain resins and gum-resins, barks, woods, dried flowers, fruits, and seeds, when burnt, and also the substances so burnt. In its literal meaning the word "incense" is one with the word "perfume," the aroma given off with the smoke (per fumum[2]) of any odoriferous substance when burnt. But, in use, while the meaning of the word "perfume" has been extended, so as to include everything sweet in smell, from smoking incense to the invisible fresh fragrance of fruits and exquisite scent of flowers, that of the word "incense," in all the languages of modern Europe in which it occurs, has, by an opposite process of limitation, been gradually restricted almost exclusively to frankincense (see Frankincense). Frankincense has always been obtainable in Europe in greater quantity than any other of the aromatics imported from the East; it has therefore gradually come to be the only incense used in the religious rites and domestic fumigations of many countries of the West, and at last to be popularly regarded as the only "true" or "genuine" (*i.e.*, "franc") incense (see Littré's *Fr. Dict.*, and Skeat's *Etym. Dict. of Engl. Lang.*).[3]

The following is probably an exhaustive list of the substances available for incense or perfume mentioned in the Hebrew Scriptures:—Algum or almug wood (almug in 1 Kings x. 11, 12; algum in 2 Chron. ii. 8, and ix. 10, 11), generally identified with sandalwood (*Santalum album*), a native of Malabar and Malaya; aloes, or lign aloes (Heb. *ahâlim, ahâlôth*), produced by *Aloexylon Agallochum*, a native of Cochin-China, and *Aquilaria Agallocha*, a native of India beyond the Ganges (compare vol. i. p. 597); balm (Heb. *tsori*), the oleo-resin of *Balsamodendron Opobalsamum* and *B. gileadense*; bdellium (Heb. *bdôlah*), the resin produced by *Balsamodendron roxburghii, B. Mukul*, and *B. pubescens*, all natives of Upper India (Lassen, however, identifies *bdôlah* with musk); calamus (Heb. *kanch*; sweet calamus, *kench bosem*, Ex. xxx. 23, Ezek. xxvii. 19; sweet cane, *kanch hattob*, Jer. vi. 20, Isa. xliii. 24), identified by Royle with the *Andropogon Calamus aromaticus* or roosa grass of India; cassia (Heb. *kiddah*) the *Cinnamomum Cassia* of China (see vol. v. p. 184); cinnamon (Heb. *kinnamon*), the *Cinnamomum zeylanicum* of the Somali country, but cultivated largely in Ceylon, where also it runs wild, and in Java; costus (Heb. *ketzioth*), the root of the *Aucklandia Costus*, native of Cashmere; frankincense (Heb. *lebônah*), the gum-resin of *Boswellia Frereana* and *B. Bhau-Dajiana* of the Somali country, and of *B. Carterii* of the Somali country and the opposite coast of Arabia (compare vols. viii. p. 122, and ix. p. 709); galbanum (Heb. *helbenah*), yielded by *Ophoidia galbanifera* of Khorassan, and *Galbanum officinale* of Syria; ladanum (Heb. *lôt*, translated "myrrh" in Gen. xxxvii. 25, xliii. 11), the resinous exudation of *Cistus creticus, C. ladaniferus*, and other species of "rock rose" or "rose of Sharon"; myrrh (Heb. *môr*), the gum-resin of the *Balsamodendron Myrrha* of the Somali country and opposite shore of Arabia; onycha (Heb. *shecheleth*), the celebrated odoriferous shell of the ancients, the operculum or "nail" of a species of *Strombus* or "wing shell," formerly well-known in Europe under the name of *Blatta byzantina*; it is still imported into Bombay to burn with frankincense and other incense to bring out their odours more strongly; saffron (Heb. *karkôm*), the stigmata of *Crocus sativus*, a native originally of Cashmere; spikenard (Heb. *nerd*), the root of the *Nardostachys Jatamansi* of Nepal and Bhutan; stacte (Heb. *nataf*), generally referred to the *Styrax officinale* of the Levant, but Hanbury has shown that no stacte or storax is now derived from *S. officinale*, and that all that is found in modern commerce is the product of the *Liquidambar orientale* of Cyprus and Anatolia.

Besides these aromatic substances named in the Bible, the following must also be enumerated on account of their common use as incense in the East; benzoin or gum benjamin (see vol. iii. p. 581), first mentioned among Western writers by Ibn Batuta (1325–1349) under the name of *lubân d' Javi* (*i.e.*, olibanum of Java), corrupted in the parlance of Europe into benjamin and benzoin; camphor, produced by *Cinnamomum Camphora*, the "camphor laurel" of China and Japan, and by *Dryobalanops aromatica*, a native of the Indian Archipelago, and widely used as incense throughout the East, particularly in China (compare vol. iv. p. 761); elemi, the resin of an unknown tree of the Philippine Islands, the elemi of old writers (see vol. viii. p. 122) being the resin of *Boswellia Frereana*; gum-dragon or dragon's blood, obtained from *Calamus Draco*, one of the ratan palms of the Indian Archipelago, *Dracæna Draco*, a liliaceous plant of the Canary Islands, and *Pterocarpus Draco*, a leguminous tree of the island of Socotra (see vol. vii. p. 389); rosemalloes, a corruption of the Javanese *rasamala*, or liquid storax, the resinous exudation of *Liquidambar Altingia*, a native of the Indian Archipelago (an American *Liquidambar* also produces a rosemalloes-like exudation); star anise, the starlike fruit of the *Illicium anisatum* of Yunan and south-western China (compare vol. ii. p. 58), burnt as incense in the temples of Japan; sweet flag, the root of *Acorus Calamus*, the *bach* of the Hindus, much used for incense in India (see vol. ix. p. 280). An aromatic earth, found on the coast of Cutch, is used as incense in the temples of western India. The animal excreta, musk and civet, also enter into the composition of modern European pastils and clous fumants. Balsam of Tolu, produced by *Myroxylon toluiferum*, a native of Venezuela and New Granada; balsam of Peru, derived from *Myroxylon Pereiræ*, a native of San Salvador in Central America; Mexican and Brazilian elemi, produced by various species of *Icica* or "incense trees," and the liquid exudation of an American species of *Liquidambar*, are all used as incense in America. Hanbury quotes a faculty granted by Pope Pius V. (August 2, 1571) to the bishops of the West Indies permitting the substitution of balsam of Peru for the balsam of the East in the preparation of the chrism to be used by the Catholic Church in America. The *Sangre del drago* of the Mexicans is a resin resembling dragon's blood obtained from a euphorbiaceous tree, *Croton Draco*.

Probably nowhere can the actual historical progress from the primitive use of animal sacrifices to the later refinement of burning incense be more clearly traced than in the pages of the Old Testament, where no mention of the latter solemnity occurs before the period of the Mosaic legislation; but in the monuments of ancient Egypt the authentic traces of the use of incense which still exist carry us back to a much earlier date. From Meroe to Memphis the

[1] *Incensum* (or *incensum thuris*) from *incendere*; Ital. and Portug. *incenso*; Span. *incienso*; Fr. *encens*. The substantive occurs in an inscription of the Arvalian brotherhood (Marini, *Gli Atti e Monumenti de' fratelli Arvali*, p. 639), but is frequent only in ecclesiastical Latin. Compare the classical *suffimentum* and *suffitus* from *suffio*. For "incense" Ulfila (Luke i. 10, 11) has retained the Greek *θυμίαμα* (thymiama); all the Teutonic names (Germ. *Weihrauch*; Old Saxon *Wirôc*; Icel. *Reykelsi*; Dan. *Rögelse*) seem to belong to the Christian period (Grimm, *Deutsche Mythologie*, i. 50).

[2] The etymological affinities of *θύω, θύος, thus, fuffio, fumus*, and the Sanskr. *dhuma*, are well known. See Max Müller, *Chips*, i. 99.

[3] Classical Latin has but one word (*thus* or *tus*) for all sorts of incense. *Libanus*, for frankincense, occurs only in the Vulgate. Even the "ground frankincense" or "ground pine" (*Ajuga Chamæpitys*) was known to the Romans as *Tus terræ* (Pliny), although they called some plant, from its smelling like frankincense, *Libanotis*, and a kind of Thasian wine, also from its fragrance, *Libanios*. The Latino-barbaric word *Olibanum* (quasi *Oleum Libani*), the common name for frankincense in modern commerce, is used in a bull of Pope Benedict IX. (1033). It may here be remarked that the name "European frankincense" is applied to *Pinus Tæda*, and to the resinous exudation ("Burgundy pitch") of the Norwegian spruce firs (*Abies excelsa*). The "incense tree" of America is the *Icica guianensis*, and the "incense wood" of the same continent *I. heptaphylla*.

commonest subject carved or painted in the interiors of the temples is that of some contemporary Phrah or Pharaoh worshipping the presiding deity with oblations of gold and silver vessels, rich vestments, gems, the firstlings of the flock and herd, cakes, fruits, flowers, wine, anointing oil, and incense. Generally he holds in one hand the censer, and with the other darts the pastils or osselets of incense into it; sometimes he offers incense in one hand and makes the libation of wine with the other. One of the best known of these representations is that carved on the memorial stone placed by Thothmes IV. (1533 B.C.) on the breast of the Sphinx at Gizeh.[1] The tablet represents Thothmes before his guardian deity, the sun-god Ra, pouring a libation of wine on one side and offering incense on the other. The ancient Egyptians used various substances as incense. They worshipped Ra at sunrise with resin, at mid-day with myrrh, and at sunset with an elaborate confection called *kuphi*, compounded of no fewer than sixteen ingredients, among which were honey, wine, raisins, resin, myrrh, and sweet calamus. While it was being mixed, holy writings were read to those engaged in the operation. According to Plutarch, apart from its mystic virtues arising from the magical combination of 4×4, its sweet odour had a benign physiological effect on those who offered it.[2] The censer used was a hemispherical cup or bowl of bronze, supported by a long handle, fashioned at one end like an open hand, in which the bowl was, as it were, held, while the other end within which the pastils of incense were kept was shaped into the hawk's head crowned with a disk, as the symbol of Ra.[3] In embalming their dead the Egyptians filled the cavity of the belly with every sort of spicery, except frankincense (Herod., ii. 86), which was regarded as specially consecrated to the worship of the gods. In the burnt offerings of male kine to Isis, the carcase of the steer, after evisceration, was filled with fine bread, honey, raisins, figs, frankincense, myrrh, and other aromatics, and thus stuffed was roasted, being basted all the while by pouring over it large quantities of sweet oil, and then eaten with great festivity.

How important the consumption of frankincense in the worship of the gods became in Egypt is shown by two of its monuments, which are of the greatest interest and value for the light they throw on the early history of the commerce of the Indian Ocean. One is an inscription in the rocky valley of Hammamat, through which the desert road from the Red Sea to the valley of Egypt opens on the green fields and palm groves of the river Nile near Coptos. It was cut on the rocks by an Egyptian nobleman named Hannu, who states that he was sent by Pharaoh Sankhara, 2500 B.C., with a force gathered out of the Thebaid, from Coptos to the Red Sea, there to take command of a naval expedition to the Holy Land of Punt, "to bring back odoriferous gums." Punt is identified with the Somali country, which is now known to be the native country of the trees that yield the bulk of the frankincense of commerce. The other bears the record of a second expedition to the same land of Punt, undertaken by command of Queen Hasop, 1600 B.C. It is preserved in the vividly chiselled and richly coloured decorations which portray the history of the reign of this famous Pharaoh on the walls of the "Stage Temple" at Thebes. The temple is now in ruins, but the entire series of gorgeous pictures recording the expedition to "the balsam land of Punt," from its leaving to its returning to Thebes, still remains intact and undefaced.[4] These are the only authenticated instances of the export of incense trees from the Somali country until Colonel Playfair, then political agent at Aden, in 1862–64, collected and sent to Bombay the specimens from which Dr Birdwood prepared his descriptions of them for the Linnean Society in 1868. King Antigonus is said to have had a branch of the true frankincense tree sent to him.

Homer tells us that the Egyptians of his time were emphatically a nation of druggists (*Od.* iv. 229, 230). This characteristic, in which, as in many others, they remarkably resemble the Hindus, the Egyptians have maintained to the present day; and, although they have changed their religion, the use of incense among them continues to be as familiar and formal as ever. The *kohl* or black powder with which the modern, like the ancient, Egyptian ladies paint their languishing eyelids, is nothing but the smeeth of charred frankincense, or other odoriferous resin, which is brought with frankincense, and phials of water from the well of Zem-zem, by the returning pilgrims from Mecca. They also melt frankincense as a depilatory, and smear their hands with a paste into the composition of which frankincense enters, for the purpose of communicating to them an attractive perfume. Herodotus (iv. 75) describes a similar artifice as practised by the women of Scythia (compare also Judith x. 3, 4). In cold weather the Egyptians warm their rooms by placing in them a brazier, "chafing-dish," or "standing-dish," filled with charcoal, in which incense is burnt; and in hot weather they refresh them by occasionally swinging a hand censer by a chain through them—frankincense, benzoin, and aloe wood being chiefly used for the purpose.[5]

In the authorized version of the Bible, the word "incense" translates two wholly distinct Hebrew words. In various passages in the latter portion of Isaiah (xl.–lxvi.), in Jeremiah, and in Chronicles, it represents the Hebrew *lebônah*, more usually rendered "frankincense"; elsewhere the original word is *ketoreth* (Ex. xxx. 8, 9, Lev. x. 1, Num. vii. 14, &c.), a derivative of the verb *kitter* (Pi.) or *hiktir* (Hiph.), which verb is used, not only in Ex. xxx. 7, but also in Lev. i. 9, iii. 11, ix. 13, and many other passages, to denote the process by which the "savour of satisfaction" in any burnt offering, whether of flesh or of incense is produced. Sometimes in the authorized version (as in 1 Kings iii. 3, 1 Sam. ii. 28) it is made to mean explicitly the burning of incense with only doubtful propriety. The expression "incense (ketoreth) of rams" in Ps. lxvi. 15 and the allusion in Ps. cxli. 2 ought both to be understood, most probably, of ordinary burnt offerings.[6] The "incense" (ketoreth), or "incense of sweet scents" (ketoreth sammim), called, in Ex. xxx. 35, "a confection after the art of the apothecary," or rather "a perfume after the art of the perfumer," which was to be regarded as most holy, and the imitation of which was prohibited under the severest penalties, was compounded of four "sweet scents" (sammim),[7] namely stacte (nataph), onycha (sheheleth), galbanum (helbenah), and "pure" or "fine" frankincense (lebonah zaccah), pounded together in equal proportions, with (perhaps) an admixture of salt (memullah).[8] It was then to be "put before the testimony" in the "tent of meeting." It was burnt on the altar of incense (see ALTAR, vol. i. p. 640) by the priest every morning when the lamps were trimmed in the holy place,

[1] Brugsch, *Egypt under the Pharaohs*, i. 77–81, 414–419.

[2] Plutarch, *De Iside et Osiride*, c. 52. In Parthey's edition (Berlin, 1850) other recipes for the manufacture of *kuphi*, by Galen and Dioscorides, are given; also some results of the editor's own experiments.

[3] Wilkinson, *Ancient Egyptians*, i. 493; ii. 49, 398–400, 414–416.

[4] Brugsch, *Egypt under the Pharaohs*, i., 303–312.

[5] See Lane, *Mod. Egyptians*, pp. 34, 41, 139, 187, 438 (ed. 1860).

[6] See Wellhausen, *Gesch. Israels*, i. 70 *sqq.*, who from philological and other data infers the late date of the introduction of incense into the Jewish ritual.

[7] According to Philo (*Opera*, i. 504, ed. Mangey), they symbolized respectively water, earth, air, and fire.

[8] Other accounts of its composition, drawn from Rabbinical sources, will be found in various works on Jewish antiquities; see, for example, Reland, *Antiq. Sacr. Vet. Hebr.*, pp. 39–41 (1712).

and every evening when they were lighted or "set up" (Ex. xxx. 7, 8). A handful of it was also burnt once a year in the holy of holies by the high priest on a pan of burning coals taken from the altar of burnt-offering (Lev. xvi. 12, 13). Pure frankincense (lebonah) formed part of the meat offering (Lev. ii. 16, vi. 15), and was also presented along with the shew bread (Lev. xxiv. 7) every Sabbath day (probably on two golden saucers; see Jos., *Ant.*, iii. 10, 7). The religious significance of the use of incense, or at least of its use in the holy of holies, is distinctly set forth in Lev. xvi. 12, 13.

The Jews were also in the habit of using odoriferous substances in connexion with the funeral obsequies of distinguished persons (see 2 Chron. xvi. 14, xxi. 19; Jer. xxxiv. 5). In Am. vi. 10 "he that burneth him" probably means "he that burns perfumes in his honour." References to the domestic use of incense occur in Cant. iii. 6, Prov. xxvii. 9, *cf.* vii. 17.

The "marbles" of Nineveh furnish frequent examples of the offering of incense to the sun-god and his consort (2 Kings xxiii. 5). The kings of Assyria united in themselves the royal and priestly offices, and on the monuments they erected they are generally represented as offering incense and pouring out wine to the tree of life. They probably carried the incense in the sacred bag which is so frequently seen in their hands and in those also of the common priests. According to Herodotus (i. 183), frankincense to the amount of 1000 talents' weight was offered every year, during the feast of Bel, on the great altar at his temple in Babylon.

The monuments of Persepolis and the coins of the Sassanians show that the religious use of incense was as common in ancient Persia as in Babylonia and Assyria. Five times a day the priests of the Persians (Zoroastrians) burnt incense on their sacred fire altars. In the Avesta (*Vendidad*, Fargard xix. 24, 40), the incense they used is named *vohu gaono.* It has been identified with benzoin, but was probably frankincense. Herodotus (iii. 97) states that the Arabs brought every year to Darius as tribute 1000 talents of frankincense. The Parsees still preserve in western India the pure tradition of the ritual of incense as followed by their race from probably the most ancient times.

The *Ramayana* and *Mahabharata* afford evidence of the employment of incense by the Hindus, in the worship of the gods and the burning of the dead, from the remotest antiquity. Its use was obviously continued by the Buddhists during the prevalence of their religion in India, for it is still used by them in Nepal, Tibet, Ceylon, Burmah, China, and Japan. These countries all received Buddhism from India, and a large proportion of the porcelain and earthenware articles imported from China and Japan into Europe consists of innumerable forms of censers. The Jains all over India burn sticks of incense before their Jina. The commonest incense in ancient India was probably frankincense. The Indian frankincense tree, *Boswellia thurifera*, Colebrooke (which certainly includes *B. glabra*, Roxburgh), is a doubtful native of India. It is found chiefly where the Buddhist religion prevailed in ancient times, in Bihar and along the foot of the Himalayas and in western India, where it particularly flourishes in the neighbourhood of the caves of Ajanta. It is quite possible therefore that, in the course of their widely extended commerce during the one thousand years of their ascendency, the Buddhists imported the true frankincense trees from Africa and Arabia into India, and that the accepted Indian species are merely varieties of them. Now, however, the incense in commonest use in India is benzoin. But the consumption of all manner of odoriferous resins, gum resins, roots, woods, dried leaves, flowers, fruits, and seeds in India, in social as well as religious observances, is enormous. The grateful perfumed powder *abir* or *randa* is composed either of rice, flour, mango bark or deodar wood, camphor, and aniseed, or of sandalwood or wood aloes, zerumbet, zedoary, rose flowers, camphor, and civet. The incense sticks and pastils known all over India under the names of *ud-buti* ("benzoin-light") or *aggar-ki-buti* ("wood aloes light") are composed of benzoin, wood aloes, sandalwood, rock lichen, patchouli, rose-malloes, *Flacourtia* leaf (*talisput-tree*), mastic, and sugar candy or gum. The *abir* and *aggir butis* made at the Mahometan city of Bijarpur in the Mahratta country are celebrated all over western India. The Indian Mussulmans indeed were rapidly degenerating into a mere sect of Hindus before the Wahabi revival, and the more recent political propaganda in support of the false caliphate of the sultans of Turkey; and we therefore find the religious use of incense among them more general than among the Mahometans of any other country. They use it at the ceremonies of circumcision, *bismillah* (teaching the child "the name of God"), virginity, and marriage. At marriage they burn benzoin with *nim* seeds to keep off evil spirits, and prepare the bride-cakes by putting a quantity of benzoin between layers of wheaten dough, closed all round, and frying them in clarified butter. For days the bride is fed on little else. In their funeral ceremonies, the moment the spirit has fled incense is burnt before the corpse until it is carried out to be buried. The begging fakirs also go about with a lighted stick of incense in one hand, and holding out with the other an incense-holder (literally, "incense chariot"), into which the coins of the pious are thrown. Large "incense trees" resembling our Christmas trees, formed of incense-sticks and pastils and osselets, and alight all over, are borne by the Shiah Mussulmans in the annual procession of the Mohurrum, in commemoration of the martyrdom of the sons of Ali. The worship of the *tulsi* plant, or holy basil, by the Hindus is popularly explained by its consecration to Vishnu and Krishna. It grows on the four-horned altar before the house, or in a pot placed in one of the front windows, and is worshipped every morning by all the female members of every Hindu household. It is possible that its adoration has survived from the times when the Hindus buried their dead in their houses, beneath the family hearth. When they came into a hot climate the fire of the sacrifices and domestic cookery was removed out of the house; but the dead were probably still for a while buried in or near it, and the *tulsi* was planted over their graves, at once for the salubrious fragrance it diffuses and to represent the burning of incense on the altar of the family lar.

As to the θύεα mentioned in Homer (*Il.* ix. 499, and elsewhere) and in Hesiod (*Works and Days*, 338), there is some uncertainty whether they were incense offerings at all, and if so, whether they were ever offered alone, and not always in conjunction with animal sacrifices. That the domestic use, however, of the fragrant wood θύον (the *Arbor vitæ* or *Callitris quadrivalvis* of botanists, which yields the resin sandarach) was known in the Homeric age, is shown by the case of Calypso (*Od.* v. 60), and the very similarity of the word θύον to θύος may be taken as almost conclusively proving that by that time the same wood was also employed for religious purposes. It is not probable that the sweet smelling gums and resins of the countries of the Indian Ocean began to be introduced into Greece before the 8th or 7th century B.C., and doubtless λίβανος or λιβανωτός first became an article of extensive commerce only after the Mediterranean trade with the East had been opened up by the Egyptian king Psammetichus (670 B.C.). The new Oriental word is frequently employed by Herodotus; and there are abundant references to the use of the thing among the writers of the golden age of Attic literature (see, for example, Aristophanes, *Plut.*, 1114; *Frogs*, 871, 888; *Clouds*, 426; *Wasps*, 96, 861). Frankincense, however, though the most common, never became the only kind of incense offered to the gods among the Greeks. Thus the Orphic Hymns are careful to specify, in connexion with the several deities celebrated, a great variety of substances appropriate to the service of each; in the case of many of these the selection seems to have been determined not at all by their fragrance but by some occult considerations which it is now difficult to divine.

Among the Romans the use of religious fumigations long preceded the introduction of foreign substances for the purpose (see, for example, Ovid, *Fast.* i. 337 *sq.*, "Et non exiguo laurus adusta sono"). Latterly the use of frankincense ("mascula thura," Virg., *Ecl.* viii. 65) became very prevalent, not only in religious ceremonials, but also on various state occasions, such as in triumphs (Ovid, *Trist.* iv. 2, 4), and also in connexion with certain occurrences of domestic life. In private it was daily offered by the devout to the *lar familiaris* (Plaut., *Aulul.*, prol., 23); and in public sacrifices it was not only sprinkled on the head of the victim by the pontifex before its slaughter, and afterwards mingled with its blood, but was also thrown upon the flames in which it was roasted.

No perfectly satisfactory traces can be found of the use of incense in the ritual of the Christian Church during the first four centuries. It obviously was not contemplated by the author of the epistle to the Hebrews; its use was foreign to the synagogue services on which, and not on those of the temple, the worship of the primitive Christians is well known to have been originally modelled; and its associations with heathen solemnities, and with the evil repute of those who were known as "thurificati," would still further militate against its employment. Various authors of the ante-Nicene period have expressed themselves as distinctly unfavourable to its religious, though not of course to its domestic, use. Thus Tertullian, while (*De Cor. Mil.*, 10) ready to acknowledge its utility in counteracting unpleasant smells ("si me odor alicujus loci offenderit, Arabiæ aliquid incendo"), is careful to say that he scorns to offer it as an accompaniment to his heartfelt prayers (*Apol.*, 30, *cf.* 42). Athenagoras also (*Legat.*, 13) gives distinct expression to his sense of the needlessness of any such ritual ("the Creator and Father of the universe does not require blood, nor smoke, nor even the sweet smell of flowers and incense"); and Arnobius (*Adv. Gent.*, vii. 26) seeks to justify the Christian neglect of it by the fact, for which he vouches, that among the Romans themselves incense was unknown in the time of Numa, while the Etruscans had always continued to be strangers to it. Cyril of Jerusalem, Augustine, and the Apostolic Constitutions make no reference to any such feature either in the public or private worship of the Christians of that time. The earliest mention, it would seem, occurs in the Apostolic Canons (can. 3), where the θυμίαμα is spoken of as one of the requisites of the eucharistic service. It is easy to perceive how it should inevitably have come in along with the whole circle of ideas involved in such words as "temple," "altar," "priest," which about this time came to be so generally applied in ecclesiastical connexions. Evagrius (vi. 21) mentions the gift of a θυμιατήριον by Chosroes the king of Persia to the church of Jerusalem; and all the Oriental liturgies of this period provide special prayers for the thurification of the eucharistic elements. The oldest *Ordo Romanus*, which perhaps takes us back to within a century of Gregory the Great, enjoins that in pontifical masses a subdeacon, with a golden censer, shall go before the bishop as he leaves the secretarium for the choir, and two, with censers, before the deacon gospeller as he proceeds with the gospel to the ambo. And less than two centuries afterwards we read an order in one of the capitularies of Hincmar of Rheims, to the effect that every priest ought to be provided with a censer and incense. That in this portion of their ritual, however, the Christians of that period were not universally conscious of its direct descent from Mosaic institutions may be inferred perhaps from the "benediction of the incense" used in the days of Charlemagne, which runs as follows: "May the Lord bless this incense to the extinction of every noxious smell, and kindle it to the odour of its sweetness." Even Thomas Aquinas (p. iii. qu. 83, art. 5) gives prominence to this idea.

The character and order of these historical notices of incense would certainly, were there nothing else to be considered, justify the conclusion which has been generally adopted, that its use was wholly unknown in the worship of the Christian Church before the 5th century. On the other hand, we know that in the first Christian services held in the catacombs under the city of Rome, incense was burnt as a sanitary fumigation at least. Tertullian also distinctly alludes to the use of aromatics in Christian burial: "the Sabæans will testify that more of their merchandise, and that more costly, is lavished on the burial of Christians, than in burning incense to the gods." And the whole argument from analogy is in favour of the presumption of the ceremonial use of incense by the Christians from the first. It is natural that little should be said of so obvious a practice until the fuller development of ritual in a later age. The slighting references to it by the Christian fathers are no more an argument against its existence in the primitive church, than the similar denunciations by the Jewish prophets of burnt offerings and sacrifices are any proof that there were no such rites as the offering of incense, and of the blood of bulls and fat of rams, in the worship of the temple at Jerusalem. There could be no real offence to Christians in the burning of incense. Malachi (i. 11) had already foretold the time when among the Gentiles, in every place, incense should be offered to God. Gold, with myrrh and frankincense were offered by the Persian Magi to the infant Jesus at his birth; and in Revelation viii. 3, 4 the image of the offering incense with the prayers of the saints, before the throne of God, is not without its significance. If also the passage in Ambrose of Milan (on Luke i. 11), where he speaks of "us" as "adolentes altaria" is to be translated "incensing the altars," and taken literally, it is an unequivocal testimony to the use of incense by the Christian Church in, at least, the 4th century.

The Missal of the Roman Church now enjoins incensation before the introit, before the gospel, and again at the offertory, in every high mass; the use of incense also occurs when the sacrament is exhibited, at consecrations of churches and the like, in processions, in the office for the burial of the dead, and at the exhibition of relics. On high festivals the altar is censed at vespers and lauds.

In the Church of England the use of incense was gradually abandoned after the reign of Edward VI., until the ritualistic revival of the present day. Its use, however, has never been abolished by law. A "Form for the Consecration of a Censer" occurs in Sancroft's *Form of Dedication and Consecration of a Church or Chapel* (1685). In various works of reference (as, for example, in *Notes and Queries*, 3d ser., vol. viii. p. 11) numerous sporadic cases are mentioned in which incense appears to have been burnt in churches; the evidence, however, does not go so far as to show that it was used during divine service, least of all that it was used during the communion office. At the coronation of George III., one of the king's grooms appeared "in a scarlet dress, holding a perfuming pan, burning perfumes, as at previous coronations."

For the manufacture of the incense now used in the Christian churches of Europe there is no fixed rule. The books of ritual are agreed that Ex. xxx. 34 should be taken as a guide as much as possible. It is recommended that frankincense should enter as largely as possible into its composition, and that if inferior materials be employed at all they should not be allowed to preponderate. In Rome olibanum alone is employed; in other places benzoin, storax, aloes, cascarilla bark, cinnamon, cloves, and musk are all said to be occasionally used. In the Russian Church, benzoin is chiefly employed. The Armenian liturgy, in its benediction of the incense, speaks of "this perfume prepared from myrrh and cinnamon."

The preparation of pastils of incense has probably come down in a continuous tradition from ancient Egypt, Babylonia, and Phœnicia. Cyprus was for centuries famous for their manufacture, and they were still known in the middle ages by the names of pastils or osselets of Cyprus.

Maimonides, in his *More Nevochim*, states that the use of incense in the worship of the Jews originated as a corrective of the disagreeable odours arising from the slaughter and burning of the animals offered in sacrifice. There can be no doubt that its use throughout the East is based on sanitary considerations; and in Europe even, in the time when the dead were buried in the churches, it was recognized that the burning of incense served essentially to preserve their salubrity. But evidently the idea that the odour of a burnt-offering (*cf.* the κνίσης ἡδὺς ἀϋτμή of *Odyss.* xii. 369) is grateful to the deity, being indeed the most essential part of the sacrifice, or at least the vehicle by which alone it can successfully be conveyed to its destination, is also a very early one, if not absolutely primitive; and survivals of it are possibly to be met with even among the most highly cultured peoples where the purely symbolical nature of all religious ritual is most clearly understood and maintained. Some such idea plainly underlies the familiar phrase "a sweet savour," more literally "a savour of satisfaction," by which an acceptable offering by fire is so often denoted in the Bible (Gen. viii. 21, Lev. i. 9, *et passim*; *cf.* Eph. v. 2). It is easy to imagine how, as men grew in sensuous appreciation of pleasant perfumes, and in empirical knowledge of the sources from which these could be derived, this advance would naturally express itself, not only in their domestic habits, but also in the details of their religious ceremonial, so that the custom of adding some kind of incense to their animal sacrifices, and at length that of offering it pure and simple, would inevitably arise. Ultimately, with the development of the spiritual discernment of men, the "offering of incense" became a mere symbolical expression for prayer (see Rev. v. 8, viii. 3, 4). Clement of Alexandria expresses this in his well-known words: "The true altar of incense is the just soul, and the perfume from it is holy prayer." (So also Origen, *Cont. Cels.*, viii. 17, 20.) The ancients were familiar with the sanitary efficacy of fumigations. The energy with which Ulysses, after the slaughter of the suitors, calls to Euryclea for "fire and sulphur" to purge (literally "fumigate") the dining-hall from the pollution of their blood (*Od.* xxii. 481, 482) would startle those who imagine that sanitation is a peculiarly modern science. There is not the slightest doubt that the censing of things and persons was first practised for acts of purification, and thus became symbolical of consecration, and finally of the sanctification of the soul. The Egyptians understood the use of incense as symbolical of the purification of the soul by prayer. Catholic writers generally treat it as typifying contrition, the preaching of the gospel, the prayers of the faithful, and the virtues of the saints. (G. B.)

INCEST, carnal connexion between persons so related that marriage could not take place between them according to the Levitical rules. In England incest has not generally been treated as a crime, although, along with other offences against morals, it was made punishable by death in 1650. Since the Restoration it has, to use Blackstone's phrase, been left to the "feeble coercion of the spiritual courts." Under the divorce law, incest is one of the aggravations of adultery which entitle a wife to divorce her husband. In the law of Scotland, it is a crime nominally punishable with death, but the penalty usually inflicted is penal servitude for life. This sentence was actually pronounced on a man in 1855. In the United States, as in England, incest is not an indictable offence at common law, but it has been made so by the legislation of some of the States.

INCHBALD, Mrs Elizabeth (1753–1821), an English actress, dramatic author, and novelist, was born 15th October 1753. She was the daughter of a farmer at Standingfield, near Bury St Edmunds, Suffolk, her maiden name being Simpson. On account of the death of her father in her eighth year, she and her sisters never enjoyed the advantages of school training or of any regular supervision in their studies, but they nevertheless seem to have acquired at an early period refined and literary tastes. A favourite amusement of the family was readings, chiefly of a dramatic kind, and Elizabeth, notwithstanding that she was afflicted with an impediment of speech, which drove her into solitude, soon conceived a strong desire, not only to see the great world, but to become an actress. After making an attempt with little success to secure an engagement in a Norwich theatre, she in April 1772 left secretly for London, where she made the acquaintance of several managers and actors, but with no better fortune. In June she, however, married Mr Inchbald, a comedian in Drury Lane Theatre, and in September following she made her debut as an actress in the character of Cordelia, her husband taking the part of Lear. For several years she acted along with her husband in the provinces, but notwithstanding her great beauty and her good mental aptitude for acting, the impediment in her speech, by rendering rapidity and ease of utterance impossible, prevented her from attaining to more than very moderate excellence. After the death of her husband in 1778 she continued for some time on the stage, but her success as a dramatic author led her to retire in 1789. She died at Kensington, August 1, 1821.

Mrs Inchbald's plays amount to nineteen in all. Some of them were for a time very successful, especially *Wives as they were and Maids as they are*. Among the others may be mentioned *Such Things Are*; *The Married Man*; *The Wedding Day*; *The Midnight Hour*; *Everyone has his Fault*; and *Lovers' Vows*. She also edited a collection of the *British Theatre*, with biographical and critical remarks, 25 vols., 1806–1809; a *Collection of Farces*, 7 vols., 1809; and *The Modern Theatre*, 10 vols., 1809. Her fame, however, now rests chiefly on her two novels, *A Simple Story*, and *Nature and Art*. These works possess many minor faults and inaccuracies, but on the whole their style is easy, natural, and graceful; and if they are tainted in some degree by a morbid and exaggerated sentiment, and display none of that faculty of creation possessed by the best writers of fiction, the pathetic situations, and the deep and pure feeling pervading them, secured for them a wide but now a waning popularity. Some time before her death Mrs Inchbald destroyed an autobiography for which she had been offered £1000 by Phillips the publisher; but her *Memoirs*, compiled by J. Boaden, chiefly from her private journal, appeared in 1833 in two volumes. An interesting account of Mrs Inchbald is contained in *Records of a Girlhood*, by Frances Ann Kemble, 1878.

INCUBATION. See Birds, vol. iii. p. 775, and Reproduction. For Artificial Incubation, see Poultry.

INDEPENDENTS, a religious denomination whose distinctive ecclesiastical principle is that the individual congregation or church is a society strictly voluntary and autonomous, standing directly under the authority of Jesus Christ, living in immediate dependence on Him, and responsible to Him alone for its beliefs and acts as a Christian society. Its ideal stands distinguished, on the one hand, from Episcopacy by having no gradations of ministerial or clerical orders, or persons above the individual congregation invested with administrative or judicial authority, and, on the other hand, from Presbytery by having no gradation of courts or representative bodies possessed of legislative and judicial functions. These distinctions imply others. Episcopacy and Presbytery are essentially organized and incorporative systems, building all the societies they comprehend into a political unity, but Independency is essentially voluntary and individualizing, satisfied with a spiritual unity, refusing to permit its various societies to be built into a political organism, lest it should do violence to the rights of conscience, or prevent or even supersede the duty of the exercise by the individual of his own judgment in matters of religion. Episcopacy and Presbytery regard the collective organization as the church, but Independency the individual congregation, investing it with the attributes and prerogatives the other systems reserve for the organized whole. Its members possess equal rights, and are bound by equal obligations. They constitute a state whose citizens are all enfranchised, and are so because citizenship is limited to the qualified, who, having sought it voluntarily, voluntarily retain it. Independency may be said to affirm its ecclesiastical in order that it may realize its religious principle, that religion is purely a matter of the conscience, not to be created, extended, or reformed by any political mechanism or agencies, but by moral means, through men who seek to have it believed and embodied by men for reasons that commend themselves to the conscience, free and unconstrained. It thus holds that the best service the state can render to religion is to leave it free to live and act according to its own nature, in obedience to its own laws, prompted by its own impulses, guided by its own spirit and judgment.

Independency rose in the reign of Elizabeth, and may be said to have been born of the despair of seeing religion reformed and vivified on any one of the then followed lines. The peculiar condition of the Anglican Church at this period is well enough known. There were men in it who wished it to be independent of Rome, but to remain as far as possible Catholic while Anglican, and there were men who wished it to be conformed in doctrine and polity to those churches of the Continent that were by pre-eminence the Reformed. These latter were the Puritans, and their endeavour was to reform the church through the state, to persuade or compel the constitutive and sovereign will to make it such as they could conscientiously approve. But it was inevitable in a time of strong religious feeling that some more daring spirits should endeavour to break through the anomalies of the Puritan position. If their consciences demanded, and the civil authority refused, reform, was it either right or dutiful to submit to the civil authority as against the conscience? Was there no other way of reformation than by its consent? Was the Christian man relieved from all responsibility and obligation to obey conscience when the magistrate forbade him to do so? In so forbidding, was not the magistrate stepping out of his own province? Was the church he could so rule as to prevent the realization of the Scriptural ideal a rightly conceived and constituted church? Was it the apostolical way so to work as to plant, to purge, to organize churches only as Cæsar gave consent? And could any but the apostolical way be right?

These were the questions that created Independency. In the writings of the first Independent, Robert Browne (see BROWN, ROBERT), lies the first crude attempt at an answer. He is possessed with the idea that reformation is necessary, and is to be accomplished, not by the state, but by the action and cooperation of men who are themselves reformed and renewed. The Puritans have committed two great mistakes: they have imagined that reformation is a thing of polity only, to be carried out by changes in the organism, as it were, or structure of the church, leaving many, perhaps the immense majority, of the individuals who constitute it unreformed; and they have waited and are waiting to have the work done through and by the magistrate. Browne sets himself absolutely against both positions. "The kingdom of God," he says, "was not to be begun by whole parishes, but rather of the worthiest, be they ever so few."[1] This means that a church cannot be created by any political act out of such material as it finds in a parish, but only of the godly, men who are consciously and sincerely Christian. So he defines a church as "a companie or number of Christians or believers, who, by a willing covenant made with their God, are under the government of God and Christ, and kepe his lawes in one holie communion."[2] This idea of a church was as unlike as possible to the Church of England ideal, and made it as it actually existed so offensive to Browne that he held communion with it to be a cardinal sin. But it also made him particularly impatient with what he called the "wickednesse of those preachers which will not reforme themselves and their charge, because they will tarie till the magistrate commaunde and compell them."[3] This led him to discuss principles and state positions that curiously anticipate some of the most modern views as to the relation of the civil authority to religion and the church.[4] But the times were not ripe for either the criticism or the realization of Browne's ideas. They were extravagances to his own day; failure attended him everywhere—due partly, perhaps, to the angularities of the man, and partly to the prematurity of the system; his name was covered with ridicule; and Brownist became the epithet the early Independents most disliked and resented.

But the problems that had exercised Browne were too vital to religion to be his alone. They occupied many minds, and of these not a few looked in a similar direction for a solution. Geneva was at once the strength and the weakness of the Puritans;—their strength, because it gave them their ideal realized; their weakness, because it made them think that the only method of realization was in and through the state. The Puritan leaders were mainly scientific theologians, like Cartwright and Travers, Perkins and Rainolds, men who strenuously adhered alike in doctrine and polity to the principles and methods of their school. But the earliest Independents were men of simpler minds, educated indeed as well as the English universities could educate them, but of less specific and elaborate training. They studied their own times and interpreted their own duties in the light of the New Testament, and

[1] *A True and Short Declaration, Both of the Gathering and Joyning together of certain Persons, and also of the Lamentable Breach and Diuision wh fell amongst them*, p. 6. This is to a certain degree autobiographical, a story of Browne's struggles and failure to realize his ideal. But see Dexter's *Congregationalism of the Last Three Hundred Years*, pp. 82, 92 *ff.*

[2] See *A Booke wh Sheweth the life and Manners of all true Christians, and howe vnlike they are vnto Turkes and Papistes and Heathen Folke*, &c. (Middlebvrgh, 1582), definition 35.

[3] So runs the sub-title of one of the tracts he published while at Middleburg—*A Treatise of Reformation without Tarying for Anie* (1582).

[4] "Thus," he says, "they (the magistrates) may doe nothing concerning the Church, but onelie civilie, and as civile Magistrates; that is, they have not that authoritie ouer the church, as to be Prophetes or Priestes, or spirituall Kings, as they are Magistrates over the same; but onelie to rule the common wealth in all outwarde Justice, to maintaine the right welfare and honor thereof with outwarde power, bodily punishment, and civill forcing of men."—*A Treatise of Reformation*, p. 12.

inferred that as the apostles had proceeded they ought to proceed, that the methods proper to the apostolic age were also the methods proper to their own. These methods were individual, not national; churches were founded, religion created and reformed, not by civil authorities or agencies, but by preachers who persuaded men to believe, gathered the believers into communities or brotherhoods, each standing in a fraternal relation to all the rest, none occupying a position of political superiority or dependence. The early Independents believed that in this way only was it possible to reform religion in England, and they acted on their belief, separating themselves from the Anglican Church, forming themselves into communities on what they regarded as the Scriptural model, and working in what was conceived to be the apostolic method. But separation from the church was a capital crime, equal to a denial of the royal supremacy; and so every inveterate separatist became liable to death. And early Independency was not without its martyrs. In the summer of 1583 two men, Thacker and Coppin, were executed at Bury St. Edmunds for refusing to conform to the church, and "dispersinge of Brownes bookes and Harrisons bookes." They justified their refusal on the ground that "her Majestie was chieffe ruler civilie, but no further." Two much more remarkable men, who met with a similar fate, were John Greenwood and Henry Barrowe. Both were graduates of Cambridge; Greenwood had been ordained a priest; Barrowe was a barrister, a member of Gray's Inn. "He made," as we know on the authority of Lord Bacon,[1] "a leap from a vain and libertine youth to a preciseness in the highest degree, the strangeness of which alteration made him very much spoken of." Both became separatists, and were very active in the numerous conventicles that were then being held in and about London. Their principles were not so extreme as Browne's, their position being, as it were, intermediate between his and the Puritan. In his notion of the church as a society of the godly or the converted, politically independent alike as regards other churches and the state, they agree with him; in his notion of its rigidly democratic constitution, they differ, inclining more to leave its government in the hands of certain specially chosen men. Their ideal is a sort of Presbyterial Independency. They think of the church as "A companie of Faithfull people; separated from the vnbelievers and heathen of the land: gathered in the name of Christ, whome they truelie worship, and redily obey as their only King, Priest, and Prophet: ioyned together as members of one bodie: ordered and gouerned by such officers and lawes as Christ in His last will and Testament hath thereunto ordeyned," &c.[2]

Of course, this conception placed them in direct antagonism to both the Genevan and Anglican ideals and methods. They condemn "Mr Calvine" because "he made no scruple to receave all the whole state, even all the profane ignorant people, into the bozome of the church, to administer the sacramentes vnto them."[3] They condemn the Church of England because it comprehends "all the profane and wicked of the land,"[4] and maintain that "Christ is onely head of His church, and His lawes may no man alter"; that the prince is no more than a mere member of it; that, if he sin, not to excommunicate him is to neglect "God's judgmentes, their dutie and the prince's salvation." The Anglican Church was thus conceived as founded on a wrong principle, worked in a wrong method, and hindered rather than helped by its dependence on the state. Whitgift asked Barrowe whether, if the prince delayed or refused to reform abuses, the church should proceed without him; and his answer was, "it might and ought, though all the princes of the world should prohibit the same upon pain of death." Ideas like these logically involved separation as a duty; the ideas they contradicted as logically made it a crime. The age was not without the courage of its convictions; and Barrowe and Greenwood died for theirs, April 6, 1593. Shortly afterwards (May 29) John Penry or Ap Henry, a friend and associate, expiated the same sin in the same way.

In spite of the severely repressive measures of the Government, the Independents continued to multiply. In the last decade of the 16th century numerous separatist communities were formed,[5] especially in London and the eastern and north-eastern counties. Their conventicles were often surprised, and in 1596 it was reckoned that as many as twenty-four had died in prison, representing of course but a small proportion of those actually confined. Plainly England had as yet no room for Independency, and the Independents who wished to keep a good conscience were forced to think of seeking a home elsewhere. Certain of their leaders had, indeed, in 1592 organized a church in London, with Francis Johnson as its pastor, and Greenwood as its teacher; but they were so watched and hunted and harassed—fifty-six of its members having been seized at one time and imprisoned—that they resolved, convinced by the fate of Barrowe, Greenwood, and Penry that a peaceable life in England was impossible, to emigrate in a body. Holland was then the common refuge of the distressed for conscience' sake, the place where the outcasts alike of France and Spain and England found a free and even generous home. The Independents, after trying Campen and Naarden, settled finally at Amsterdam. There they completed their church organization, appointing Francis Johnson pastor and Henry Ainsworth teacher. Johnson was a native of Richmond in Yorkshire, had been a fellow of Christ's College, Cambridge, had been expelled the university for publicly teaching the Presbyterian polity, and had become pastor of the English merchants' church at Middleburg. There he had been zealous against the Independents, had helped to seize and destroy an edition of one of Barrowe's works, but, preserving a copy, had read it and been persuaded to adopt its views. He returned to England, associated himself with the author, and became, as we have seen, the pastor of the first Independent church in England. He was a pragmatic man, self-willed, emphasizing his separatism, easily drifting into controversies and consequent divisions on minute questions alike of conduct and opinion. Ainsworth (see AINSWORTH, HENRY) was an

[1] "Observations on a Libel"; *Letters and Life*, by Spedding, vol. i. p. 165.

[2] *A Collection of certaine Letters and Conferences, lately passed betwixt certaine Preachers and Two Prisoners in the Fleet* (1590), p. 67. These letters were addressed to the Puritan leaders, and state the radical point of divergence of the two systems. This was the church idea; Greenwood and Barrowe, in all their prison Conferences, which were many, fall back on this idea:—"Christ's church always consisteth of a holy free people, separate from the world, rightly called and gathered unto Christ, walking forth in faith and obedience."

[3] Barrowe, *A Brief Discouerie of the False Church* (1590), p. 33. This is Barrowe's principal work, but he and Greenwood were both prolific and vigorous writers. They had a lengthy controversy with Mr George Gifford, a "Conformable Puritan," who charged them with being the "Donatists of England." They and the Puritans were curiously most deeply at feud. Yet it was only natural. The Puritans were anxious to show that they had no kinship with the Brownists, the Brownists were anxious to drive the Puritans to the logical outcome of their position—separation. Barrowe's first reply to Gifford was the "Plain Refutation, wherein is discovered the Forgery of the whole Ministry; the Confvsion; False Worship; and Anti-Christian Disorder, of these Parish Assemblies called the Church of England" (1591).

[4] *Ibid.*, p. 9.

[5] In 1593, in a debate on a Bill to explain the statute 23d of Eliz. 1580, and for the further reducing "disloyal subjects to obedience," Sir Walter Raleigh declared that there were "as many as twenty thousand" Brownists in England. He was anxious that they should be "rooted out of the commonwealth," but was alarmed lest the law that was needed to do so should turn out to be capable of use against liberal-minded Conformists like himself. See D'Ewes, p. 517, An. 35 Eliz.

altogether nobler spirit, devout, simple-minded, erudite, one who "had not his better for the Hebrew tongue in the university (of Leyden) nor scarce in Europe," anxious only to be allowed to search out the meaning of Scripture and teach it to his people. The church under these two men had a somewhat troubled history, and divided at length, part going with Johnson, part with Ainsworth, the cause of the division being as to the office and power of the elder. The former held that the church had power to elect, but not to depose, the elders, who were its real governors, but the latter held that the elders were responsible to the church, which had the power, as to appoint, so also to depose and excommunicate them. Johnson was moving away from Independency, as it is now understood, but Ainsworth towards it. Their church is significant as an attempt to realize the ideal of Barrowe and Greenwood, a provisional or tentative Independency, but no more.

A much more successful attempt at realizing the Independent ideal was made at Leyden under the leadership of John Robinson (see ROBINSON, JOHN). He and his people came from Scrooby, in Nottinghamshire. Their headquarters had been at first at Gainsborough-on-Trent. In 1606 one section of the church under John Smyth—who was to become the most extreme of separatists, discovering that baptism by a corrupt church was none, to rebaptize himself and become founder of the General Baptists—emigrated to Amsterdam; the other organized themselves under Robinson at Scrooby. But peace was impossible; flight became necessary. So in 1607 and 1608 they succeeded in escaping in detachments to Holland, settling first in Amsterdam, ultimately in Leyden. There the fine qualities of Robinson found a congenial soil, and developed as they could not have done in the less generous air of England. Leyden helped to make English separatism into Independency. What is developed in antagonism is ill developed, full of exaggerations, undue emphases, antitheses so sharply stated as to be almost, even when true, dangerously near the false. A proscribed faith may be strong, but can never be sweet; and the strength that is bitter is not a purely religious strength. So Independency in England in the days of Whitgift and Bancroft was too much hated and hunted to be able to say the best word and do the best thing for itself. But Independency in Leyden,—breathing the free air of the Dutch republic, living in open fellowship with all its institutions, braced by its strong enthusiasm for liberty, its robust religious faith, its brilliant and fruitful intellectual activity, then at its best and brightest in the young university of the city,—was Independency planted where it could do approximate justice to its own ideal. The influence of the changed conditions soon became manifest in its happier spirit. The church at Leyden lost the narrow and ungenerous spirit of separatism, pleaded for the duty of communion with the godly in the Church of England and the other reformed churches. On this point Robinson wrote with eloquence and acted with courage, his spirit growing the larger the longer he lived. While professing "a separation from the English national, provincial, diocesan, and parochial church, and churches, in the whole former state and order thereof," he yet confessed and declared that he had still "the same faith, hope, spirit, baptism, and Lord" as in the Church of England, that he enjoyed fellowship with her "many thousands" of godly sons, and that occasional "hearing of the word of God as there preached" was both lawful and necessary to him as a Christian man.[1] This most generous spirit and conduct involved Robinson in a long and bitter controversy with Helwys and other extreme separatists, who held approval of anything or any one connected with the Anglican Church to be altogether a sin; but it in no way modified the rigour of his Independency. His definition of a church is almost identical with Barrowe's: "A company, consisting though but of two or three, separated from the world, whether unchristian or anti-christian, and gathered into the name of Christ by a covenant made to walk in all the ways of God known unto them, is a church, and so hath the whole power of Christ."[2] Its independence, its sufficiency as a church alike in what concerned idea and reality, he strenuously maintained. Thus "neither was Peter or Paul more one, whole, entire, and perfect man, consisting of their parts essential and integral, without relation unto other men, than is a particular congregation, rightly instituted and ordered, a whole, entire, and perfect church immediately and independently, in respect of other churches, under Christ."[3] Above a church so conceived there could be no authoritative person or court, ecclesiastical or civil; it was armed with all the powers necessary to do the will of its Head, and to interfere with it was an unlawful interference with rights it had received from Him. Office did not exalt a man above the brotherhood; the clergy were but Christians, and good only as Christians. To saintship, and not to office, was promised the forgiveness of sins. "The estate of a saint is most happy and blessed, though the person never so much as come near an office; but, on the contrary, an officer, if he be not also and first a saint, is a most wretched and accursed creature."[4] Acts to be acts of the church must be collective, done, not by the clergy or the officers only, but by the brethren as well.[5] The church was, indeed, an ecclesia, an assembly, called out and called together by the public preaching of the word, but forming in its collective and corporate character a body possessed of supreme authority, of all the attributes, rights, and prerogatives that belong to those who rule. It is evident that a conception of this kind was full of promise. It showed a firm trust in the capabilities of individual Christian men to exercise the rights of citizenship within the kingdom of God. It made it in the highest degree wrong for any ruler or body of rulers to enforce their own belief on the people. And it was as opposed to ecclesiastical as to civil tyranny, whether in its Episcopal or Presbyterial form. Robinson, indeed, was far from seeing or courageously deducing all the consequences implied in his Independency. He was even illogical enough to state, though in a hesitating way, principles radically incompatible with it. He concedes "that godly magistrates are by compulsion to repress public and notable idolatry," by some penalty "to provoke their subjects universally unto hearing for their instruction and conversion"; but he denies that any king is at liberty to inflict death upon all that refuse to be drawn into covenant with God, or remain wicked and unrepentant.[6] He knows well enough the utmost coercion can do. "By this course of compulsion many become atheists, hypocrites, and familists, and, being at first constrained to practise against conscience, lose all conscience afterwards." Liberty is too complex a notion to be easily and in all its bearings grasped; and liberty in religion too great a thing to be suddenly and all at once understood and realized.

The Leyden church is the parent of Independency alike in England and America. In 1616 Henry Jacob, a native of Kent, a graduate of Oxford, one of Johnson's converts, pastor awhile of a church at Middleburg, then a resident with Robinson at Leyden, returned to England, and founded an Independent church at Southwark. In 1620 a little company led by Elder Brewster and Deacon Carver sailed from Delfthaven, landed in the midst of a severe and stormy

[1] Robinson, *Works*, iii. 377-8.

[2] Robinson, *Works*, ii. 132. [3] *Ibid.*, iii. 16. [4] *Ibid.*, ii. 228. [5] *Ibid.*, 449. [6] *Ibid.*, ii. 314, 315.

winter on the North American coast, and there laid the foundations of the New England States, with all they were to be and to create. Jacob had been all through his exile anxiously looking towards England. In 1609 he had addressed to King James "An Humble Supplication for Toleration,"[1] in which he begs that "each particular church may be allowed to partake in the benefit of the said toleration, may have, enjoy, and put in execution and practice this her right and privilege," viz., "to elect, ordain, and deprive her own ministers, and to exercise all the other points of lawful ecclesiastical jurisdiction under Christ." This may be regarded as a clear and explicit statement of the early Independent position, its claim for toleration based on its conception of the Christian church, its plea for liberty of worship based on its principle of individualism and the rights of the individual conscience. With what was here asked it would at any time in the 17th century have been satisfied, but the Anglican policy of Elizabeth, and James, and Charles I. proceeded on this principle, that to allow diversity was to destroy unity, to permit the growth of elements that would prove fatal to the church, involve the denial of the royal authority and the break-up of the state. Yet the very severity of the Anglican policy strengthened Independency. It helped to identify the struggle for liberty of conscience with the struggle for English liberty.

Up to 1640 little formal progress was made. Churches did not multiply; Laud was too active, and the Star Chamber too vigorous. But the real progress was immense. Statesmen were persuaded that a system which required so harsh a policy could not be right. Religious men who could not conform went to live in lands and under laws where obedience to conscience was possible. There was a double emigration, to the Continent and to New England. In Arnheim, Thomas Goodwin and Philip Nye ministered to a small congregation; in Rotterdam, Hugh Peters and William Ames, the most skilled, scholastic, and disputatious theologian of the early Independents, who came from his professorial chair at Franeker in 1632 to die at Rotterdam a year later. Here, too, when Ames was dead and Peters gone to New England, came Jeremiah Burroughs, William Bridge, and Sidrach Simpson, all of them names that were to be conspicuous and influential in days to come.

But the emigration to New England was much the more important alike as regards its influence on Independency and English history. It has been calculated that in the period 1620–1640 upwards of 22,000 Puritan emigrants (the figures have been placed as high as 50,000) sailed from English and Dutch ports. The reasons that compelled their departure determined their quality; they were all men of rigorous consciences, who loved their fatherland much, but religion more, not driven from home by mercantile necessities or ambitions, but solely by their determination to be free to worship God. They were, as Milton said,[2] "faithful and freeborn Englishmen and good Christians constrained to forsake their dearest home, their friends, and kindred, whom nothing but the wide ocean and the savage deserts of America could hide and shelter from the fury of the bishops." Men so moved so to act could hardly be commonplace; and so among them we find characters strong and marked, with equal ability to rule and to obey, as Bradford and Brewster, Winslow and Standish, Winthrop and Dr Samuel Fuller, and men so inflexible in their love of liberty and faith in man as Roger Williams and young Harry Vane. And as were the people so were their ministers. Of these it is enough to name John Cotton, able both as a divine and as a statesman, potent in England by his expositions and apologies of the "New England way," potent in America for his organizing and administrative power; Thomas Hooker, also famed as an exponent and apologist of the "New England way," whose book was commended to theologians at home by Thomas Goodwin, and whose early death was lamented by Cotton in lines which told how

> "Zion's beauty did most clearly shine
> In Hooker's rule and doctrine, both divine;"

John Eliot, famous as the "apostle of the Indians," first of Protestant missionaries to the heathen; Richard Mather, whose influence and work were carried on by his distinguished son, and his still more distinguished grandson, Cotton Mather. The motives and circumstances of the emigrants determined their polity; they went out as churches and settled as church states. They were all Puritans, but not all Independents—indeed, at first only the men from Leyden were, and they were throughout more enlightened and tolerant than the men of the other settlements. Winthrop's company were noncomformists but not separatists, esteemed it "an honour to call the Church of England, from whence we rise, our dear mother," emigrated that they might be divided from her corruptions, not from herself.[3] But the new conditions, backed by the special influence of the Plymouth settlement, were too much for them; they became Independent,—first, perhaps, of necessity, then of conviction and choice. Only so could they guard their ecclesiastical and their civil liberties. These, indeed, were at first formally as well as really identical. In 1631 the general court of the Massachusetts colony resolved, "that no man shall be admitted to the freedom of this body politic, but such as are members of some of the churches within the limits of the same."[4] Church and state, citizenship in the one and membership in the other, thus became identical, and the foundation was laid for those troubles and consequent severities that vexed and shamed the early history of Independency in New England, natural enough when all their circumstances are fairly considered, indefensible when we regard their idea of the relation of the civil power to the conscience and religion, but explicable when their church idea alone is regarded. And this latter was their own standpoint; their acts were more acts of church discipline than those of civil penalty.

Meanwhile, the growth of the New England States and their Independency in religion exercised extraordinary influence in England. It encouraged the Puritans, opened to them a refuge from the Anglican tyranny, showed them an English state where the bishop had ceased to trouble and where their own principles were active and realized. Laud thoroughly comprehended the situation, saw that Independency in the colonies must be struck down if Anglican policy was to succeed at home. They were a

[1] *An Humble Supplication for Toleration, and Liberty to enjoy and observe the Ordinances of Jesus Christ in the Administration of his Churches in lieu of Human Constitutions* (1609; no place or printer). In the following year Jacob published a work on *The Divine Beginning and Institution of Christ's true Visible or Ministerial Church*; and in 1612 a sequel to the above, *A Declaration and Plainer Opening of certain Points* (published at Middleburg). This latter is remarkable as containing the earliest use, in the ecclesiastical sense, of the word "Independent." "Where each ordinary congregation giveth their free consent in their own government, there certainly each is an entire and independent body-politic, and endued with power immediately under and from Christ, as every proper Church is, and ought to be," p. 13. It is interesting to note that the above *Supplication* is the earliest plea for toleration in the English language, but a few years later appeared a much more thoroughgoing work, *Religious Peace, or a Plea for Liberty of Conscience* (1614). This was by Leonard Busher, a Baptist, and to this body belongs the honour of being the first to develop the liberty implied in Independency. See Busher's and other tracts on "Liberty of Conscience" in publications of Hanserd Knollys Society.

[2] "Of Reformation in England," bk. ii., *Works*, p. 14 (ed. 1834).

[3] "The Humble Request of His Majesties Loyall Subjects, the Governour and the Company late gone for New England," 1630; referred to in Young's *Chron. Massach.*, pp. 295–299 (1846).

[4] Dexter, *Congregationalism of the Last Three Hundred Years*, p. 420.

receptacle for schismatics, "from whence, as from the bowels of the Trojan horse, so many incendiaries might break out to inflame the nation;" and so it would be necessary to send them a bishop "for their better government, and back him with some forces to compel, if he were not otherwise able to persuade, obedience."[1] But home politics alone were too much for Laud; and on his downfall and the outbreak of the civil war New England Independency became, on account of its influence on the ecclesiastico-political question, still more potent in English affairs. The Independent party in the Westminster Assembly—which had been called to advise parliament—was small, but influential. Its ministerial members were Thomas Goodwin, a ponderous but learned and conscientious man; Philip Nye, a skilful debater and adroit man of business; Jeremiah Burroughs, a man of sweet manners and gentle disposition, but great prudence and firmness; William Bridge, and Sidrach Simpson. These were all marked by conspicuous moderation of view, but the lay members, like Lord Saye and Sele and Sir Harry Vane, were more advanced, especially on the cardinal question of toleration. The importance of the New England States was at once recognized by the parliamentary Independents, who made an effort to bring over their three most eminent ministers, John Cotton, John Davenport, and Thomas Hooker. The effort failed; but in place of the men books and pamphlets, expository and defensive of the "New England way," were discharged in quick succession upon the English public. What gave New England its importance was this—it was the first realization on a large scale of the principles of Independency. Here they had been tried under most difficult conditions, and had proved thoroughly successful, capable of maintaining order in the churches, religion in the state, purity of doctrine, and efficiency of discipline. What Geneva had been to the Puritans under Elizabeth New England was now to the Independents—it was their religious ideal realized, their polity commended by an illustrious example. They were no longer, as in the days of John Robinson or Henry Jacob, the apologists of an unpopular and strange theory, hitherto unrealized save on a scale and under conditions that made it ridiculous, charged with all the evils that could be proved logically certain to follow from it. On the contrary, they had now behind them the church-state beyond the ocean, and they could proudly tell how men of English blood, who had fled from the Anglican oppression, had tried Independency and prevailed. So there was the amplest controversy on the points at issue, the Scotch divines being specially active on the one side, and American divines, prefaced and introduced and explained by English, on the other. The controversy did something to lessen the distance between Presbyterians and Independents, and did much to strengthen the position of the latter in England. It showed that independence did not mean isolation, that churches that refused to be organized into a political unity still constituted a Christian brotherhood, that societies that were so jealous of their freedom and rights as to deny to every external authority judicial and legislative functions could yet seek and follow fraternal advice, and meet in common councils to advise and be advised. But the Westminster Assembly and the English Parliament did not approve the "New England way," and the Independents had to be contented to plead for toleration. This, indeed, became their great demand—the point on which they and the Presbyterians differed radically. Here the Presbyterians were inflexible. Toleration was to them the very man of sin. But to the Independents it was the very condition of continued existence. Without it England would be no better for them under Presbytery than it had been under Episcopacy. As to the nature and degree of this toleration, they were divided into two sections, one moderate, the other more advanced. To the former belonged the ministerial members of the assembly, who wished only a limited toleration. They did not desire all views to be tolerated, but only the views of good men, men of pious, tender consciences, not those of infidels or blasphemers. But the more advanced section courageously advocated absolute toleration, denied that so long as a man was a peaceable citizen the magistrate had any right to interfere with his conscience or conscientious beliefs. To this section belonged Harry Vane, Henry Burton, John Goodwin of Coleman Street, ablest and most restless of controversialists in that controversial age; Roger Williams, now a Baptist, but still an Independent, home from America, bringing with him the MS. of a great book on this very subject; finally, above all, John Milton. These were the advanced guard, and theirs was the section that made Independency so immense a political power in the England of the Commonwealth.

This is not the place to inquire into the causes of the sudden and extraordinary ascendency of the Independents in the time of the Commonwealth. Enough to say, it was due to causes both political and religious—to what may be termed the transmutation of a great religious into a great political question. The men Independency formed and forced to the front were remarkable men, strong of will, clear of eye, mighty through faith in their principles. And their principles were precisely of the kind suited to the emergency, republican and revolutionary, but steeped in the commanding emotions and enthusiasms of religion. They were principles that ennobled man, that asserted the rights of the individual, that made it an easy matter to deal with the divine rights of kings, or kings too assertive of their rights and forgetful of their duties. So the Independents had the incalculable advantage of always seeing clearly before them, knowing their end and never being in any doubt about the way to it. Besides, their theory of the church fell in with the spirit of the Commonwealth. It made but small distinction between clergy and laity, and the man with the gift of speech could easily exercise it in preaching. So the army when new modelled, formed of men of spirit and conviction, became quite a nursery of Independents, and men like Richard Baxter found that in it there were quite as many ready to edify as wishful to be edified. Religion thus became, not a matter for the clergy, but the possession of the people, not simply the concern of the church, but the business of the whole nation. There was considerable diversity in theological opinion. The moderate men were Calvinists, but among the extreme men were Arminians, like John Goodwin, and men as yet of no recognized school, like John Milton. Independency, in short, meant the equal concern of every man in religion, alike in its deepest mysteries and most practical precepts; and so in a period of religious enthusiasm and ferment it naturally came to the front and took the lead. But the extent of its power under the Commonwealth was the measure of the disfavour that came to it after the Restoration. The Presbyterians had been mainly instrumental in the bringing back of Charles, and so it had been indecent had no attempt been made to comprehend them within the church. But in the case of the Independents there was not even an abortive attempt at comprehension. And they did not ask what they knew they would not receive. They only wished to be tolerated, to be allowed to live, and no more. At first they thought that this might be. Philip Nye had seen the king, and was hopeful. But their illusions were soon dispelled. In 1661 the Corporation Act was passed, which disqualified Nonconformists for municipal offices; in 1662 the Act of Uniformity, which drove upwards of two thousand ministers out of the church, and

[1] Heylyn, *Life of Laud*, p. 369.

silenced all who did not conform; in 1663 the Conventicle Act, which prevented Nonconformist congregations meeting, not allowing in houses more than five persons beyond the family to be present at once. In 1665 the Five Mile Act forbade non-conforming ministers to come within 5 miles of any corporate borough; in 1670 the Conventicle Act was made more rigorous; and in 1673 the Test Act made Nonconformists ineligible for offices, civil, naval, or military, under the crown. Charles, indeed, in his weak way, tried to be more generous than his church or parliament, wished to tolerate the Nonconformists that he might the better tolerate the Roman Catholics. Out of this feeling came the Declaration of Indulgence in 1672,—which was, incidentally, the means of proving the strength of dissent, three thousand applications being made for licences to use or erect places of worship; but parliament resisted, and Charles gave way.

In the dark days that had now come to them, the Independents, it may well be said, lived with patient courage, and learned through their sufferings. They had men among them that adorned their adversity, and made even their sudden obscurity illustrious. John Owen, late vice-chancellor of Oxford, massive, erudite, the ideal of the scholastic theologian, building up with patient skill his loved science and fencing it round with the sort of arguments his age understood; Thomas Goodwin, less varied but more subtle, not so broad but quite as analytic as Owen, dealing with rich delight in the dialectical subtleties that pleased his age; John Howe, with a soul above the narrowness and bitterness of his day, serene in the midst of his troubles, living in sublime contemplation on "the Living Temple," or the "Vision of God"; Joseph Caryl and William Greenhill, quaint expositors, rich in the lore then used to explain the Old Testament; Theophilus Gale, the equal of Cudworth in his knowledge of the ancient world, full of the great and fruitful idea he has embodied in his *Court of the Gentiles*,—these were some of the ejected from church or university, and they may help to show the quality of the men who were now, because of their Independency, outcasts from the Church of England, and for it deprived of their common rights as citizens. Their conduct under James showed that they would not purchase their own privileges at the expense of the public safety, and under William their fidelity to the constitution and liberties of England had its first reward in the Act of Toleration. This was but a small concession, and one that by the Occasional Conformity Act of Anne was almost as good as repealed. But what had been done could not be altogether undone. The coming in of the Hanoverian dynasty brought a more liberal spirit into politics, and history has ever since, with an occasional period of declension, been a progressive movement towards freedom. As one by one its principles and claims have been admitted by the state, England has become a roomier and healthier place for spirits who feel that for religion to be religious it must be free.

In estimating the work done in England by the Independents, it is necessary to bear in mind the extent to which they have supplemented the deficiencies of the Anglican Church. But for them religion in many places would have almost, perhaps altogether, died out. They have helped to quicken and deepen the religious consciousness and life of the English people. Their preachers, too, have not been without influence, which is the more remarkable as from the time of the Act of Uniformity till a few years ago they were excluded from the national universities. Soon after the passing of the Act of Toleration we find Independent preachers rising to eminence. The Foster who was celebrated in Pope's couplet—

> "Let modest Foster, if he will, excel
> Ten metropolitans in preaching well—

was an Independent, and as vigorous as a thinker as he was eloquent as a preacher, his answer to Tindal anticipating in its leading lines the celebrated argument of Butler in his *Analogy*. Isaac Watts is a name that must still be honoured, and Philip Doddridge a name that must be mentioned with respect. Edward Williams did much to revive the study of theology in the end of last century and early years of this, and Dr Pye Smith showed that within dissent scholarship and theological learning were still possible. The last generation had not a few men of distinction. The names of Henry Rogers, Joseph Gilbert, J. Angell James, Dr Winter Hamilton, Dr Ralph Wardlaw, Dr Robert Vaughan, his distinguished son Alfred Vaughan, Dr Halley, the historian of Nonconformity in Lancashire, and Thomas Binney of London are names representative of the kind of men that Independency can still produce.

But to complete this sketch of the Independents we must add one other element—the work done by their academies and colleges. They have always believed in an educated ministry, and when cast out of the universities one of their very first acts was to found academies. These they had great difficulty in maintaining, because of the operation of the oppressive acts passed in Charles II.'s reign; but in spite of the difficulties they contrived to do so. Theophilus Gale had an academy; so had Samuel Cradock, Thomas Doolittle, Richard Frankland, and others of the ejected ministers. It was possible to keep these only by the most frequent changes of place, so as to elude the vigilance of the authorities. When toleration was granted, the academies were able in the greater quiet they now enjoyed to do better work. One of these may serve as a sample. At Gloucester and then at Tewkesbury was an academy conducted by the Rev. Samuel Jones. Here were educated Thomas Secker, afterwards archbishop of Canterbury; Joseph Butler, bishop of Durham, and author of the *Analogy*; Samuel Chandler, one of the finest scholars of his day, who remained in poverty the scholar and the Christian Nonconformist still; and Jeremiah Jones. We know, on the authority of an early letter of Secker's, the method of education followed in Tewkesbury; and certainly, measured by the standard of the day, it was as thorough as the education was ample. Out of these academies the present Congregational colleges have grown.

It is unnecessary to attempt any exposition of the principles of Independency. These have been made apparent in the progress of this sketch. It may simply be said here that the Independents conceive their church order as the primitive and apostolic, and that out of their idea of the constitution and order of the primitive Christian churches their own system has grown. They believe that their conception of the church necessarily involves freedom of conscience, the interference with no man's belief, the concession of equal rights to all churches or religious societies by the state, and they may well remember with pride that John Locke based his plea for toleration on a conception of the church essentially akin to theirs.[1] Their notion of the pastoral office is in no respect sacerdotal, but is based on the Old Testament idea of the prophet, on the New Testament idea of the preacher—the man who by help or inspiration of God speaks for God to men. And the call to his office comes through the people; the divine choice is expressed through the men the divine word enlightens and the divine Spirit guides. Their theology has been predominantly Calvinistic, though of the more moderate type; but there has always been variety of theological opinion, subscription and the uniformity it attempts to secure being alike impossible to Independency.

[1] *Works*, ii. 245 (ed. 1759).

For statistics of the denomination and the reasons which have induced it to assume the name Congregationalist, see CONGREGATIONALISM.

Authorities.—Fletcher, *History of Independency*, 4 vols. 1847-9; Heywood and Wright, *Cambridge University Transactions*, 2 vols., 1854; Vaughan, *Memorials of the Stuart Dynasty*, 2 vols., 1831; Roger Williams, *The Bloudy Tenent of Persecution*, ed. Underhill, 1848; Hanbury, *Historical Memorials relating to the Independents*, 3 vols., 1839-44; Carlyle, *Cromwell's Letters and Speeches*, 1845; Underhill, *Tracts on Liberty of Conscience and Persecution*, 1846; Masson, *Life of Milton*, 6 vols., 1859-80; Vaughan, *The Protectorate of Cromwell*, 2 vols, 1839; Stoughton, *Church and State Two Hundred Years Ago*, 1862; Underhill, *Broadmead Records*, 1847; Gould, *Documents relating to Act of Uniformity*, 1862; Calamy, *Nonconformists' Memorial*, 3 vols., 1802; Toulmin, *Protestant Dissenters in England*, 1814; Stoughton, *Religion in England under Queen Anne and the Georges*, 2 vols., 1878; Bennet, *History of Dissenters during the last Thirty Years*, 1839; Barclay, *Inner Life of the Religious Societies of the Commonwealth*, 1877; Vaughan, *English Nonconformity*, 1862; Price, *History of Protestant Nonconformity in England*, 2 vols., 1836-38; Bogue and Bennet, *History of Dissenters*, 4 vols., 1808-12; Wilson, *History and Antiquities of Dissenting Churches*, &c., 4 vols., 1808-14; Stoughton, *Ecclesiastical History of England*, 5 vols., 1867-74; Dexter, *The Congregationalism of the Last Three Hundred Years*, 1880; Neal, *History of the Puritans*, 5 vols.; Waddington, *Congregational History*, 5 vols., 1869-80. (A. M. F.)

INDEX is a word that may be understood either specially as a table of references to a book or, more generally, as an indicator of the position of required information on any given subject. According to classical usage, the Latin word *index* denoted a discoverer, discloser, or informer; a catalogue or list; an inscription; the title of a book; and the fore or index-finger. Cicero also used the word to express the table of contents to a book, and explained his meaning by the Greek form *syllabus*. Shakespeare uses the word with the general meaning of a table of contents or preface—thus Nestor says (*Troilus and Cressida*, i. 3)—

> "And in such indexes, although small pricks
> To their subsequent volumes, there is seen
> The baby figure of the giant mass."

Table was the usual English word, and index was not thoroughly naturalized until the beginning of the 17th century, and even then it was usual to explain it as "index or table." By the present English usage, according to which the word table is reserved for the summary of the contents as they occur in a book, and the word index for the arranged analysis of the contents, we obtain an advantage not enjoyed in other languages, for the French *table* is used for both kinds, as is *indice* in Italian and Spanish. There is a group of words each of which has its distinct meaning but finds its respective place under the general heading of index work; these are calendar, catalogue, digest, inventory, register, summary, syllabus, and table.[1] The value of indexes was recognized in the earliest times, and many old books have full and admirably constructed ones. A good index has sometimes kept a dull book alive by reason of the value or amusing character of its contents. Mr Carlyle refers to Prynne's *Histrio-Mastix* as "a book still extant, but never more to be read by mortal;" but the index must have given amusement to many from the curious character of its entries, and Attorney-General Noy particularly alluded to it in his speech at Prynne's trial. Indexes have sometimes been used as vehicles of satire, and the witty Dr William King was the first to use them as a weapon of attack. His earliest essay in this field was the index added to the second edition of the Hon. Charles Boyle's attack upon Bentley's *Dissertation on the Epistles of Phalaris*, 1698.

[1] Another old word occasionally used in the sense of an index is "pye." The late Sir T. Duffus Hardy, in some observations on the derivation of the word "Pye-Book" (which most probably comes from the Latin *pica*), remarks that the earliest use he had noted of pye in this sense is dated 1547—"a Pye of all the names of such Balives as been to accompte pro anno regni regis Edwardi Sexti primo."

To serve its purpose well, an index must be compiled with care, the references being placed under the heading that the reader is most likely to seek. An index should be one and indivisible, and not broken up into several alphabets; thus every work, whether in one or more volumes, ought to have its complete index. This important rule has been often neglected in English books, and is almost universally rejected in foreign ones, to the great inconvenience of readers. The mode of arrangement calls for special attention; this may be either chronological, alphabetical, or according to classes, but great confusion will be caused by uniting the three systems. The alphabetical arrangement is so simple, convenient, and easily understood that it has naturally superseded the other forms, save in some exceptional cases. Much of the value of an index depends upon the mode in which it is printed, and every endeavour should be made to set it out with clearness. In old indexes the indexed word was not brought to the front, but was left in its place in the sentence, so that the alphabetical order was not made perceptible to the eye. There are few points in which the printer is more likely to go wrong than in the use of marks of repetition, and many otherwise good indexes are full of the most perplexing cases of misapplication in this respect. The oft-quoted instance—

> Mill on Liberty
> —— on the Floss

actually occurred in a catalogue. There appears now to be a revived interest in indexes, and as books daily increase the need of some satisfactory digest of information becomes more keenly felt. In 1877 the Index Society was formed with the object of making and printing indexes of books unprovided with them, of compiling and printing indexes of particular subjects, and of gradually preparing a universal index for reference. In order to obtain uniformity in the compilation of indexes a series of rules for indexing have been drawn up by the society. Several publications have already been issued to the subscribers.

The following is a list of some of the most important indexes, both of words and of subjects. The chief indexes of words are dictionaries, but these are a special class by themselves. Next come concordances: the first one to the Bible was compiled by Hugo of St Cher in 1247, the first English concordance to the New Testament was published in 1536, and to the whole Bible in 1550, compiled by John Marbeck. Other Biblical concordances are those of R. F. Hervey, 1579; C. Cotton, 1622 (frequently reprinted); J. Downame, 1632; R. Wickens, 1655; S. Newman, 1650, 3d ed. 1682; A. Cruden, 1737 (this superseded all works of the same character); and R. Young, 1880. The following concordances may also be mentioned:—to the Psalter, 1834; to the Prayer Book, 1851; to the *Iliad*, by G. L. Prendergast, 1875, to Shakespeare, by S. Ayscough (1790), by F. Twiss (1805), by Mrs Cowden Clarke (1845), by J. O. Halliwell (*Handbook Index*, 1866), and by A. Schmidt (1874), and to Shakespeare's *Poems*, by Mrs H. H. Furness, 1874; to Milton's *Paradise Lost* (1741), and to his *Poetical Works*, by H. J. Todd (1809), by G. L. Prendergast (1857), and by C. D. Cleveland (1867); to Pope's *Works*, by E. Abbott, 1875; to Tennyson's *Works*, by D. B. Brightwell, 1869, and another published by Strahan, 1870; to *In Memoriam* (1862); to Keble's *Christian Year*, 1871; and to Watts's *Psalms*, by D. Guy, 1774. A large number of historical works have been supplied with indexes in separate volumes. Among the more important indexes of prose writers are those of the works of Samuel Richardson (1755), Joanna Southcott (n. d., and 1815), John Strype (1828), and T. Carlyle (1874); *The Wellington Despatches* (1839); Wesley's *Journals* (1872). A large number of series of publications of societies and of periodicals have been supplied with general indexes.

The Indexes to the Statutes and to the Journals of the Houses of Parliament are perhaps the most elaborate works of the kind ever published. In 1778 a sum of £12,900 was voted for indexes to the Journals of the House of Commons. Few parliamentary papers are issued without a satisfactory index being added. Most of the indexes mentioned above refer to particular books, but in 1848 Mr W. F. Poole published in New York an index to subjects treated in reviews and other periodicals; a second edition was published in 1853 as *An Index to Periodical Literature*. A greatly enlarged edition is now in preparation with the co-operation of English and American librarians. A larger work of a similar character for scientific literature, but arranged under authors' names instead of subjects has been compiled by the Royal Society and is entitled *Catalogue of Scientific Papers* (1800-73), 8 vols. 4to, 1867–1879. (H. B. W.*)

INDEX LIBRORUM PROHIBITORUM is the title borne by the official list of those books which on doctrinal or moral grounds the Roman Catholic Church, under penalty of ecclesiastical censures, authoritatively forbids the members of her communion to possess or to read. Most Governments, whether civil or ecclesiastical, have at all times in one way or another acted on the general principle that some control may and ought to be exercised over the literature circulated among those under their jurisdiction; for various examples, both in ancient and in modern times, reference may be made to the article BIBLIOGRAPHY (vol. iii. p. 658). The earliest known instance of a list of proscribed books being issued with the authority of a bishop of Rome is sometimes assigned to the pontificate of Gelasius (494) and sometimes to that of Hormisdas (514), but most probably ought not to be dated earlier than the 8th century. The document is for the most part, as its name implies, a *Notitia Librorum Apocryphorum qui non recipiuntur*, and chiefly consists of an enumeration of such apocryphal works as by their titles might be apt to mislead the unwary into attaching an undue weight to their teaching (the "Acts" of Philip, Thomas, Peter, Philip, and the Gospels of Thaddæus, Matthias, Peter, James the Less, and others). Its concluding paragraph, however, sweepingly declares all the writings of Simon Magus and of many other heretics who are mentioned by name, as also of many more whose names have been completely forgotten (*minime retinentur*), to be repudiated, eliminated entirely from the Roman Catholic and Apostolic Church, and eternally condemned.[1] Subsequent pontiffs continued to exhort the episcopate and the whole body of the faithful to be on their guard against heretical writings, whether old or new; and one of the functions of the Inquisition when it was established was to exercise a rigid censorship over books put in circulation. The bishops in their dioceses had always, however, a considerable discretion. With the discovery of the art of printing, and the wide and cheap diffusion of all sorts of books which ensued, the need for new precautions against heresy and immorality in literature made itself felt, and more than one pope (Sixtus IV. in 1479 and Alexander VI. in 1501) gave special direction to the archbishops of Cologne, Mainz, Treves, and Magdeburg regarding the growing abuses of the printing press; in 1515 the Lateran council formulated the decree *De Impressione Librorum*, which required that no work should be printed without previous examination by the proper ecclesiastical authority, the penalty of unlicensed printing being excommunication of the culprit, and confiscation and destruction of the books. The council of Trent in its fourth session, 8th April 1546, forbade the sale or possession of any anonymous religious book which had not previously been seen and approved by the ordinary; in the same year the university of Louvain, at the command of Charles V., prepared an "Index" of pernicious and forbidden books, a second edition of which appeared in 1550. In 1557, and again in 1559, Pope Paul IV., through the Inquisition at Rome, published what may be regarded as the first Roman *Index* in the modern ecclesiastical use of that term (*Index auctorum et librorum qui tanquam hæretici aut suspecti aut perversi ab Officio S. R. Inquisitionis reprobantur et in universa Christiana republica interdicuntur*). All anonymous works published since 1519 were condemned without exception in this Index, which directed its hostility chiefly against works that seemed unfavourable to the claims of the Roman curia, or maintained the superiority of councils over popes. A list of sixty-two printers of heretical books was appended. At the 18th session of the council of Trent (26th February 1562), in consideration of the great increase in the number of suspect and pernicious books, and also of the inefficacy of the many previous "censures" which had proceeded from the provinces and from Rome itself, certain fathers were appointed to enquire into these "censures," and to consider what ought to be done in the circumstances. At the 25th session (4th December 1563) this committee of the council was reported to have completed its work, but as the subject did not seem (on account of the great number and variety of the books) to admit of being properly discussed by the council, the result of its labours was handed over to the pope (Pius IV.) to deal with as he should think proper. In the following March accordingly were published, with papal approval, the *Index librorum prohibitorum*, which continues to be reprinted and brought down to date, and the "Ten Rules" which, supplemented and explained by Clement VIII., Sixtus V., Alexander VII., and finally by Benedict XIV. (10th July 1753), still regulate the preparation of that catalogue. By the first of these rules the condemnation of all books already condemned by pope or council prior to 1515 is renewed; by the second the works of "heresiarchs" (Luther, Zwingli, Calvin, Schwenkfeld, Hübmaier) are condemned whatever be their subject, but it is provided that the non-religious works of those who are heretics merely may on examination and approval be permitted; the third and fourth relate to translations of the Bible; the fifth orders the expurgation of lexicons, concordances, and similar compilations by heretics; the sixth discourages the circulation of books in the vulgar tongue about controversies between Catholics and heretics; the seventh, eighth, and ninth relate to obscene or grossly superstitious publications; the tenth contains various details of procedure about the licensing of books, and concludes with the declaration that the possessor or reader of heretical books is forthwith to be excommunicated, while the possessor or reader of books prohibited on other grounds falls into mortal sin, and is to be dealt with severely at the discretion of the bishop. The business of correcting the Index to date is now in the hands of an ecclesiastical board known as the "Congregation of the Index," which consists of a prefect (who is always a cardinal) and other cardinals, with whom are associated the "consulters" and "examiners of books" (*qualificatores*). The *Index Librorum Expurgandorum* or *Expurgatorius* catalogues the works which may be read after the deletion of specified passages. Bishops have the power of granting at their discretion the right to read forbidden books, except in some reserved cases, where the papal dispensation is required. The Roman Index is unfortunately very far from being an exhaustive catalogue of works inconsistent with Catholic orthodoxy, and thus lacks the interest and vast importance it would otherwise have had for the bibliographer.

The early Reformers, by their attitude towards writings which from their point of view seemed objectionable, furnished many an *argumentum ad hominem* to the Catholics (see Gretser's learned work, *De Jure et More prohibendi, expurgandi, et abolendi libros hæreticos et noxios*, 1603); thus we find Calvin writing to the ministers at Frankfort about one of the books of Servetus, with a view to its being burnt (*Ep.* 153). Gradually, however, all the Protestant churches have recognized the expediency of leaving individuals and communities practically free to select for their instruction and amusement the works which in the conscientious exercise of their own responsible judgment they may find best adapted to their wants.

[1] Hardouin, *Conc.*, ii. 940; Labbé, *Conc.*, ii. 938-941. The whole document has also been reprinted in Smith's *Dict. of Chr. Antiq.*, art. "Prohibited Books."


HERAT
60
64
68
72
76
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28
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16
12
8
PERSIA
AFGHANISTAN
BALUCHISTAN
Sabzawar
Farrah
Laush
Girishk
Ghazni
KABUL
Jalalabad
PESHAWAR
Attock
Kohat
Rawal pindi
Khelat-i-Ghilzai
KANDAHAR
Quetta
Nuski
Sarawan
Dadar
KHELAT
Jacobabad
Kozdar
Bela
Sonmiani
Karachi
Cape Monze
Hab R.
PANJAB
Multan
Lahore
Amritsar
Jalandhar
Ludhiana
Simla
Umballa
Patiala
Sirsa
Hissar
Rohtak
DELHI
Meerut
Bahawalpur
BAHAWALPUR
Bikaner
Ratangarh
RAJPUTANA
Jaisalmir
Jodhpur
Ajmer
Nasirabad
Sukkur
Shikarpur
Haidarabad
Umarkot
Tropic of Cancer
Rann of Cutch
Cutch
Bhuj
Gulf of Cutch
ARABIAN SEA
Rajkot
Porbandar
Ahmadabad
Baroda
Broach
Surat
Udaipur
Ujjain
Indore
Mhow
Bhopal
Sagar
Jabalpur
Gwalior
Agra
Cawnpur
Lucknow
Gulf of Cambay
BOMBAY
Poonah
Satara
Aurangabad
Jalna
NAGPUR
Kampti
BERAR
NIZAMS DOMINIONS
HAIDARABAD
Bijapur
Belgaum
Goa
Dharwar
Bellary
Kurnul
Cuddapah
Nellore
MYSORE
Bangalore
Mangalore
Cannanore
Calicut
Beypur
Coimbatore
Trichinopoli
Tanjore
Madura
Tinnevelli
Cochin
Trevandrum
Cape Comorin
Malabar Coast
MADRAS
Pondicherry
Tranquebar
Negapatam
Palk's Strait
Gulf of Manar
Colombo
Laccadive Islands
Minikoi
INDIAN
Scale 220 miles = to 1 inch
100 50 0 100 200 300 400
Longitude East 68 of Greenwich
Pt de Galle


REFERENCES
British Territory colored Pink
Dependent & Subordinate Native States Yellow
Independent States Green
The numerals denote the height above sea level in feet.
84
88
92
96
100
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C H I N A
Bhamo
Manipur
Samjok
Tamu
Momeit
Mandalay
Amarapura
Ava
Thebau
Muang lem
Kiang Tung
Kiang hai
Kiang-mai or Zimme
Labong
Oudh
Gonda
Gorakhpur
Dharampur
Jalpaiguri
Kuch Behar
Goalpara
Gauhati
Nowgong
Samaguting
Shillong
Cherra punji
Jaintia
Sylhet
Silchar
Rangpur
Dinajpur
Maldah
Bogra
Rajmahal
Deogarh
Murshidabad
Birbhum
Gaya
Patna
Dinapur
Benares
Chunar
Sherghati
Palamau
Chutia Nagpur or Doranda
Sirguja
Barwa
Jashpur
Chaibasa
Ratanpur
Bilaspur
Sambalpur
Gangpur
Keunjhar
Midnapur
Bamanhati
Balasor
Burdwan
Nadiya
Jessor
Barisal
DACCA
HILL TIPPERAH
Bhulua
Chittagong or Islamabad
Ramu
CALCUTTA
Barrackpur
Diamond Harbour
Mouths of the Ganges
Pt. Palmyras
False Pt.
Cuttack
Angul
Sonpur
Bod
Nawagada
O R I S S A
B E N G A L
Puri or Jagannath
Ganjam
Russelkonda
Jaipur
Chicacole
Kalingapatam
Vizagapatam
Samulkotta
Vizianagaram
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Kyouk-hpyu
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Padaung
Paungdo
Meadai
Prome
Toungu
Henzada
Bassein
Pegu
RANGOON
Sitang
Shwegyen
Martaban
Maulmain
Amherst
Gulf of Martaban
Cape Negrais
Pagoda Pt.
Alguada Reef Light House
Preparis Id.
Great Coco
Little Coco
Narkondam Id.
Andaman Ids.
Barren Id. Volcano
Port Blair
Invisible Bank
Little Andaman Id.
Mergui Archipelago
Tavoy
Tavoy Pt.
Tavoy I.
King I.
Mergui
Tenasserim
Bentinck
Domel Id.
Clara Id.
Sullivans Id.
St. Mathews Id.
Roes Bank
Kra
Pt. Victoria
Bankok
GULF OF SIAM
Car Nicobar Id.
Nicobar Islands
Seyer Ids.
Junk Ceylon or Salanga
Lantak Id.
Pulo Ronda
O C E A N
B U R M A
P E G U
A R A K A N
Thayet Myo
Blue Mt.
Maulmain
dipatam

INDIA

INDIA is a great empire of Asia, composed of twelve provinces under direct British administration, and about one hundred and fifty feudatory states and principalities, which equally with the British provinces acknowledge the paramount sovereignty of the British crown. The whole empire contains close on $1\frac{1}{2}$ million square miles, and 240 millions of inhabitants. The area, therefore, is almost equal to, and the population is just equal to, the area and population of all Europe, less Russia. The people exactly double Gibbon's estimate of 120 millions for all the races and nations which obeyed Imperial Rome.

The Name.—The natives of India can scarcely be said to have a word of their own by which to express their common country. In Sanskrit, it would be called "Bhárata-varsha," from Bharata, a legendary monarch of the Lunar line; but Sanskrit is no more the vernacular of India than Latin is of Europe. The name "Hindustán," which was at one time adopted by European geographers, is of Persian origin, meaning "the land of the Hindus," as Afghánistán means "the land of the Afgháns." According to native usage, however, "Hindustán" is limited either to that portion of the peninsula lying north of the Vindhyá mountains, or yet more strictly to the upper basin of the Ganges where Hindí is the spoken language. The "East Indies," as opposed to the "West Indies," is an old-fashioned and inaccurate phrase, dating from the dawn of maritime discovery, and still lingering in certain parliamentary papers. "India," the abstract form of a word derived through the Greeks from the Persicized form of the Sanskrit *sindhu*, a "river," pre-eminently the Indus, has become familiar since the British acquired the country, and is now officially recognized in the imperial title of the sovereign.

The Country.

General Outline.—India, as thus defined, is the middle of the three irregularly shaped peninsulas which jut out southwards from the mainland of Asia, thus corresponding roughly to the peninsula of Italy in the map of Europe. Its form is that of a great triangle, with its base resting upon the Himálayan range, and its apex running far into the ocean. The chief part of its western side is washed by the Arabian Sea, and the chief part of its eastern side by the Bay of Bengal. It extends from the 8th to the 35th degree of north latitude, that is to say, from the hottest regions of the equator to far within the temperate zone. The capital, Calcutta, lies in 88° E. long.; so that when the sun sets at six o'clock there, it is just past mid-day in England, and early morning in New York. The length of India from north to south, and its greatest breadth from east to west, are both about 1900 miles; but the triangle tapers with a pear-shaped curve to a point at Cape Comorin, its southern extremity. To this compact dominion the English have added, under the name of British Burmah, the strip of country on the eastern shores of the Bay of Bengal. But on the other hand, the adjacent island of Ceylon has been artificially severed, and placed under the colonial office. Two groups of islands in the Bay of Bengal, the Andamans and the Nicobars; one group in the Arabian sea, the Laccadives; and the outlying station of Aden at the mouth of the Red Sea, are all politically included within the Indian empire; while dots on the shore of the peninsula itself, representing Portuguese and French settlements, break at intervals the continuous line of British territory.

Boundaries.

India is shut off from the rest of Asia on the north by a vast mountainous region, known in the aggregate as the Himálayas, amid which lie the independent states of Bhután and Nepál, with the great table-land of Tibet behind. The native principality of Kashmír occupies the north-western angle of India, with Eastern Turkestán stretching to the north beyond it. At this north-western angle (in 35° N. lat., 74° E. long.) the mountains curve southwards, and India is separated by the well-marked ranges of the Sufed Koh and Sulaímán from Afghánistán; and by a southern continuation of lower hills (the Hálas, &c.) from Baluchistán. The last part of the western land frontier of India is formed by the river Hab, and the boundary ends at Cape Monze, at the mouth of its estuary, in 24° 50′ N. lat., 66° 38′ E. long. Still farther southwards, India is bounded along the W. and S.W. by the Arabian Sea and Indian Ocean. Turning northwards from the southern extremity at Cape Comorin (8° 4′ 20″ N. lat., 77° 35′ 35″ E. long.), the long sea-line of the Bay of Bengal forms the main part of its eastern boundary. But on the north-east, as on the north-west, India has again a land frontier. The Himálayan ranges at the north-eastern angle (in about 28° N. lat., 97° E. long.) throw off spurs and chains to the south-east. These spurs, which have been but imperfectly explored, and may possibly constitute an independent mountain system, separate the British provinces of Assam and Eastern Bengal from Independent Burmah. They are known successively as the Abar, Nágá, Patkoi, and Barel ranges. Turning almost due south in 25° lat., they culminate in the Blue Mountain (7100 feet), in 22° 37′ N. lat., 93° 10′ E. long., and then stretch southwards under the name of the Arakan Yomas, separating British Burmah from Independent Burmah, until they again rise into the mountain of Myeng-mateng (4700 feet), in $19\frac{1}{2}$° of N. lat. Up to this point, the eastern frontier follows, generally speaking, the watershed which divides the river systems of the Brahmaputra, Meghna, Kuladan (Koladyne), &c., in Bengal and British Burmah, from the Irawadi basin in Independent Burmah. But from near the base of the Myeng-mateng Mountain, in about $19\frac{1}{2}$° lat., the British frontier stretches almost due east, in an artificial line which divides the lower districts and delta of the Irawadi in British Burmah from the middle and upper districts of that river in Independent Burmah. Stretching south-eastwards from the delta of the Irawadi, a confused succession of little explored ranges separates the British province of Tenasserim from the native kingdom of Siam. The boundary line runs down to Point Victoria at the extremity of Tenasserim (9° 59′ N. lat., 98° 32′ E. long.), following in a somewhat rough manner the watershed between the rivers of the British territory on the west and of Siam on the east.

Three regions.

The empire included within these boundaries is rich in varieties of scenery and climate, from the highest mountains in the world to vast river deltas raised only a few inches above the level of the sea. It forms a continent rather than a country. But if we could look down on the whole from a balloon, we should find that India consists of three separate and well-defined tracts. The first includes the lofty Himálaya mountains, which shut it out from the rest of Asia; and which, although for the most part beyond the British frontier, form an overruling factor in the physical geography of northern India. The second region stretches southwards from the base of the Himálayas, and comprises the plains of the great rivers which issue from them. The third region slopes upward again from the edge of the river plains, and consists of a high three-sided table-land, supported by the Vindhyá mountains on the north, and by the

Eastern and Western Gháts, which run down the coast on either side till they meet at a point near Cape Comorin. The interior three-sided table-land thus enclosed is broken by peaks and ranges, interspersed with broad expanses of level uplands, and covers the whole southern half of the peninsula.

Himálayas.

The first of the three regions is the Himálaya mountains and their offshoots to the southward. The Himálayas—literally, the "Dwelling-place of Snow," from the Sanskrit *hima*, frost (Latin, *hiems*, winter), and *álaya*, a house—comprise a system of stupendous ranges, the loftiest in the world. They are the *Emodus* of Ptolemy (among other names), and extend in the shape of a scimitar, with its edge facing southwards, for a distance of 1500 miles along the northern frontier of India. At the north-eastern angle of that frontier, the Dihang river, the connecting link between the Tsan-pu (Sangpu) of Tibet and the Brahmaputra of Assam, bursts through the main axis of the range. At the opposite or north-western angle, the Indus in like manner pierces the Himálayas, and turns southwards on its course through the Punjab. The Himálayan region has been fully described in a separate article, vol. xi. p. 821.

This wild region is in many parts impenetrable to man, and nowhere yields a passage for a modern army. It should be mentioned, however, that the Chinese outposts extend as far as a point only 6000 feet above the Gangetic plain, north of Khatmandu. Indeed, Chinese armies have seriously threatened Khatmandu itself; and Sir David Ochterlony's advance from the plains of Bengal to that city in 1816 is a matter of history. Ancient and well-known trade routes exist, by means of which merchandise from the Punjab finds its way over heights of 18,000 feet into Eastern Turkestán and Tibet. The Muztagh (Snowy Mountain), the Karakoram (Black Mountain), and the Changchenmo are the most famous of these passes.

The Himálayas not only form a double wall along the north of India, but at both their eastern and western extremities send out ranges to the south, which protect its north-eastern and north-western frontiers. On the north-east, those offshoots, under the name of the Nágá and Patkoi mountains, &c., form a barrier between the civilized British districts and the wild tribes of Upper Burmah. The southern continuations of these ranges, known as the Yomas, separate British from Independent Burmah, and are crossed by pa ses, the most historic of which, the Aeng or An, rises to 4668 (formerly given at 4517) feet, with gradients of 472 feet to the mile.

On the opposite or north-western frontier of India, the mountainous offshoots run down the entire length of the British boundaries from the Himálayas to the sea. As they proceed southwards, their best marked ranges are in turn known as the Sufed Koh, the Suláimán, and the Hála mountains. These massive barriers have peaks of great height, culminating in the Takht-i-Suláimán or Throne of Solomon, 11,317 feet above the level of the sea. But the mountain wall is pierced at the corner where it strikes southwards from the Himálayas by an opening through which the Kábul (Cabul) river flows into India. An adjacent opening, the Khyber Pass (rising to 3373 feet), the Kuram Pass to the south of it, the Gwalarí Pass near Derá Ismáil Khán, the Tál Pass debouching near Derá Ghází Khán, and the famous Bolán Pass (5800 feet at top) still farther south, furnish the gateways between India and Afgháuistán. The Hála, Brahui, and Pab mountains form the southern hilly offshoots between India and Baluchistán, and have a much less elevation.

River plains.

The wide plains watered by the Himálayan rivers form the second of the three regions into which we have divided India. They extend from the Bay of Bengal on the east to the Afghán frontier and the Arabian Sea on the west, and contain the richest and most densely crowded provinces of the empire. One set of invaders after another has from prehistoric times entered by the passes at their eastern and north-western frontiers. They followed the courses of the rivers, and pushed the earlier comers southwards before them towards the sea. About 150 millions of people now live on and around these river plains, in the provinces known as the lieutenant-governorship of Bengal, Assam, the North-Western Provinces and Oudh, the Punjab, Sind, Rájputána, and other native states.

River systems.

The vast level tract which thus covers northern India is watered by three distinct river systems. One of these systems takes its rise in the hollow trough beyond the Himálayas, and issues through their western ranges upon the Punjab as the Sutlej and Indus. The second of the three river systems also takes its rise beyond the double wall of the Himálayas, not very far from the sources of the Indus and the Sutlej. It turns, however, almost due east instead of west, enters India at the eastern extremity of the Himálayas, and becomes the Brahmaputra of Assam and Eastern Bengal. These rivers collect the drainage of the northern slopes of the Himálayas, and convey it, by long and tortuous although opposite routes, into India. Indeed, the special feature of the Himálayas is that they send down the rainfall from their northern as well as from their southern slopes to the Indian plains. Of the three great rivers of northern India, the two longest, namely the Indus with its feeder the Sutlej and the Brahmaputra, take their rise in the trough on the north of the Himálayas. The third river system of northern India receives the drainage of their southern slopes, and eventually unites into the mighty stream of the Ganges. In this way the rainfall, alike from the northern and southern slopes of the Himálayas, pours down into the river plains of Bengal.

Crops.

Throughout the river plains of northern India, two harvests, and in some provinces three, are reaped each year. These crops are not necessarily taken from the same land; but in many districts the best fields have to yield two harvests within the twelve months. In Lower Bengal, pease, pulses, oil-seeds, and green crops of various sorts are reaped in spring; the early rice crops in September; the great rice harvest of the year, and other grains, in November and December. Before these last have been gathered in, it is time to prepare the ground for the spring crops, and the Bengal husbandman knows no rest except during the hot weeks of May, when he is anxiously waiting for the rains. But it should always be remembered that rice is the staple crop in only a limited area of India, and that it forms the everyday food of only a comparatively small proportion of the population. It has been estimated that, in the absence of irrigation, the rice crop requires an annual rainfall of at least 36 inches; and an Indian province requires an average fall of not less than 50 or 60 inches in order to grow rice as its staple crop. A line might almost be drawn across Behar, to the north of which the food of the people ceases to be rice and becomes wheat and millets, &c. There are, indeed, great rice-growing tracts in irrigated or low-lying districts of north-western India, but their produce is consumed by the richer classes or exported.

Scenery.

A detailed account of the most important products will be found under the heading of "Agriculture," farther on in the present article. They are here alluded to only so far as is necessary to give a general idea of the scenery of the river plains. In the northern and drier regions along the upper courses of the rivers, the country rises gently from their channels in fertile undulations, dotted with mud villages and adorned with noble trees. Mango groves scent the air with their blossom in spring, and yield their abundant fruit in summer. The spreading banyan, with its colonnades of hanging roots; the stately *pipal*, with its green masses of foliage; the leafless wild cotton-tree, glowing with heavy crimson flowers; the tall, feathery tamarind, and the quick-growing *bábul*, rear their heads above the fields. As the rivers approach the coast, the palms begin to take possession of the scene. The ordinary landscape in the delta is a flat stretch of rice-fields, fringed round with evergreen masses of bamboos, cocoa-nuts, date-trees, areca, and other coronetted palms. This densely peopled tract seems at first sight bare of villages, for each hamlet is hidden away amid its own grove of plantains and wealth-giving trees. The bamboo and cocoa-nut play a conspicuous part in the industrial life of the people; and the number of products derived from them, including rope, oil, food, and timber, has been dwelt on with admiration by many writers.

The crops also change as we sail down the rivers. In the north, the principal grains are wheat, barley, Indian corn, and a variety of millets, such as *joár* (*Holcus Sorghum*) and *bájra* (*Holcus spicatus*). In the delta, on the other hand, rice is the staple crop and the universal diet. In a single district, Rangpur, 295 separate kinds of rice are known to the peasant, who has learned to grow his favourite crop in every locality, from the solid field, which yields the *áman* harvest, to the swamps 12 feet deep, on the surface of whose waters the rice ears may be seen struggling upwards for air. Sugar-cane, oil-seeds, flax, mustard, sesamum, palma-christi, cotton, tobacco, indigo, safflower, turmeric, ginger, coriander, capsicum, cummin, and many precious spices and dyes are grown both in the North-Western or Upper Provinces, and in the moister valleys and delta of Lower Bengal. A whole pharmacopœia of native medicines, from the well-known aloe and castor-oil to obscure but valuable febrifuges, is derived from shrubs, herbs, and roots. Resins, gums, varnishes, scents, and a hundred articles of commerce or luxury are collected in the fields or forests. Vegetables of many sorts, both indigenous and imported from Europe, form a large part of the food of the people. The melon and huge yellow pumpkin spread themselves over the thatched roofs; fields of potatoes, yams, and *brinjal* are attached to the homesteads. The tea-plant is reared on the hilly ranges that skirt the plains both in the north-west and in Assam; the opium poppy about half down the Ganges, around Benares and Patná; the silk-worm mulberry still farther down in Lower Bengal; while the jute fibre is essentially a crop of the delta, and would exhaust any soil not fertilized by river floods. Even the jungles yield the costly lac dye and *tasar* silk cocoons. The *mahuá*, also a product of the jungle, produces the fleshy flowers which form a staple article of food among the hill tribes, and when distilled supply a cheap spirit. The *sál*, *sissu*, *tún*, and many other indigenous trees yield excellent timber. Flowering creepers, of gigantic size and gorgeous colours, festoon the jungle; while each tank bears its own beautiful crop of the lotus and water-lilies. Nearly every vegetable product that feeds and clothes a people, or enables it to trade with foreign countries, abounds.

them le- d.

We come now to the third division of India, namely the three-sided table-land which covers the southern half or more strictly peninsular portion of India. This tract, known in ancient times as the Deccan (Dakshin), literally "the right hand or south," comprises the Central Provinces, Berar, Madras, Bombay, Mysore, and the native territories of the nizám, Sindhia, Holkar, and other feudatory states. It had in 1872 an aggregate population of over 90 millions. For the sake of easy remembrance, therefore, we may take the inhabitants of the river plains in the north to be now nearly 150 millions, and those of the southern three-sided table-land at nearly 100 millions. The Deccan, in its local acceptation, is restricted to the high tract between the Narbadá (Nerbudda) and the Kistná rivers; but it is popularly understood to include the whole country south of the Vindhyás as far as Cape Comorin. It slopes up from the southern edge of the Gangetic plains. Three ranges of hills support its northern, its eastern, and its western side; and the last two meet at a sharp angle near Cape Comorin.

The Deccan.

The northern side rests on confused ranges, running with a general direction of east to west, and known in the aggregate as the Vindhyá mountains. The Vindhyás, however, are made up of several distinct hill systems. Two sacred peaks guard the flanks in the extreme east and west, with a succession of ranges stretching 800 miles between. At the western extremity, Mount Abu, famous for its exquisite Jain temples, rises, as a solitary outpost of the Aravalli hills, 5650 feet above the Rájputána plain, like an island out of the sea. Beyond the southern limits of that plain, the Vindhyá range of modern geography runs almost due east from Guzerat, forming the northern wall of the Narbadá valley. The Sátpura mountains stretch also east and west to the south of that river, and form the watershed between it and the Tápti. Towards the heart of India the eastern extremities of these two converge in the highlands of the Central Provinces and their lofty level plains. Passing still farther east, the hill system finds a continuation in the Káimur range and its congeners, which eventually end in the outlying peaks and spurs that form the western boundary of Lower Bengal, and abut on the old course of the Ganges under the name of the Rájmahál hills. On the extreme east, Mount Párasnáth—like Mount Abu on the extreme west, sacred to Jain rites—rises to 4400 feet above the level of the Gangetic plains. The various ranges of the Vindhyás, from 1500 to over 4000 feet high, form, as it were, the northern wall and buttresses which support the central table-land. Though now pierced by road and railway, they stood in former times as a barrier of mountain and jungle between northern and southern India, and formed one of the main obstructions to welding the whole into an empire. They consist of vast masses of forests, ridges, and peaks, broken by cultivated valleys and broad high-lying plains.

Gháts.

The other two sides of the elevated southern triangle are known as the Eastern and Western Gháts (Ghauts). These start southwards from the eastern and western extremities of the Vindhyá system, and run along the eastern and western coasts of India. The Eastern Gháts stretch in fragmentary spurs and ranges down the Madras Presidency, here and there receding inland and leaving broad level tracts between their base and the coast. The Western Gháts form the great sea-wall of the Bombay Presidency, with only a narrow strip between them and the shore. In many parts they rise in magnificent precipices and headlands out of the ocean, and truly look like colossal "passes or landing-stairs" (*gháts*) from the sea. The Eastern Gháts have an average elevation of 1500 feet. The Western Gháts ascend more abruptly from the sea to an average height of about 3000 feet, with peaks up to 4700, along the Bombay coast, rising to 7000 and even 8760 in the upheaved angle which they unite to form with the Eastern Gháts, towards their southern extremity.

The inner triangular plateau thus enclosed lies from 1000 to 3000 feet above the level of the sea. But it is dotted with peaks and seamed with ranges exceeding 4000 feet in height. Its best known hills are the Nilgiris (Neilgherries), with the summer capital of Madras, Utakamand, 7000 feet above the sea. The highest point is Dodábetta Peak (8760 feet), at the upheaved southern angle. The interior plateau is approached by several

Western Gháts. famous passes from the level coast-strip on the western side. The Bor-Ghát, for example, ascends a tremendous ravine about 40 miles south-east of Bombay city, to a height of 1798 feet. In ancient times this pass was regarded as the key of the Deccan, and could be held by a small band against any army attempting to penetrate from the coast. A celebrated military road was constructed by the British up the Bor-Ghát, and practically gave the command of the interior to the then rising port of Bombay. A railway line has now been carried up the pass, twisting round the shoulders of mountains, tunnelling through intervening crags, and clinging by a narrow ledge to the face of the precipices. At one point the zigzag is so sharp as to render a circuitous turn impossible, and the trains have to stop and reverse their direction on a levelled terrace. The Thall Ghát, to the north of Bombay, has in like manner been scaled both by road and railway. Another celebrated pass, farther down the coast, connects the military centre of Belgáum with the little port of Vingurla. These "landing-stairs" from the sea to the interior present scenes of rugged grandeur. The trap rocks stand out, after ages of denudation, like circular fortresses flanked by round towers, from the mass of hills behind,—natural fastnesses, which in the Marhattá times were rendered impregnable to Oriental warfare. To the south of Bombay, the passes climb up from the sea through thick forests, the haunt of the tiger and the stately bison. Still farther down the coast, the western mountain wall dips down into the Palghát valley, a remarkable gap, 25 miles broad, and leading by an easy route, only 1500 feet above the sea at its highest point, from the sea-board to the interior. A railway now extends by this passage from Beypur across the peninsula to Madras.

Eastern Gháts. On the eastern side of India, the Gháts form a series of spurs and buttresses for the elevated inner plateau, rather than a continuous mountain wall. They are traversed by a number of broad and easy passages from the Madras coast. Through these openings the rainfall of the southern half of the inner plateau reaches the sea. The drainage from the northern or Vindhyán edge of the three-sided table-land falls into the Ganges. The Narbadá (Nerbudda) and Tápti carry the rainfall of the southern slopes of the Vindhyás and of the Sátpura hills, in almost parallel lines, into the Gulf of Cambay. But from Surat, in 21° 9′ lat., to Cape Comorin, in 8° 4′ lat., no large river succeeds in reaching the western coast from the interior table-land. The Western Gháts form, in fact, a lofty unbroken barrier between the waters of the central plateau and the Indian Ocean. The drainage has therefore to make its way across India to the eastwards, now turning sharply round projecting ranges, now tumbling down ravines, or rushing along the valleys, until the rain which the Bombay sea-breeze has dropped upon the Western Gháts finally falls into the Bay of Bengal.

Rivers of Southern table-land. In this way the three great rivers of the Madras Presidency, viz., the Godávari, the Krishna, and the Káveri (Cauvery), rise in the mountains overhanging the western coast, and traverse the whole breadth of the central table-land before they reach the sea on the eastern shores of India.

The physical geography and the political destiny of the two sides of the Indian peninsula have been determined by the characteristics of the mountain ranges on either coast. On the east, the country is comparatively open, and was everywhere accessible to the spread of civilization. On the east, therefore, the ancient dynasties of southern India fixed their capitals. Along the west, only a narrow strip of lowland intervenes between the barrier range and the seaboard. The inhabitants of those tracts remained apart from the civilization of the eastern coast. To this day one of their ruling races, the Nairs, retain land-tenures and social customs, such as polyandry, which mark a much ruder stage of human advancement than Hinduism, and in other parts of India only linger among isolated hill tribes. On the other hand, the people of the western coast enjoy a bountiful rainfall, unknown in the inner plateau and the east.

Rainfall of southern table-land. The monsoon dashes its rain-laden clouds against the Western Gháts, and pours from 250 to 100 inches of rain upon their maritime slopes from Khándesh down to Malabar. By the time that the monsoon has crossed the Western Gháts, it has dropped the greater part of its aqueous burden, and central districts, such as Bangalore, obtain only about 35 inches. The eastern coast also receives a monsoon of its own; but, except in the neighbourhood of the sea, the rainfall throughout the Madras presidency is scanty, seldom exceeding 40 inches in the year. The deltas of the three great rivers along the Madras coast form, of course, tracts of inexhaustible fertility; and much is done by irrigation on the thirsty inland plateau to husband and utilize both the local rainfall and the accumulated waters which the rivers bring down.

Crops. In the valleys, and upon the elevated plains of the central plateau, tillage has driven back the jungle to the hilly recesses, and fields of rice and many kinds of smaller grain or millets, tobacco, cotton, sugar-cane, and pulses spread over the open country. The black soil of the Deccan is proverbial for its fertility; and the level strip between the Western Gháts and the sea rivals even Lower Bengal in its fruit-bearing palms, rice harvests, and rich succession of crops. The deltas on the eastern side have from time immemorial been celebrated as rice-bearing tracts. The interior of the table-land, as may be inferred from the scanty rainfall, is liable to drought. The people contend against the calamities of nature by varied systems of irrigation,—drawing their water-supply in some districts from wells, in others from tanks and reservoirs, or from large artificial lakes formed by damming up the ends of river valleys. They thus store the rain brought during a few months by the monsoon, and husband it for use throughout the whole year. The food of the common people consists chiefly of small grains, such as *joár*, *bájra*, and *rági*. The great export is cotton, with wheat from the northern districts of Bombay. The pepper trade with Malabar dates far beyond the age of Sindbad the Sailor, and probably reaches back to Roman times. Cardamoms, spices of various sorts, dyes, and many medicinal drugs are also grown.

Minerals. It is on the three-sided table-land, and among the hilly spurs which project from it, that the mineral wealth of India lies hid. Coal-mining now forms a great industry on the north-eastern side of the table-land, in Bengal, and also in the Central Provinces. The commercial aspects of this and similar undertakings will be dealt with in a later section of the present article. Beds of iron-ore and limestone have been worked in several places, and hold out a possibility of a new era of enterprise to India in the future. Many districts are rich in building stone, marbles and the easily worked laterite. Copper and other metals exist in small quantities. Gold dust has from very ancient times been washed out of the river-beds, and gold-mining is being attempted on scientific principles in Madras and Mysore.

Of the three regions of India, now briefly surveyed, the first, or the Himálayas, lies for the most part beyond the British frontier, but a knowledge of it supplies the key to the ethnology and history of India. The second region, or the great river plains in the north, formed the theatre of the ancient race-movements which shaped the civilization and the political destinies of the whole Indian peninsula. The third region, or the triangular table-land in the south, has a character quite distinct from either of the other two divisions, and a population which is now working out a separate development of its own. Broadly speaking, the Himálayas are peopled by Turanian tribes; the great river plains of Hindustán are still the home of the Aryan race; the triangular table-land has formed an arena for a long struggle between that gifted race from the north and what is known as the Dravidian stock in the south.

British Burmah. To this vast empire the English have added British Burmah, consisting of the lower valley of the Irawadi (Irrawaddy) with its delta, and a long flat strip stretching down the eastern side of the Bay of Bengal. Between the narrow maritime tract and the Irawadi runs a backbone of lofty ranges. These ranges, known as the Yoma (Roma) mountains, are covered with dense forests, and both historically and geographically separate the Irawadi valley from the strip of coast. The Yoma (Roma) ranges have peaks exceeding 4000 feet, and culminate in the Blue Mountain (7100 feet). They are crossed by passes, one of which, the An or Aeng, rises to 4668 feet above the sea-level. A thousand creeks indent the seaboard; and the whole of the level country, both on the coast and in the Irawadi valley, forms one vast rice-field. The river floats down an abundant supply of teak and bamboos from the north. Tobacco, of an excellent quality, supplies the little cigars which all Burmese (men, women, and children) smoke. Arakan and Pegu, or the provinces of the coast strip and the Irawadi valley, contain mineral oil-springs. Tenasserim forms a long narrow maritime province, which runs from the mouths of the Irawadi southward to Point Victoria, where the British territory adjoins Siam. It is rich in tin mines, and contains iron-ores equal to the finest Swedish, besides gold and copper in smaller quantities, and a very pure limestone. Rice and timber form the staple exports of Burmah; and rice is also the universal food of the people. British Burmah, with Tenasserim, has an area of 88,556 square miles, and had a population, in 1876, of just under 3 millions of persons.

Geology.

For geological purposes India may be mapped out into the three geographical divisions of the Himálayan region, the Indo-Gangetic plain, and Peninsular India.

Himálayas.

The Himálayan Region.—The geology of this district is far more complex and less fully known than that of the Peninsular area. Until the ground has been carefully gone over by the Geological Survey, many points must remain doubtful; probably even then the problems will not be fully solved, as large areas of the Himálayas (Nepál and Bhután) are at present inaccessible to Europeans. The oldest rock of the Himálayas is gneiss, but its age is quite unknown. It generally differs in character from the gneiss of the Peninsula, and also from that of Assam and Burmah. The Himálayan gneiss is usually white and grey, its felspars being orthoclase and albite; it contains much mica and mica schist, and is generally much more uniform in character than the gneiss of the Peninsula. The latter is usually pink, its felspar being orthoclase and oligoclase; it contains little mica schist, but often has quartzite and hornblendic rock. Hornblende occurs in the syenitic gneiss of the Northern Himálayan (or Ladákh) range. The Central Himálayan region may be roughly described as consisting of two gneissic axes, with a trough or synclinal valley between them, in which fossiliferous beds have been deposited and are now preserved. The gneiss of the southern or main axis (the "central gneiss" of Dr Stoliczka) is the oldest; that of the northern or Ladákh axis comes next in age. The gneiss of the Ladákh axis is generally syenitic, or is that variety of the Himálayan gneiss already described as containing hornblende. It is probably an extremely altered condition of ordinary marine sediment. The gneiss of the central axis is the ordinary kind; it is penetrated by granite, which ranges along some of the highest peaks. Between these two gneissic axes occurs the basin-shaped valley, or the Hundes and Zanskar synclinal. In this valley fossiliferous rocks are preserved, giving representatives of the Silurian, Carboniferous, Triassic, Jurassic, and Cretaceous formations. All these seem there to have followed each other without important breaks or unconformities; but after the deposition of the Cretaceous rocks of the Himálayan region, there appear to have been important changes in physical geography. The Nummulitic (Eocene) strata were laid down on the eroded edges of some of the older beds, and in a long trough within the Silurian gneiss of the Ladákh axis. On the south of this true Himálayan region there is a band of country known as the Lower Himálaya, in which the beds are often greatly disturbed, and even completely inverted, over great areas, the old gneiss apparently overlying the sedimentary rocks. This Lower Himálayan region is about 50 miles wide, and consists of irregular ridges, varying from 5000 to 8000 feet in height, and sometimes reaching 12,000 feet.

Lower Himálayas.

Resting upon the gneiss, but often through inversion apparently underlying it, in the neighbourhood of Simla, is a series of unfossiliferous beds (schists, quartzites, sandstones, shales, limestones, &c.) known in descending order as the Król, Infra-Król, Blaini, and Infra-Blaini beds. In the Król beds is a massive limestone (Król limestone) probably representing the limestone of the Pir Panjál range, which is most likely of Carboniferous age. The Blaini and Infra-Blaini beds are probably Silurian. The Lower Himálayan range ends at the Sutlej valley, west of which the continuation of the central range is followed immediately by the third or Sub-Himálayan range. This occurs almost always on the south of the Lower Himálayas; it is composed of later Tertiary rocks (Siwáliks, &c.), which range parallel with the main chain. Generally the Sub-Himálayas consist of two ranges, separated by a broad flat valley ("dún" or "doon"); the southern slope, overlooking the great Indo-Gangetic plain, is usually the steepest. Below Náini Tál and Dárjíling (Darjeeling), the sub-Himálayan range is wanting; on the Bhután frontier the whole range is occasionally absent, and then the great plain slopes up to the base of the Lower Himálayan region. It is within the Sub-Himálayan range that the famous Siwálik beds occur, long since known for their vast stores of extinct mammalia. Of about the same age are the Manchhar beds of Sind, which also contain a rich mammalian fauna. The Lower Manchhars probably correspond to the Náhan beds, the lowest of the Siwáliks; they rest upon the Gaj beds, which are probably Upper Miocene. From this it would seem that the lowest Siwáliks are not older than Upper Miocene. The higher Siwálik beds are considered by Mr W. T. Blanford to be Pliocene, and to this later period he also refers the mammalian beds of Pikermi in Greece. These have a large number of fossils in common with the Siwáliks; but they contain, at their base, a marine band with Pliocene shells. The Manchhar and Siwálik beds are chiefly of freshwater origin.

Sub-Himálayas.

Siwáliks.

Salt Range.

The Salt Range in the north-west of the Punjab has, in addition to its economic value, a special geological importance; and from that point of view it is one of the most interesting districts in India. Representatives of most of the great European formations of Silurian and later epochs are found there; and throughout all the vast length of time represented by these formations there is here no direct evidence of any important break in succession, or unconformity. The lowest beds (salt marl, probably Silurian) and the highest (Siwáliks) are found throughout the range. But the others cannot all be traced continuously throughout; some occur well developed in one place, some in another. All the principal fossiliferous beds of the Jurassic, Triassic, and Carboniferous formations are confined to the western part of the range.

Indo-Gangetic Plain.

The *Indo-Gangetic Plain* covers an area of about 300,000 square miles, and varies in width from 90 to nearly 300 miles. It rises very gradually from the sea at either end; the lowest point of the watershed between the Punjab rivers and the Ganges is about 924 feet above the sea. This point, by a line measured down the valley, but not following the winding of the river, is about 1050 miles from the mouth of the Ganges and 850 miles from the mouth of the Indus, so that the average inclination of the plain, from the central watershed to the sea, is only about 1 foot per mile. It is less near the sea, where for long distances there is no fall at all. It is generally more near the watershed; but there is here no ridge of high ground between the Indus and the Ganges, and a very trifling change of level would often turn the upper waters of one river into the other. It is not unlikely that such changes have in past time occurred; and if so an explanation is afforded of the occurrence of allied forms of freshwater dolphins (*Platanista*) and of many other animals in the two rivers and in the Brahmaputra.

Its age. There is no evidence that the Indo-Gangetic plain existed as such in Pre-Tertiary times. It is highly probable that the Jurassic and Cretaceous coast-line ran across the northern part of the Bay of Bengal, and that most of the area now occupied by the Gangetic plain was then above the sea. Probably the Jurassic traps of the Rájmahál hills, west of the delta of the Ganges, were continuous with those of Sylhet, east of the delta. Marine Jurassic and Cretaceous beds are absent from the margins of the true Gangetic plain; so too are marine Eocene beds. In Eocene times the sea spread up the Punjab; but that too was land only in Miocene times.

Alluvial deposits. The alluvial deposits of the plain, as made known by the boring at Calcutta, prove a gradual depression of the area through the later Tertiary times. There are peat and forest beds, which must have grown quietly at the surface, alternating with deposits of gravel, sand, and clay. The thickness of the delta deposit is unknown; 481 feet was proved at the bore hole, but probably this represents only a very small part of the deposit. Outside the delta, in the Bay of Bengal, is a deep depression known as the "swatch of no ground"; all around it the soundings are only of 5 to 10 fathoms, but they very rapidly deepen to over 300 fathoms. Mr J. Ferguson has shown that the sediment is carried away from this area by the set of the currents; probably then it has remained free from sediment whilst the neighbouring sea bottom has gradually been filled up. If so, the thickness of the alluvium is at least 1800 feet, and may be much more.

The Indo-Gangetic plain dates back to Eocene times; the origin of the Himálayas may be referred to the same period. Numerous minor disturbances occurred in the area which is now northern India during Palæozoic and Secondary times, but the great disturbance which has resulted in the formation of the existing chain of the Himálayas took place after the deposition of the Eocene beds. Disturbances even greater in amount occurred after the deposition of the Pliocene beds. The Eocenes of the Sub-Himálayan range were deposited upon uncontorted Palæozoic rocks, but the whole has since been violently contorted and disturbed. There are some indications that the disturbing forces were more severe to the eastward during middle Tertiary times, and that the main action to the westward was of later date. It seems highly probable that the elevation of the mountain ranges and the depression of the Indo-Gangetic plain were closely related. This view gains some support from a glance at the map, where we see that the curves of the great mountain chains are strictly followed by those of the great alluvial plain. Probably both are due to almost contemporary movements of the earth's crust; these movements, though now of vastly diminished intensity, have not wholly ceased. The alluvial deposits prove depression in quite recent geological times; and within the Himálayan region earthquakes are still common, whilst in Peninsular India they are rare.

Peninsular India.—The oldest rocks of this area consist of gneiss, which occurs in three districts:—a very large part of Bengal and Madras, extending to Ceylon; the Aravalli; and Bundelkhand. Of these formations, the gneiss of Bundelkhand is known to be the oldest, because the oldest Transition rocks rest upon it; whereas the same Transition rocks are altered and intersected by granitic dykes which proceed from the gneiss of the other districts. The Transition rocks are of great but unknown age. The Vindhyan rocks which succeed them are of very old Palæozoic age, perhaps Pre-Silurian. But long before the earliest Vindhyan rocks were laid down the Transition rocks had been altered and contorted. The great movements of the earth's crust which produced that contortion are the latest which have taken place to any great extent in the Indian Peninsula. In more recent times there have been local disturbances, and large faults have in places been found; but the greater part of the Peninsula rocks are only slightly disturbed, and the most recent of the great and wide-spread earth movements of this region date back to Pre-Vindhyan times. The Vindhyan series are generally sharply marked off from older rocks; but in the Godávari valley there is no well-defined line between these and the Transition rocks. The Vindhyan beds are divided into two groups. The lower, with an estimated thickness of only 2000 feet, or slightly more, cover a large area,—extending, with but little change of character, from the Son valley in one direction to Cuddapah, and in a diverging line to near Bijápur—in each case a distance of over 700 miles. The upper Vindhyans cover a much smaller area, but attain a thickness of about 12,000 feet. The Vindhyans are well stratified beds of sandstone and shale, with some limestones. As yet they have yielded no trace of fossils, and their exact age is consequently unknown. So far as the evidence goes, it appears probable that they are of very ancient Palæozoic age, perhaps Pre-Silurian. The total absence of fossils is a remarkable fact, and one for which it is difficult to account, as the beds are for the most part quite unaltered. Even if they are entirely of freshwater origin, we should expect that some traces of life from the waters or neighbouring land would be found.

Pen[insu]lar [gneiss]. Vin[dhyan] rock[s].

Gondwána series. The Gondwána series is in many respects the most interesting and important series of the Indian Peninsula. The beds are almost entirely of freshwater origin. Many subdivisions have been made, but here we need only note the main division into two great groups:—Lower Gondwánas, 13,000 feet thick; Upper Gondwánas, 11,000 feet thick. The series is mainly confined to the area of country between the Narbadá and the Son on the north and the Krishna on the south; but the western part of this region is in great part covered by newer beds. The lowest Gondwánas are very constant in character, wherever they are found; the upper numbers of the lower division show more variation, and this divergence of character in different districts becomes more marked in the Upper Gondwána series. Disturbances have occurred in the lower series before the formation of the upper.

The Gondwána beds contain fossils which are of very great interest. In large part these consist of plants which grew near the margins of the old rivers, and which were carried down by floods, and deposited in the alluvial plains, deltas, and estuarine areas of the old Gondwána period. So vast was the time occupied by the deposition of the Gondwána beds that great changes in physical geography and in the vegetation repeatedly occurred. The plants of the Lower Gondwánas consist chiefly of acrogens (*Equisetaceæ* and ferns) and gymnogens (cycads and conifers), the former being the more abundant. The same classes of plants occur in the Upper Gondwánas; but there the proportions are reversed, the conifers, and still more the cycads, being more numerous than the ferns, whilst the *Equisetaceæ* are but sparingly found. But even within the limits of the Lower Gondwána series there are great diversities of vegetation, three distinct floras occurring in the three great divisions of that formation. In many respects the flora of the highest of these three divisions (the Pánchet group) is more nearly related to that of the Upper Gondwánas than it is to the other Lower Gondwána floras.

One of the most interesting facts in the history of the Gondwána series is the occurrence near the base (in the Tálcher group) of large striated boulders in a fine mud or silt, the boulders in one place resting upon rock (of Vindhyan age) which is also striated. There seems good reason for believing that these beds are the result of ice-action. They probably nearly coincide in age with the Permian beds of Western Europe, in which Professor Ramsay long since discovered evidence of glaciation. But the remarkable fact is that this old ice-action occurred within the tropics, and probably at no very great height above the sea.

The Dámodar series, the middle division of the Lower Gondwánas, is the chief source of coal in Peninsular India, yielding more of that mineral than all other formations taken together. The Karharbári group is the only other coal-bearing formation of any value. The Dámodars are 8400 feet thick in the Rániganj coal-field, and about 10,000 feet thick in the Sátpura basin. They consist of three divisions; coal occurs in the upper and lower, ironstone (without coal) in the middle division. The Ránîganj coal-field is the most important in India. So far as is yet known, it covers an area of about 500 square miles, extending about 18 miles from north to south and about 39 miles from east to west; but it extends further to the east under the laterite and alluvium. It is traversed by the Dámodar river, along which run the road from Calcutta to Benares and the East Indian Railway. From its situation and importance this coal-field is better known than any other in India. Much has been learnt concerning it since the last examination by the Geological Survey, and our remarks are in great part based on recent reports by Mr H. Bauerman. The upper or Ránîganj series (stated by the Geological Survey to be 5000 feet thick) contains eleven seams, having a total thickness of 120 feet, in the eastern district, and thirteen seams, 100 feet thick, in the western district. The average thickness of the seams worked is from 12 to 18 feet, but occasionally a seam acquires a great thickness—20 to 80 feet. The lower or Barákhar series (2000 feet thick) contains four seams, of a total thickness of 69 feet. Compared with English coals those of this coal-field are of but poor quality; they contain much ash, and are generally non-coking. The seams of the lower series are the best, and some of these at Sánktoria, near the Barákhar river, are fairly good for coke and gas. The best coal in India is in the small coal-field at Karharbári. The beds there are lower in the series than those of the Ránîganj field; they belong to the upper part of the Tálcher group, the lowest of the Gondwána series. The coal-bearing beds cover an area of only about 11 square miles; there are three seams, varying from 9 to 33 feet thick. The lowest seam is the best, and this is as good as English steam coal. This coalfield, now largely worked, is the property of the East Indian Railway, which is thus supplied with fuel at a cheaper rate than any other railway in the world. Indian coal usually contains phosphoric acid; which greatly lessens its value for iron-smelting.

The Dámodar series, which, as we have seen, is the chief source of coal in India, is also one of the most important sources of iron. The ore occurs in the middle division, coal in the highest and lowest. The ore is partly a clay ironstone, like that occurring in the Coal-measures of England, partly an oxide of iron or hæmatite. It generally contains phosphorus, which prevents its use in the preparation of the finer qualities of steel. A similar difficulty attends the use of the Cleveland ore of North Yorkshire. Experiments have been in progress for years in search of a process which shall, in an economical manner, obtain iron from Cleveland ore free from phosphorus, latterly, it is hoped, with some success. If this be so, India will be a great gainer. Excellent iron-ore occurs in the Metamorphic rocks south of the Dámodar river. Laterite (see below) is sometimes used as ore. It is very earthy and of a low percentage; but it contains only a comparatively small proportion of phosphorus.

The want of limestone for flux, within easy reach, is generally a great drawback as regards iron-smelting in India. *Kankar* or *ghutin* (concretionary carbonate of lime) is collected for this purpose from the river beds and alluvial deposits. It sometimes contains as much as 70 per cent. of carbonate of lime; but generally the amount is much less and the fluxing value proportionally diminished. The real difficulty in India is to find the ore, the fuel, and the flux in sufficiently close proximity to yield a profit.

Deccan trap. The enormous mass of basaltic rock known as the Deccan trap is of great importance in the geological structure of the Indian Peninsula. It now covers an area of about 200,000 square miles, and probably formerly extended over a much wider area. Where thickest, the traps are at least 6000 feet thick. They form the most striking physical features of the country, many of the most prominent hill ranges being the denuded edges of the basaltic flows. The great volcanic outbursts which produced this trap commenced in the Cretaceous period and lasted on into the Eocene period.

Laterite. Laterite is a ferruginous and argillaceous rock, varying from 30 to 200 feet thick, which often occurs over the trap area, but is also found in other districts. As a rule it makes rather barren land; it is highly porous, and the rain rapidly sinks into it. Laterite may be roughly divided into two kinds, high-level and low-level laterites. The former, which covers a large area of the high basaltic plains, is believed by Mr R. B. Foote to be very frequently the product of decomposition of the trap, and to have been thus formed in the place in which it is now found. Sometimes the high-level laterite overlies gneiss or other rocks; and in these cases it has probably been transported. The low-level laterite is generally more sandy in character, and is often associated with gravels. In most cases this has clearly been carried down to its present position, probably largely by subaerial action, aided by rains and streams. Possibly in some cases it has been spread out along the coasts by marine action. The low-level laterite fringes the coast of the Peninsular more or less from near Bombay on the west and Orissa on the east to Cape Comorin. It is not continuous throughout these districts; and it is of very varying width and elevation. The age of the high-level laterite is unknown. Its formation probably extended throughout a long period of time, much of which must be of very ancient date; for the laterite, together with the underlying basalt, has suffered extensive denudation.

The mercantile aspects of the coal, iron, and other mineral products of India will be fully treated of under a subsequent section (pp. 764-66). The geologist comes in this matter to the same conclusion as the economist, viz., that the mineral wealth of India, as represented by its precious stones, was the product of forced labour, and that the search for them in our days can scarcely repay the working expenses.

[For the above section on Geology we are indebted to Mr W. Topley of the English Geological Survey.]

Meteorology.

Meteorology. The great peninsula of India, with its lofty mountain ranges behind and its extensive seaboard exposed to the first violence of the winds of two oceans, forms an exceptionally valuable and interesting field for the study of meteorological phenomena. But only within the last few years have trustworthy statistics been obtained for some of its most important registration stations.

Meteorological Geography.—After the general description of the country which has been given at the beginning of this article, it is only necessary here to sketch very briefly the meteorological geography of the peninsula. The following sentences are condensed from an interesting account in the first *Report on the Meteorology of India* (for 1875), by Mr H. F. Blanford. From the gorge of the Indus to that of the Dihong (Brahmaputra), a distance of 1400 miles, the Himálayas form an unbroken watershed, the northern flank of which is drained by the upper valleys of these two rivers; while the Sutlej (Satlaj), starting from the southern foot of the Kailas Peak, breaks through the watershed, dividing it into two very unequal portions, that to the north-west being the smaller. The average elevation of the Himálaya crest may be taken at not less than 19,000 feet, and therefore equal to the height of the lower half of the atmosphere; and indeed few of the passes are under 16,000 or 17,000 feet. Across this mountain barrier there appears to be a constant flow of air, more active in the day-time than at night, northwards to the arid plateau of Tibet. There is no reason to believe that any transfer of air takes place across the Himálayas in a southerly direction, unless, indeed, in those most elevated regions of the atmosphere which lie beyond the range of observation; but a nocturnal flow of cooled air, from the southern slopes, is felt as a strong wind where the rivers debouch on the plains, more especially in the early morning hours; and this probably contributes in some degree to lower the mean temperature of that belt of the plains which fringes the mountain zone.

Himálayas.

Indus plain. At the foot of the great mountain barrier, and separating it from the more ancient land which now forms the highlands of the peninsula, a broad plain, for the most part alluvial, stretches from sea to sea. On the west, in the dry region, this is occupied partly by the alluvial deposits of the Indus and its tributaries and the saline swamps of Kahhch (Cutch), partly by the rolling sands and rocky surface of the desert of Jáisalmír and Bíkanir, and the more fertile tracts to the eastward watered by the Lúnai. Over the greater part of this region rain is of rare occurrence; and not infrequently more than a year passes without a drop falling on the parched surface. On its eastern margin, however, in the neighbourhood of the Aravalli hills, and again on the northern Punjab, rain is more frequent, occurring both in the south-west monsoon, and also at the opposite season in the cold weather. As far south as Sírsa and Múltán (Mooltan), the average rainfall does not much exceed 7 inches.

Gangetic plain. The alluvial plain of the Punjab passes into that of the Gangetic valley without visible interruption. Up or down this plain, at opposite seasons, sweep the monsoon winds, in a direction at right angles to that of their nominal course; and thus vapour which has been brought by winds from the Bay of Bengal is discharged as snow and rain on the peaks and hillsides of the Western Himálayas. Nearly the whole surface is under cultivation, and it ranks among the most productive as well as the most densely populated regions of the world. The rainfall diminishes from 100 inches in the south-east corner of the Gangetic delta to less than 30 inches at Agra and Delhi, and there is an average difference of from 15 to 25 inches between the northern and southern borders of the plain.

Eastern Bengal. Eastward from the Bengal delta, two alluvial plains stretch up between the hills which connect the Himálayan system with that of the Burmese peninsula. The first, or the valley of Assam and the Brahmaputra, is long and narrow, bordered on the north by the Himálayas, on the south by the lower plateau of the Gáro, Khásí, and Nágá hills. The other, short and broad, and in great part occupied by swamps and *jhils*, separates the Gáro, Khásí, and Nágá hills from those of Tipperah and the Lusháí country. The climate of these plains is damp and equable, and the rainfall is prolonged and generally heavy, especially on the southern slopes of the hills. A meteorological peculiarity of some interest has been noticed, more especially at the stations of Síbságar and Silchár, viz., the great range of the diurnal variation of barometric pressure during the afternoon hours,—which is the more striking, since at Rúrkí (Roorkee), Lahore, and other stations near the foot of the Western Himálayas, this range is less than in the open plains.

Central tableland. The highlands of the peninsula, which are cut off from the encircling ranges by the broad Indo-Gangetic plain, are divided into two unequal parts, by an almost continuous chain of hills running across the country from west by south to east by north, just south of the Tropic of Cancer. This chain may be regarded as a single geographical feature, forming one of the principal watersheds of the peninsula, the waters to the north draining chiefly into the Narbadá and the Ganges, those to the south into the Tápti, the Godávari, the Mahánadi, and some smaller streams. In a meteorological point of view it is of considerable importance. Together with the two parallel valleys of the Narbadá (Nerbudda) and Tápti (Taptee), which drain the flanks of its western half, it gives, at opposite seasons of the year, a decided easterly and westerly direction to the winds of this part of India, and condenses a tolerably copious rainfall during the south-west monsoon.

Separated from this chain by the valley of the Narbadá on the west, and that of the Son on the east, the plateau of Málwá and Baghelkhand occupies the space intervening between these valleys and the Gangetic plain. On the western edge of the plateau are the Aravalli hills, which run from near Ahmadábád up to the neighbourhood of Delhi, and include one hill, Mount Abu, over 5000 feet in height. This range exerts an important influence on the direction of the wind, and also on the rainfall. At Ajmír (Ajmere), an old meteorological station at the eastern foot of the range, the wind is predominantly south-west, and there and at Mount Abu the south-west monsoon rains are a regularly recurrent phenomenon,—which can hardly be said of the region of scanty and uncertain rainfall that extends from the western foot of the range and merges in the Bíkanir desert.

Southern plateau. The peninsula south of the Sátpura range consists chiefly of the triangular plateau of the Deccan, terminating abruptly on the west in the Sahyádri range (Western Gháts), and shelving to the east (Eastern Gháts). This plateau is swept by the south-west monsoon, but not until it has surmounted the western barrier of the Gháts; and hence the rainfall is, as a rule, light at Poona and places similarly situated under the lee of the range, and but moderate over the more easterly parts of the plateau. The rains, however, are prolonged some three or four weeks later than in tracts to the north of the Sátpuras, since they are also brought by the easterly winds which blow from the Bay of Bengal in October and the early part of November, when the recurved southerly wind ceases to blow up the Gangetic valley, and sets towards the south-east coast. This was formerly thought to be a north-east monsoon, and is still so spoken of by certain writers; but the rainy wind is really a diversion of the south-west monsoon.

At the junction of the Eastern and Western Gháts rises the bold triangular plateau of the Nílgiris, and to the south of them come the Anamalais, the Palnis (Pulneys), and the hills of Travancore. These ranges are separated from the Nílgiris by a broad depression or pass known as the Pálghát Gap, some 25 miles wide, the highest point of which is only 1500 feet above the sea. This gap affords a passage to the winds which elsewhere are barred by the hills of the Ghát chain. The country to the east of the gap receives the rainfall of the south-west monsoon; and during the north-east monsoon ships passing Beypur meet with a stronger wind from the land than is felt elsewhere on the Malabar coast. According to Captain Newbold, this gap "affords an outlet to those furious storms from the eastward which sweep the Bay of Bengal, and, after traversing the peninsula, burst forth through it to the neighbouring sea."

In the strip of low country that fringes the peninsula below the Gháts, the rainfall is heavy and the climate warm and damp, the vegetation being dense and characteristically tropical, and the steep slopes of the Gháts, where they have not been artificially cleared, thickly clothed with forest.

In Burmah, the country around Ava, as well as the hill country to the north, has suffered from severe earthquakes, one of which destroyed Ava in 1839. The general meridianal direction of the ranges and valleys determines the direction of the prevailing surface winds, this being, however, subject to many local modifications. But it would appear, from Dr Anderson's observations of the movement of the upper clouds, that throughout the year there is, with but slight interruption, a steady upper current from the south-west, such as has been already noticed over the Himálayas. The rainfall in the lower part of the Irawadi valley, viz., the delta and the neighbouring part of the province of Pegu, is very heavy; and the climate is very mild and equable at all seasons. But higher up the valley, and especially north of the Pegu frontier, the country is drier, and is characterized by a less luxuriant vegetation, and a retarded and more scanty rainfall.

Observatories.—Meteorological observatories have been established at one hundred and three stations in India (including British Burmah and the Andamans). These observatories are situated at all elevations, from the highest, Leh (11,538 feet above mean sea-level) and Chakráta (7051 feet), to Negapatam (15 feet) and Ságar Island, the lowest, which is only 6 feet above mean sea-level.

Temperature of the Air.—From the average annual mean temperatures of 83 stations (derived from the means of three or more years) the following figures are taken. In the following four stations in this list, the average mean yearly temperature was over 82° F.:—Trichinopoli, 82·8°; Vizagapatam, 82·7°; Madras, 82·4°; and Madura, 82·2.° All of these stations are in the Madras Presidency. The next highest means are returned by Negapatam (also in Madras), 81·9°; Cuttack and Port Blair, each 80·5°; False Point, 80·20°; Goa, 79·9°; Cochin, 79·8°; Ságar Island, 79·5°; Deesa, 79·4°; and Calcutta, 79·2°. The mean annual temperature of Bombay is 78·8°, so that it is the coolest of the three presidency towns. The lowest means are obtained at the hill stations of Dárjíling, 53·9°; Simla, 54·4°; Murree, 55·8°; and Chakráta, 56·1°. Between these and the next coolest stations is a great gap, Ráníkhet following with 60·4°, Pachmarhi with 68·7°, and Ráwal Pindí with a yearly mean of 69·4°. The highest mean monthly temperatures given are:—95° at Múltán, in June; 94·3° at Delhi, in June; 94·1° at Jhánsi, in May; 93·6° at Lucknow, in June. The lowest monthly means are returned by the four coldest hill stations mentioned above, the figures being:—Murree—January 37·7°, February 39·4°; Simla—January 39·6°, February 41·1°; Chakráta—January 40·8°, February 42·9°; Dárjíling—January 40·7°, February 43·2°. The mean temperature at Leh in January is 17·6°, and in December 24·4°.

Atmospheric Pressure.—The meteorological report for 1877 contains a table showing the annual mean pressure at 72 stations, corrected (except in the case of Madras) to the Calcutta standard, which reads 0·011 inch higher than that of Kew. From that table the following figures are obtained. The mean yearly pressure at the highest stations is—23·274 at Chakráta, 23·371 at Dárjíling, 24·058 at Ráníkhet, 26·416 at Pachmarhi, and 26·932 at Bangalore. The greatest annual mean pressures returned are—29·862 at Negapatam, 29·856 at Madras, 29·822 at Bombay, and 29·821 at False Point.

Rainfall.—The average annual rainfall at 294 stations is recorded in the 1877 meteorological report, from which the following figures have been obtained:— Rainfall.

In the Punjab the highest average fall (123·21 inches) is at Dharmsála, which is situated on the face of the hills, and exposed to the full force of the monsoon; the next highest recorded is little more than half that amount, or 68·61 inches at Simla. The lowest average falls in the Punjab are—6·16 inches at Muzaffargarh, 6·93 at Múltán, 7·35 at Derá Ghází Khán, and 8·23 at Derá Ismáil Khán. All these stations are protected by the Suláimán range from the monsoon.

In Rájputána and Central India the maximum average is 20·27 at Jáipur (Jeypore), and the minimum, 60·85 at Mount Abu, the highest point in this part of India.

In the North-Western Provinces the heaviest average falls are at Náini Tál (94·17 inches) and Dehra (70·06), both of which lie high; the minimum average fall is 24·32 at Alígarh, the next lowest figures being 26·18 at Muttra (Mathura), 26·46 at Agra, and 26·74 at Etah—all stations on the plains.

In Oudh the maximum rainfall is at Sultánpur, 46·72 inches; and the minimum at Rái Bareli, 39·99 inches.

The following stations of Bengal have an average rainfall of more than 100 inches:—Jalpáiguri, 122·16; Dárjíling, 119·25; and Kuch Behár, 119·05—all at the base of the hills; Noákhálí, 107·52, and Chittagong, 105·61, both on the north-east coast of the Bay of Bengal. The lowest averages are returned by Chapra, 37·06 inches; Patná, 38·21; and Gáyá, 41·38. The average rainfall for Bengal is 67 inches.

Assam possesses in Cherra Poonjee (Chárá Punji) the station with the largest recorded rainfall in the world. The registered fall during the three years ending 1876 averaged 368·41 inches. A total fall of 805 inches was reported in 1861, of which 366 were assigned to the single month of July. In 1850 Dr Hooker registered 30 inches in twenty-four hours, and returned the fall from June to November of that year at 530 inches. In the four days 9th to 12th September 1877, 56·19 inches were registered. The following stations in Assam have also a very high rainfall:—Silchár, 121·07; Sylhet, 153·80; Dibrugarh, 116·43; and Tura, 115·76. The lowest recorded averages in Assam are at Samaguting (52·58 inches) and Gauháti (69·23 inches), both on the northern side of the hills separating Cachar from Assam.

In the Central Provinces the highest average falls are at Pachmarhi (82·20 inches) and Bálághát (64·11 inches); lowest averages, Khandwa, 32·26 inches, and Bednúr, 41·21 inches.

In Bombay, three stations on the Gháts are recorded as having an average rainfall of over 250 inches, viz.:—Matheran, 256·75 inches; Malcolmpet (Mahábleshwar), 252·25; and Baura (Fort), 251·80. The lowest average rainfalls recorded in Bombay are—12·99 inches at Mandargi; 17·25 at Dhulia; and 19·93 at Gokak. The average rainfall for Bombay is 67 inches.

In Sind the average rainfall is very low, varying from 16·31 inches at Nagar, and 11·78 at Umarkot, to 5·09 at Shikárpur, and 4·28 at Jacobábád.

In Madras the highest averages recorded are—135·60 inches at Cannanore; 131·91 at Mangalore; 125·63 at Tellicherri; 113·62 at Calicut; and 112·15 at Cochin—all on the west coast. The lowest falls recorded are—at Bellary, 16·06; Tuticorin (sheltered by the Gháts), 18·50; Guti (Gooty), 20·85; and Coimbatore, 20·90. All these stations lie low. The average fall at the stations on the east coast is about 41 inches. The average rainfall for Madras is 44 inches.

The rainfall along the coast of British Burmah is heavy, as might be expected, the following averages being recorded:—Sandoway, 218·58 inches; Tavoy, 195·47; Maulmain, 191·34; Akyab, 189·23; Khyouk-hpyu, 170·76. The smallest rainfall is at Thayet-myo (51·04) and Prome (59·46), sheltered by the Yoma range.

The rainfall at Port Blair, in the Andamans, is also naturally heavy, the average being returned as 116·25 inches.

Sun-spot Cycles.—The conclusions arrived at by the Indian meteorological department on the subject of the sun-spot cycles, which have been engaging the attention of scientific men, are thus summed up in the 1877 report:—"In conclusion, the following are the more important inferences that the meteorology of India in the years 1877 and 1878 appear to suggest, if not to establish. There is a tendency at the minimum sun-spot periods to prolonged excessive pressure over India, to an unusual development of the winter rains, and to the occurrence of abnormally heavy snowfall over the Himálayan region (to a greater extent probably in the western than the eastern Himálayas). This appears also to be usually accompanied by a weak Sun-spot cycles and rainfall.

south-west monsoon. The characteristics of a weak monsoon are—great irregularity in the distribution of the rainfall over the whole of India, and the occurrence of heavy local rainfalls, which tend, by a law of rainfall and of air-motion, to recur over the same limited areas. The irregularity of rainfall distribution is often shown by the persistent and prolonged absence of rain over considerable areas. These areas of drought and famine are partly marked off by nature, depending to a certain extent on the geographical features and position of the district. Thus the rains are more likely to fall below the amount necessary for cultivation in the dry region of the Deccan or in Upper India, than over the Malabar coast area or the province of Bengal."

Flora.

Flora.

Unlike many other large geographical areas, India is remarkable for having no distinctive botanical features peculiar to itself. It differs conspicuously in this respect from such countries as Australia or South Africa. Its vegetation is in point of fact of a composite character, and is constituted by the meeting and more or less blending of adjoining floras,—of those of Persia and the south-eastern Mediterranean area to the north-west, of Siberia to the north, of China to the east, and of Malaya to the south-east.

Our space does not admit of any minute discussion of the local features peculiar to separate districts, but regarded broadly, four tolerably distinct types present themselves.

Himálayas.

Himálayan.—The base of the Himálayas is occupied by a narrow belt forming an extreme north-western extension of the Malayan type described below. Above that there is a rich temperate flora which in the eastern chain may be regarded as forming an extension of that of northern China, gradually assuming westwards more and more of a European facies. *Magnolia*, *Aucuba*, *Abelia*, and *Skimmia* may be mentioned as examples of Chinese genera found in the eastern Himálayas, and the tea-tree grows wild in Assam. The same coniferous trees are common to both parts of the range. *Pinus longifolia* extends to the Hindu-Kush; *P. excelsa* is found universally except in Sikkim, and has its European analogue in *P. Peuce*, found in the mountains of Greece. *Abies smithiana* extends into Afghánistán; *Abies webbiana* forms dense forests at altitudes of 8000 to 12,000 feet, and ranges from Bhután to Kashmír; several junipers and the common yew (*Taxus baccata*) also occur. The deodar (*Cedrus Deodara*), which is indigenous to the mountains of Afghánistán and the north-west Himálaya, is nearly allied to the Atlantic cedar and to the cedar of Lebanon, a form of which has recently been found in Cyprus. A notable further instance of the connexion of the western Himálayan flora with that of Europe is the holm oak (*Quercus Ilex*), which is characteristic of the Mediterranean region.

The upper levels of the Himálayas slope northwards gradually to the Tibetan uplands, over which the Siberian temperate vegetation ranges. This is part of the great temperate flora which, with locally individualized species, but often with identical genera, ranges over the whole of the temperate zone of the northern hemisphere. In the western Himálayas this upland flora is marked by a strong admixture of European species, such as the columbine (*Aquilegia*) and hawthorn (*Cratægus Oxyacantha*). These disappear rapidly eastward, and are scarcely found beyond Kumáun.

North-west.

North-Western.—This is best marked in Sind and the Punjab, where the climate is very dry (the rainfall averaging less than 15 inches), and where the soil, though fertile, is wholly dependent on irrigation for its cultivation. The flora is a poor one in number of species, and is essentially identical with that of Persia, southern Arabia, and Egypt. The low scattered jungle contains such characteristic species as *Capparis aphylla*, *Acacia arabica* (babúl), *Populus euphratica* (the "willows" of Ps. cxxxvii. 2), *Salvadora persica* (erroneously identified by Royle with the mustard of Matt. xiii. 31), tamarisk, *Zizyphus*, *Lotus*, &c. More than nine-tenths of the Sind vegetation is estimated to be indigenous to Africa. The dry flora extends somewhat in a south-east direction, and then blends insensibly with that of the western peninsula; some species representing it are found in the upper Gangetic plain, and a few are widely distributed in dry parts of the country.

Ass and Ma pen sul.

Malayan.—This Sir Joseph Hooker describes as forming "the bulk of the flora of the perennially humid regions of India, as of the whole Malayan peninsula, the Upper Assam valley, the Khásí mountains, the forests of the base of the Himálaya from the Brahmaputra to Nepál, of the Malabar coast, and of Ceylon." It is not of course intended that over this wide and disjointed area there is an actual identity of species; but the affinities and general agreement of facies are sufficiently close to leave no doubt that they belong essentially to one and the same flora. A few illustrations must suffice:—pitcher-plants (*Nepenthes*), so richly developed in Borneo, occur at Singapore, on the Khásí mountains, and in Ceylon, while they are absent from the western peninsula; wood-oil trees (*Dipterocarpeæ*), which abound in the forests of the Malayan archipelago, are well represented by species individualized by isolation in the Malayan peninsula, Ceylon, and southern India; the gamboge of Singapore is scarcely distinguishable botanically from the Ceylon species; rubber-yielding trees are characteristic, such are the climbing *Apocynaceæ* found in the Malayan peninsula and Borneo, and the well-known *Ficus elastica*, indigenous to Assam and Java; numerous palms and several species of *Cycas* also distinguish this flora from that of the western peninsula. Teak (*Tectona grandis*), which is indigenous to the Malayan archipelago, is native to both peninsulas as far as 25° N. lat., and is more tolerant of a dry climate than most of its associates.

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Western Peninsula.—This type is difficult to characterize, and is in many respects intermediate between the two just preceding. It occupies a comparatively dry area, with a rainfall under 75 inches. In respect to positive affinities, Sir Joseph Hooker has pointed out some relations with the flora of tropical Africa as evidenced by the prevalence of such genera as *Grewia* and *Impatiens*, and the absence, common to both countries, of oaks and pines which abound in the Malayan archipelago. The annual vegetation which springs up in the rainy season includes numerous genera, such as *Sida* and *Indigofera*, which are largely represented both in Africa and Hindustán. Palms also in both countries are scanty, the most notable in southern India being the wild date (*Phœnix sylvestris*); *Borassus* and the cocoa-nut are cultivated. The forests, though occasionally very dense, as in the western Gháts, are usually drier and more open than those of the Malayan type, and are often scrubby. The most important timber trees are the toon (*Cedrela Toona*), sál (*Shorea robusta*), the present area of which forms two belts separated by the Gangetic plain, satin wood (*Chloroxylon Swietenia*), common in the drier parts of the peninsula, sandalwood, especially characteristic of Mysore, iron-wood (*Mesua ferrea*), and teak, which has already been alluded to.[1]

[1] For a general sketch of the flora of India recourse must still be had to the introductory essay to the *Flora Indica*, published by Hooker and Thomson in 1855. The *Flora of British India*, the preparation of which is (1881) in progress at Kew, will comprise brief descriptions of all the species known to science up to the date of publication. But although no complete analysis of the vegetation is yet possible, its general features are now tolerably well understood.

[For the above section on the Flora we are indebted to Mr W. T. T. Dyer of Kew.]

Wild Animals.

Mammals.—First among the wild animals of India must be mentioned the lion (*Felis leo*), which is known to have been not uncommon within historical times in Hindustán Proper and the Punjab. At present, the lion is supposed to be confined to the sandy deserts of Guzerat. A peculiar variety is there found, marked by the absence of a mane; but whether this variety deserves to be classed as a distinct species naturalists are not yet determined. The former extent of the lion's range, or at least the degree to which its presence impressed the imagination, may be inferred from the common personal names, Sinh or Sing, Sher, and Hyder, which all signify "lion." The characteristic beast of prey in India is the tiger (*F. tigris*), which is found in every part of the country from the slopes of the Himálayas to the Sundarban swamps. Sir Joseph Fayrer, the highest living authority on this subject, believes that 12 feet is the maximum length of the tiger, when measured from nose to tip of tail immediately after death. The advance of cultivation, even more than the incessant attacks of sportsmen, has gradually caused the tiger to become a rare animal in large tracts of country; but it is scarcely probable that he will ever be exterminated from India. The malarious *tarái* fringing the Himaláyas, the uninhabitable swamps of the Gangetic delta, and the wide jungles of the central plateau, are at present the chief home of the tiger. His favourite food appears to be deer, antelope, and wild hog. When these abound he will disregard domestic cattle. Indeed, the natives are disposed to consider him as in some sort their protector, as he saves their crops from destruction by the wild animals on which he feeds. But when once he develops a taste for human blood, then the slaughter he works becomes truly formidable. The confirmed man-eater, which is generally an old beast, disabled from overtaking his usual prey, seems to accumulate his tale of victims in sheer cruelty rather than for food. A single tiger is known to have killed 108 people in the course of three years. Another killed an average of about 80 persons per annum. A third caused thirteen villages to be abandoned, and 250 square miles of land to be thrown out of cultivation. A fourth, so late as 1869, killed 127 people, and stopped a public road for many weeks, until the opportune arrival of an English sportsman, who at last killed him. Such cases are, of course, exceptional, and generally refer to a period long past, but they explain and justify the superstitious awe with which the tiger is regarded by the natives. The favourite mode of shooting the tiger is from the back of elephants, or from elevated platforms (*macháns*) of boughs in the jungle. In Central India they are shot on foot. In Assam they are sometimes speared from boats, and in the Himálayas they are said to be ensnared by bird-lime. Rewards are given by Government to native *shikáris* for the heads of tigers, varying in time and place according to the need. In 1877, 819 persons and 16,137 cattle were reported to have been killed by tigers; on the other side of the account, 1579 tigers were reported slain, and £3777 was paid in rewards.

The leopard or panther (*F. pardus*) is far more common than the tiger in all parts of India, and at least equally destructive to life and property. The greatest length of the leopard is about 7 feet 6 inches. A black variety, as beautiful as it is rare, is sometimes found in the extreme south of the peninsula, and also in Java. The cheetah or hunting leopard (*Gueparda jubata*) must be carefully distinguished from the leopard proper. This animal appears to be a native only of the Deccan, where it is trained for hunting the antelope. In some respects it approaches the dog more nearly than the cat tribe. Its limbs are long, its hair rough, and its claws blunt and only partially retractile. The speed with which it bounds upon its prey, when loosed from the cart, exceeds the swiftness of any other mammal. If it misses its first attack, it scarcely ever attempts to follow, but returns to its master. Among other species of the family *Felidæ* found in India may be mentioned the ounce or snow leopard (*F. uncia*), the clouded tiger (*F. macroscelis*), the marbled tiger cat (*F. marmorata*), the jungle cat (*F. chaus*) and the common viverrine cat (*F. viverrina*).

Wolf tribe.

Wolves (*Canis lupus*) abound throughout the open country, but are rare in the wooded districts. Their favourite prey is sheep, but they are also said to run down antelopes and hares, or rather catch them by lying in ambush. Instances of their attacking man are not uncommon. In 1827 upwards of thirty children were carried off by wolves in a single *parganá*; and the story of Romulus and Remus has had its counterpart in India within recent times. The Indian wolf has a dingy reddish-white fur, some of the hairs being tipped with black. By some naturalists it is regarded as a distinct species, under the name of *Canis pallipes*. Three distinct varieties, the white, the red, and the black wolf, are found in the Tibetan Himálayas. The Indian fox (*Vulpes bengalensis*) is comparatively rare, but the jackal (*C. aureus*) abounds everywhere, making night hideous by its never-to-be-forgotten yells. The jackal, and not the fox, is usually the animal hunted by the packs of hounds occasionally kept by Europeans. The wild dog or dhole (*C. dhola*) is found in all the wilder jungles of India, including Assam and British Burmah. Its characteristic is that it hunts in packs, sometimes containing thirty dogs, and does not give tongue. When once a pack of wild dogs has put up any animal, whether deer or tiger, that animal's doom is sealed. They do not leave it for days, and finally bring it to bay, or run it down exhausted. These wild dogs have sometimes been half domesticated, and trained to hunt for the use of man. A peculiar variety of wild dog exists in the Karen hills of Burmah, thus described from a specimen in confinement. It was black and white, as hairy as a skye-terrier, and as large as a medium-sized spaniel. It had an invariable habit of digging a hole in the ground, into which it crawled backwards, remaining there all day with only its nose and ferrety eyes visible. Among other dogs of India are the pariah, which is merely a mongrel, run wild and half starved; the poligar dog, an immense creature peculiar to the south; the grey-hound, used for coursing; and the mastiff of Tibet and Bhután. The striped hyæna (*Hyæna striata*) is common, being found wherever the wolf is absent. Like the wolf, it is very destructive both to the flocks and to children.

Dog.

Bear.

Of bears, the common black or sloth bear (*Ursus labiatus*) is common throughout India wherever rocky hills and forests occur. It is distinguished by a white horse-shoe mark on its breast. Its food consists of ants, honey, and fruit. When disturbed it will attack man, and it is a dangerous antagonist, for it always strikes at the face. The Himálayan or Tibetan sun bear (*U. tibetanus*) is found along the north, from the Punjab to Assam. During the summer it remains high up in the mountains, near the limit of snow, but in the winter it descends to 5000 feet and even lower. Its congener, the Malayan sun bear (*Helarctos malayanus*), is found in British Burmah, where also there is a smaller species (*H. euryspilus*), and a very large animal reported to be as big as the American grizzly.

Elephant.

The elephant (*Elephas indicus*) is found in many parts of India, though not in the north-west. Contrary to what might be anticipated from its size and from the habits of its African cousin, the Indian elephant is now, at any rate, an inhabitant, not of the plains, but of the hills; and even on the hills it is usually found among the higher ridges and plateaus, and not in the valleys. From the peninsula of

India the elephant has been gradually exterminated, being only found now in the primæval forests of Coorg, Mysore, and Travancore, and in the tributary states of Orissa. It still exists in considerable number along the *tarái* or submontane fringe of the Himálayas. The main source of supply at the present time is the confused mass of hills which forms the north-east boundary of British India, from Assam to Burmah. Two varieties are there distinguished, the *gunda* or tusker, and the *makna* or *hine*, which has no tusks. The reports of the height of the elephant, like those of its intelligence, seem to be exaggerated. The maximum is probably 12 feet. If hunted, the elephant must be attacked on foot, and the sport is therefore dangerous, especially as the animal has but few parts vulnerable to a bullet. The regular mode of catching elephants is by means of a *kheda* or gigantic stockade, into which a wild herd is driven, then starved into submission, and tamed by animals already domesticated. The practice of capturing them in pitfalls is discouraged as cruel and wasteful. Elephants now form a Government monopoly everywhere in India. The shooting of them is prohibited, except when they become dangerous to man or destructive to the crops; and the right of capturing them is only leased out upon conditions. A special law, under the title of "The Elephants Preservation Act" (No. VI. of 1879), regulates this licensing system. Whoever kills, captures, or injures an elephant, or attempts to do so, without a licence, is punishable by a fine of 500 rupees for the first offence; and a similar fine, together with six months' imprisonment, for a second offence. In the year 1877–78 a total of two hundred and sixty-four elephants were captured in the province of Assam, yielding to Government a revenue of £3600. In the season of 1873–74 no less than fifty-three were captured at one time by Mr Sanderson, the superintendent of the Kheda Department in Mysore, who has made a special study of the Indian elephant, as Sir S. Baker has of the same animal in Ceylon. Though the supply is decreasing, elephants continue to be in great demand. Their chief use is in the timber trade, and for Government transport. They are also bought up by native chiefs at high prices for purposes of ostentation.

Rhinoceros. Of the rhinoceros, four distinct varieties are enumerated, two with a single and two with a double horn. The most familiar is the *Rhinoceros unicornis*, commonly found in the Brahmaputra valley and in the Sundarbans. It has but one horn, and is covered with massive folds of naked skin. It sometimes attains a height of 6 feet; its horn, which is much prized by the natives for medicinal purposes, seldom exceeds 14 inches in length. It frequents swampy, shady spots, and wallows in mud like a pig. The inveterate antipathy of the rhinoceros to the elephant seems to be mythical. The Javan rhinoceros (*R. sondaicus*) is found in the same localities. It also has but one horn, and mainly differs from the foregoing in being smaller, and having less prominent "shields." The Sumatran rhinoceros (*R. sumatrensis*) is found from Chittagong southwards through Burmah. It has two horns and a bristly coat. The hairy-eared rhinoceros (*R. lasiotis*) is only known from a specimen captured at Chittagong.

Wild hog. The wild hog (*Sus scrofa*, var. *indica*) is well known as affording the most exciting sport in the world—"pig-sticking." It frequents cultivated situations, and is the most mischievous enemy of the villager. A rare animal, called the pigmy hog (*Porculia salviania*), exists in the *tarái* of Nepál and Sikkim, and has been shot in Assam. Its height is only 10 inches, and its weight does not exceed 12 lb.

Wild ass. The wild ass (*Asinus onager*) is confined to the sandy deserts of Sind and Kachhch (Cutch), where, from its speed and timidity, it is almost unapproachable.

Many wild species of the sheep and goat tribe are to be found in the Himálayan ranges. The *Ovis ammon* and *O. poli* are Tibetan rather than Indian species. The *urial* and the *shapu* are kindred species of wild sheep, found respectively in Ladákh and the Suláimán range. The former comes down to 2000 feet above the sea, the latter is never seen at altitudes lower than 12,000 feet. The *barhal*, or blue wild sheep, and the *markhur* and *tahr* (both wild goats) also inhabit the Himálayas. A variety of the ibex is also found there, as well as in the highest ranges of southern India. The *sarau* (*Nemorhædus rubida*), allied to the chamois, has a wide range in the mountains of the north, from the Himálayas to Assam and Burmah.

The antelope tribe is represented by comparatively few species, as compared with the great number peculiar to Africa. The antelope proper (*Antilope bezoartica*), the "black buck" of sportsmen, is very generally distributed. Its special habitat is salt plains, as on the coast-line of Guzerat and Orissa, where herds of fifty does may be seen, accompanied by a single buck. The doe is of a light fawn colour, and has no horns. The colour of the buck is a deep brown-black above, sharply marked off from the white of the belly. His spiral horns, twisted for three or four turns like a corkscrew, often reach the length of 30 inches. The flesh is dry and unsavoury, but is permitted meat for Hindus, even of the Bráhman caste. The *nílgai* or blue cow (*Portax picta*) is also widely distributed, but specially abounds in Hindustan Proper and Guzerat. As with the antelope, the male alone has the dark blue colour. The *nílgai* is held peculiarly sacred by Hindus, from its fancied kinship to the cow, and on this account its destructive inroads upon the crops are tolerated. The four-horned antelope (*Tetraceros quadricornis*) and the gazelle (*Gazella bennetti*) are also found in India. The *chiru* (*Pantholops hodgsoni*) is confined to the Himálayan plateaus.

The king of the deer tribe is the *sámbhar* or *gerau* (*Rusa aristotelis*), erroneously called "elk" by sportsmen. It is found on the forest-clad hills in all parts of the country. It is of a deep-brown colour, with hair on its neck almost like a mane; and it stands nearly 5 feet high, with spreading antlers nearly 3 feet in length. Next in size is the swamp deer or *bara-singha*, signifying "twelve points" (*Rucervus duvaucelli*), which is common in Lower Bengal and Assam. The *chitál* or spotted deer (*Axis maculata*) is generally admitted to be the most beautiful inhabitant of the Indian jungles. Other species include the hog deer (*Cervus porcinus*), the barking deer or muntjac (*Cervulus vaginalis*), and the mouse deer (*Meminna indica*). The musk deer (*Moschus moschiferus*) is confined to Tibet.

The ox tribe is represented in India by some of its noblest species. The *gaur* (*Bibos gaurus*), the "bison" of sportsmen, is found in all the hill jungles of the country, in the Western Gháts, in Central India, in Assam, and in British Burmah. This animal sometimes attains the height of 20 hands (close on 7 feet), measuring from the hump above the shoulder. Its short curved horns and skull are enormously massive. Its colour is dark chestnut, or coffee-brown. From the difficult nature of its habitat, and from the ferocity with which it charges an enemy, the pursuit of the bison is no less dangerous and no less exciting than that of the tiger or the elephant. Akin to the *gaur*, though not identical, are the *gayál* or *mithan* (*B. frontalis*), confined to the hills of the north-east frontier, where it is domesticated for sacrificial purposes by the aboriginal tribes, and the *tsine* or *banting* (*B. sondaicus*), found in Burmah. The wild buffalo (*Bubalus arni*) differs from the tame buffalo only in being larger and more fierce. The finest specimens come from Assam and Burmah. The horns of the bull are thicker than those of the cow, but the horns of the cow are larger. A head has been known to measure 13 feet 6 inches in circumference, and 6 feet 6 inches between the tips. The greatest height is 6 feet. The colour is a slaty black; the hide is immensely thick, with scanty hairs. Alone perhaps of all wild animals in India, the buffalo will charge unprovoked. Even tame buffaloes seem to have an inveterate dislike to Europeans.

The rat and mouse family is only too numerous. Conspicuous in it is the loathsome bandicoot (*Mus bandicota*), which sometimes measures 2 feet in length, including its tail, and weighs 3 lb. It burrows under houses, and is very destructive to plants, fruit, and even poultry. More interesting is the tree rat (*M. arboreus*), a native of Bengal, about 7 inches long, which makes its nest in cocoa-nut palms and bamboos. The voles or field mice (genus *Arvicola*) occasionally multiply so exceedingly as to diminish the out-turn of the local harvest, and to require special measures to be organized for their suppression.

ls. *Birds.*—The ornithology of India, though it is not considered so rich in specimens of gorgeous and variegated plumage as that of other tropical regions, contains many splendid and curious varieties. Some are clothed in nature's gay attire, others distinguished by strength, size, and fierceness. The parrot tribe is the most remarkable for beauty. So various are the species that we cannot even enumerate them, and must refer for details to the scientific works on the subject.[1] Among birds of prey, four vultures are found, including the common scavengers (*Gyps indicus* and *G. bengalensis*). The eagles comprise many species, but none to surpass the golden eagle of Europe. Of falcons, there are the peregrine (*F. peregrinus*), the *shain* (*F. peregrinator*), and the *lagar* (*F. jugger*), which are all trained by the natives for hawking; of hawks, the *shikara* (*Astur badius*), the sparrow hawk (*Accipiter nisus*), and the crested goshawk (*Astur trivirgatus*). Kingfishers of various kinds, and herons are sought for their plumage. No bird is more popular with natives than the *maina* (*Acridotheres tristis*), a member of the starling family, which lives contentedly in a cage, and can be taught to pronounce the name of Krishna. Water-fowl are especially numerous. Of game-birds, the floriken (*Sypheotides auritus*) is valued as much for its rarity as for the delicacy of its flesh. Snipe (*Gallinago scolopacina*) abound at certain seasons, in such numbers that one gun has been known to make a bag of eighty brace in a day. Pigeons, partridges, quail, plover, duck, teal, sheldrake, widgeon—all of many varieties—complete the list of small game. The red jungle fowl (*Gallus ferruginesis*), supposed to be the ancestor of our own poultry, is not good eating; and the same may be said of the peacock (*Pavo cristatus*), except when young. The pheasant does not occur in India Proper, though a white variety is found in Burmah.

tiles. *Reptiles.*—The serpent tribe in India is numerous; they swarm in all the gardens, and intrude into the dwellings of the inhabitants, especially in the rainy season. Most are comparatively harmless, but the bite of others is speedily fatal.[2] The cobra di capello (*Naga tripudians*)—the name given to it by the Portuguese, from the appearance of a hood which it produces by the expanded skin about the neck—is the most dreaded. It seldom exceeds 3 or 4 feet in length, and is about an inch and a quarter thick, with a small head, covered on the forepart with large smooth scales; it is of a pale brown colour above, and the belly is of a bluish-white tinged with pale brown or yellow. The Russelian snake (*Daboia russellii*), about 4 feet in length, is of a pale yellowish brown, beautifully variegated with large oval spots of deep brown, with a white edging. Its bite is extremely fatal. Itinerant showmen carry about these serpents, and cause them to assume a dancing motion for the amusement of the spectators. They also give out that they render snakes harmless by the use of charms or music,—in reality it is by extracting the venomous fangs. But, judging from the frequent accidents which occur, they sometimes dispense with this precaution. All the salt-water snakes in India are poisonous, while the freshwater forms are wholly innocuous. Sir J. Fayrer has demonstrated that there is no cure for the bite of the cobra, if the snake is full-grown, and if its poison fang is full and is not interfered with by clothing. The most hopeful remedy in all cases of snake bite is the injection of ammonia. The loss of life from this cause in India is painful to contemplate, nor does any means of diminishing the evil seem feasible. It is impossible to exterminate poisonous snakes altogether, even in England. In India the impossibility is yet more evident, from the greater number of the snakes, the character of the country, and the scruples of the people. Something, however, is being effected by the offer of rewards. In 1877 a total of 16,777 persons are reported to have been killed by snakes, as compared with only 819 by tigers. In the same year, rewards to the amount of £811 were given for the destruction of 127,295 snakes.

The other reptiles include two varieties of crocodile (*C. porosus* and *C. biporcatus*) and the gavial (*Gavialis gangeticus*). These are more ugly in appearance than destructive to human life. Scorpions also abound.

Fishes.—All the waters of India—the sea, the rivers, and the tanks—swarm with a great variety of fishes, which are caught in every conceivable way, and furnish a considerable proportion of the food of the poorer classes. They are eaten fresh, or as nearly fresh as may be, for the art of curing them is not generally practised, owing to the exigencies of the salt monopoly. In Burmah the favourite relish of *nga-pi* is prepared from fish; and at Goálandá, at the junction of the Brahmaputra with the Ganges, an important station has recently been established for salting fish in bond. The indiscriminate slaughter of fry, and the obstacles opposed by irrigation dams to breeding fish, are said to be causing a sensible diminution in the supply in certain rivers. Measures of conservancy have been suggested, but their execution would be almost impracticable. Among Indian fishes, the *Cyprinidæ* or carp family and the *Siluridæ* or cat-fishes are best represented. From the angler's point of view, by far the finest fish is the *mahsir*, found in all hill streams, whether in Assam, the Punjab, or the South. One has been caught weighing 60 lb, which gave play for more than seven hours. Though called the salmon of India, the *mahsir* is really a species of barbel. The most recent authority on Indian fishes and their economic aspects is Dr Francis Day. Fishes.

In this connexion may be mentioned the *susu* or Gangetic dolphin (*Platanista gangetica*), which is often erroneously called a porpoise. Both the structure and habits of this animal are very singular. It measures from 6 to 12 feet in length, and in colour is sooty-black. Its head is globular, with a long, narrow, spoon-shaped snout. Its eyes are rudimentary, like those of the mole; and its ear-orifices are no bigger than pin-holes. Its dentition, also, is altogether abnormal. It frequents the Ganges and Indus from their mouths right up to their tributaries within the hills. A specimen has been taken at least 1000 miles above Calcutta. Ordinarily its movements are slow, for it wallows in the muddy bed of the river, and but rarely comes to the surface to blow. The *susu* belongs to the order *Cetacea*; and inquiries have recently been directed to the point whether its blubber might not be utilized in commerce.

Insects.—The insect tribes in India may be truly said to be innumerable; nor has anything like a complete classification been given of them in the most scientific treatises. Insects.

[1] See especially Jerdon and Gould.

[2] See Sir J. Fayrer's *Thanatophidia*

The heat and the rains give incredible activity to noxious or troublesome insects, and to others of a more showy class, whose large wings surpass in brilliancy the most splendid colours of art. Stinging musquitoes are innumerable, and moths and ants of the most destructive kind, as well as others equally noxious and disagreeable. Amongst those which are useful are the bee, the silk-worm, and the insect that produces lac. Clouds of locusts occasionally appear, which leave no trace of green behind them, and give the country over which they pass the appearance of a desert. Dr Buchanan saw a mass of these insects in his journey from Madras to the Mysore territory, about 3 miles in length, like a long narrow red cloud near the horizon, and making a noise somewhat resembling that of a cataract. Their size was about that of a man's finger, and their colour reddish. They are swept north by the wind till they strike upon the outer ranges of the Himálayas.

The People.

Population. The population of India, with British Burmah, amounts to 240 millions, or, as already mentioned, exactly double the number which Gibbon estimated for the Roman empire in the height of its power. But the English Government, like the Roman, has respected the rights of native chiefs who are willing to govern peaceably and well, and one-third of the country still remains in the hands of hereditary rulers. Their subjects (including Mysore) make up 54 millions, or over one-fifth of the whole Indian people. The British territories (including Mysore, temporarily under British administration), therefore comprise only two-thirds of the area of India, and less than four-fifths, or 191 millions, of its inhabitants.

Census. For the first time in the history of India an attempt was made in the years 1871–72 to ascertain the population of the country by actual counting. The results obtained on that occasion, though in certain points they leave much to be desired, may be accepted generally as a tolerable approximation to the truth. Prior to this census, occasional enumerations had been made, with varying degrees of accuracy, in some of the provinces; while in others mere conjectural estimates had been allowed to pass uncriticized. In Bengal, for example, where statistical inquiry was in a backward state, the Government had year by year accepted a loose estimate of 42 millions for the population under its control, and based upon this all its calculations for legislation and finance. The census of 1872 disclosed a total of nearly 67 millions for Bengal and Assam, being an increase upon the estimate of more than one-half. In Berar, or the Assigned Districts of Hyderabad, a census had been taken in 1867, in the Punjab in 1868, and in Oudh in 1869. In these provinces, therefore, it was considered impolitic to trouble the people by a fresh enumeration. Throughout all the rest of India under British administration, including the native state of Mysore, a general census was effected on uniform principles, which may be said to have begun in November 1871 and ended in August 1872. So far as possible, the work was done in a single night; but in certain remote and uncivilized tracts it was of necessity prolonged over several months. Considering the absolute novelty of the undertaking, at least in some provinces, and the scanty means at the disposal of the authorities, the general accuracy of the results may be regarded with not a little satisfaction. Subsequent local investigations tend to show that the numbers were under rather than overstated. In a few cases paid enumerators were engaged; but generally the work was left to the ordinary staff of each district, assisted by the police, the landlords, and their agents. The total expenditure throughout all British India was only £82,203, being at the rate of less than half a farthing per head. The suspicions of the ignorant villagers were naturally aroused by the counting, which they imagined to be preliminary to some fresh exaction by the Sarkár or Government. Only in two or three cases was any real opposition offered; and there is little reason to believe that any material evasion was accomplished.

Gen[eral] resu[lts]. The total population of British India was ascertained to amount to 191,096,603 persons, on an area of 898,381 square miles, being an average of 212 persons per square mile. Deducting the frontier province of Assam and British Burmah beyond the sea, the average is 243 persons per square mile. The population of the several native states is returned, partly from actual enumeration and partly from mere guessing, at 49,155,746 persons, on an area of 575,265 square miles, being an average of 85 persons to the square mile. The French possessions have an area of 178 square miles and a population of 271,460 persons; the Portuguese possessions, 1086 square miles and 407,712 persons. The aggregate figures for all India, therefore, are 1,474,910 square miles and 240,931,521 persons, or an average of 163 persons per square mile.

The following tables exhibit the results of the census of 1872 in a tabular form, arranged according to provinces and aggregates of native states, as presented to Parliament in 1879 in the *Statistical Abstract for British India*, No. XIII. for 1877–78. For certain details the Memorandum on the Census of 1872 presented to Parliament in 1875 has been used. No really important changes in the returns will be made till the next census, but slight alterations or adjustments are from time to time effected.

Area and Population of India under British Administration.

	Area in Sq. Miles.	Population.	Persons per Sq. Mile.
Under Governor-General—			
Ajmír	2,711	396,889	146
Berar	17,711	2,227,654	126
Mysore[1]	29,325	5,055,412	172
Coorg	2,000	168,312	84
Under Governors—			
Madras	138,856	31,672,613	228
Bombay (including Sind)	123,142	16,349,206	132
Under Lieutenant-Governors—			
Bengal	156,200	60,502,897	383[3]
North-Western Provinces	81,403	30,781,204	378
Punjab	104,975	17,611,498	168
Under Chief-Commissioners—			
Oudh[2]	23,992	11,220,232	468
Central Provinces	84,208	8,201,519	97
British Burmah	88,556	2,747,148	31
Assam	45,302	4,162,019	99[3]
Total	898,381	191,096,603	212

Area and Population of Native States in India.

	Area in Sq. Miles.	Population.	Persons per Sq. Mile.
Under Governor-General—			
Central India and Bundelkhand	89,098	8,360,571	93
Rájputána	130,989	10,192,871	77
Hyderabad (Haidarábád, Nizám's Dominions)	80,000	9,000,000	112
Baroda	4,399	2,000,225	454
Manipur	7,584	126,000	16
Under Bengal	37,988	2,328,440	61
,, North-Western Provinces	5,125	657,013	128
,, Punjab	114,742	5,367,042	46
,, Central Provinces	29,112	1,049,710	36
,, Madras	9,818	3,289,392	335
,, Bombay	66,410	6,784,482	102
Total	575,265	49,155,746	85

1 Mysore will be handed back in 1881 to the administration of its native rájá.
2 Oudh is incorporated for most purposes with the N.W. Provinces.
3 The area of the wild country in which the population is not reckoned has been excluded in calculating these averages.

Total Area and Population of All India.

	Area in Sq. Miles.	Population.	Density per Sq. Mile.
Under British administration	898,381	191,096,603	212
Native States	575,265	49,155,746	85
Portuguese Possessions	1,086	407,712	chiefly
French Possessions	178	271,460	in towns.
Grand total	1,474,910	240,931,521	163

ısity ·opu- on. According to the report of the registrar-general upon the English census of 1871, "any density of a large country approaching 200 to a square mile implies mines, manufactures, or the industry of cities." But in India a density of thrice this limit, or 600 to the square mile, is often attained throughout large districts which are entirely dependent upon agriculture. Sáran, for example, in North Behar, with an area of 2654 square miles and no town exceeding 50,000 inhabitants, has an average density of 778 to the square mile, with a maximum of 984 in the purely agricultural *thâná* or police circle of Mashrak. Taking the valley of the Ganges as a whole, from Saháranpur down to Calcutta, the average density is about 500 to the square mile, or nearly double that of the United Kingdom.

ıan ula- This high density is obtained without the presence of many large towns or centres of manufacturing life. Of the total number of 493,444 towns and villages in British India, only 44 are returned as having more than 50,000 inhabitants, 374 as having from 10,000 to 50,000, and 1070 as having from 5000 to 10,000. The 44 towns with more than 50,000 inhabitants have an aggregate urban population of a little more than 5½ millions, or less than 3 per cent. of the total population of British India; whereas the 34 towns in England and Wales exceeding the same limit have an aggregate urban population of nearly 7½ millions, or 32 per cent. of the total. Taking a lower limit, there are 139 towns in British India with more than 20,000 inhabitants, having an aggregate of 8,484,066, or less than 4½ per cent. of the total.

Towns with more than 100,000 *Inhabitants.*

Calcutta[1]	776,579	Bangalore	142,513
Bombay[2]	644,405	Amritsar	142,381
Madras[2]	397,552	Lahore[2]	128,441
Lucknow	284,779	Cawnpur	122,770
Benares	175,188	Poona	118,886
Delhi[2]	160,553	Ahmadábád	116,873
Patná	158,900	Rangoon	108,000
Agra	149,008	Surat	107,149
Allahábád	143,693	Bareilly	102,982

ted ses. The total number of inhabited houses enumerated in British India is 37,041,259. The average number of houses per square mile is 41, ranging from 102 in Oudh to 6 in British Burmah. The average number of persons per house is 5·15, being pretty uniform throughout. Contrary to the experience of the United Kingdom it is found that the number of inmates to each house is lower in the towns than in the country, the reason assigned being that the shopkeepers do not bring their families into the towns with them. The houses are grouped into a total of 493,444 villages or townships, giving an average of 75 houses and 386 persons to each. The average area of each village or township is ·55 of a square mile. The villages seem to be largest in Bombay, with 614 inhabitants each, and smallest in British Burmah, with 195 inhabitants.

and s Out of the total of 191,096,603 persons in British India, 98,055,381 are returned as males and 92,580,886 as females, leaving 460,336 of whom the sex was unspecified. The proportion of males to females is thus as 100 to 94. In England the females outnumber the males in the proportion of 105 to 100, an excess attributed mainly to emigration. In India, whence there is practically no emigration, it might be expected that this excess of females would disappear, and the two sexes be found on an equality. In the two great provinces of Bengal and Madras this is practically the case, the excess of females being not greater than 1 per cent., and the proportion being maintained uniformly throughout the districts. But in Oudh the excess of males is 7 per cent., in Bombay 8 per cent., in the North-Western Provinces 12 per cent., and in the Punjab as high as 16 per cent. We have no reason to suppose that the approximate equality of boys and girls does not hold good in the births throughout India, as in other countries; and therefore this great excess of males can only be assigned to two causes—(1) defective registration of females, especially of girls, and (2) female infanticide formerly, and carelessness of infant female life at the present day. Of the existence of these causes we possess independent testimony. In 1870 an act of the legislature was passed applying special regulations to villages or tracts suspected of infanticide, which is the besetting sin of certain high caste tribes of Rájputs. In one tribe of Meerut district only 8 girls under 12 were found to 80 boys. The act is put in force wherever there are less than 54 girls to 100 boys, but the exact limit is at the discretion of Government. The crime is now almost stamped out.

The returns according to age throw some light upon this question. Children under 12 number altogether 66,969,764, and adults above 12 number 123,200,022, leaving 926,817 unspecified. The proportion of children to adults is, therefore, as 54 to 100, the corresponding proportion in England being 41 to 100. The highest proportion of children (62 to 100) is found in the Central Provinces, where the aboriginal tribes are strongest; and the lowest proportion (50 to 100) in the North-Western Provinces. An examination of the Bengal returns, district by district, also leads to the conclusion that the aboriginal tribes are more prolific than the Hindus proper. Subdividing these returns according to sex, we discover an extraordinary disparity. Of the adults, 62,022,461 are males and 61,197,561 are females. The proportion of male adults to females is, therefore, about 100 to 99, as compared with 100 males to 94 females in the general population. But on turning to the children under 12, we find as many as 35,787,564 boys to only 31,182,200 girls, or 100 boys to only 87 girls. This arises from the defective registration of girls, females under 12 being often returned as women.

The following table shows the population of British India as roughly subdivided according to religion. Broadly speaking, it may be said that at least nineteen out of every twenty people in India are either Hindus or Mahometans, and that there are seven of the former to two of the latter. Religious division.

Population according to Religion in British India.

Religion.	Number.	Per cent.	Tracts where most numerous.
Hindus	139,343,820	73·07	South; and Upper Valley of Ganges.
Mahometans	40,867,125	21·45	Sind, Punjab, Eastern Bengal, and North-West Provinces.
Buddhist and Jains	2,832,851	1·49	British Burmah only.
Sikhs	1,174,436	·62	Punjab only.
Christians	897,682	·47	Extreme South.
Others[3]	5,417,304	2·68	Central Provinces and Bombay.
Unspecified	561,069	·22	

The schedules of the census fail entirely to give a satisfactory classification of the races among which the vast population of India is divided. Using language as our criterion, the people might perhaps be arranged in five classes:—(1) The old races of the south, known as the Dravidian stock, which includes, not only the great peoples using the literary languages of Tamil, Telugu, Malayálam, and Kanarese, but also scattered tribes speaking dialects of the same family, who are found as far north as the hills of Chutiá Nágpur; (2) the hill tribes of Central India, from the Bhíls of Bombay to the Santáls of Bengal, whose physical characteristics are negroid, and whose family of languages has received the name of Kolarian; (3) the tribes of Indo-Chinese origin, who inhabit the southern slopes of the Himálayas, the greater part of the Assam valley, and the whole of Burmah;—it seems probable that the semi-Hinduized low castes of Northern Bengal also belong to this stock; (4) high-caste Hindus, or that offshoot of the august Aryan race which has imposed its language, its religion, and its name upon the greater part of the country; (5) successive waves of Mahometan conquerors, Arab, Afghán, Mughal, and Persian, who form in the aggregate but an infinitesimal element in the general population. Whether pure Aryans are now to be traced in any other class than that of the Bráhmans Ethnical division.

[1] With suburbs, but excluding Howrah. [2] With suburbs.

[3] Professing for the most part various forms of aboriginal belief.

may perhaps be disputed. Even the so-called Rájputs have probably a considerable admixture of Scythic blood. The Vaisya or third caste of Manu's system is admitted to be almost extinct, while his Súdras are to be found in the pre-existing non-Aryan population.

Principal Divisions of the Population.

Race, &c.	Number.	Tracts where most numerous.
Hindus.		
Bráhmans	10,131,541	N.-W. Provinces, Oudh, Bengal, Madras.
Rájputs	5,641,138	N.-W. Provinces, Bengal, Oudh, Punjab.
Out-castes	8,712,998	Madras.
Aboriginal tribes	17,716,825	Bengal, Central Provinces, Assam.
Native Christians	595,815	South and West.
Mahometans.		
Mughals	219,755	Punjab.
Afgháns or Patháns	1,841,693	Do.
Sayyids	790,984	
Shaikhs	4,700,320	
Foreigners.		
Pársís	69,000	Bombay city and Surat.
Nepális	31,000	Bengal.
Manipuris	12,000	Assam.
Arabs	8,300	Bombay.
Persians	3,500	Do.
Armenians	1,250	Bengal.
Chinese	13,300	Burmah.
Malays	1,500	Do.
Jews	7,600	Bombay.
Eurasians and Indo-Portuguese	108,000	Calcutta, Madras, and Bombay cities.
Europeans	121,000	of whom 75,700 are British.

Mahometans. Among Mahometans, who number in all 40,227,552, four classes are commonly distinguished. *Mughals*, or the descendants of the last conquering race, number only 219,755, of whom nearly half are to be found in the Punjab. *Afgháns* or *Patháns* on the other hand, from their proximity to the frontier, are much more strongly represented, numbering 1,841,693 in all, chiefly in the Punjab and in the Rohilkhand division of the North-West. *Sayyids*, who claim to be lineally descended from the prophet, number 790,984; and *Shaikhs*, 4,700,320. The remainder are unspecified, but the following tribes or classes among Indian Musalmáns are worthy of notice. In Bengal the vast majority of the Mahometans manifestly belong to the same race as the lowest castes of Hindus. They are themselves subdivided into many classes, which in their devotion to hereditary occupations are scarcely to be distinguished from Hindu castes. Of late years a reforming spirit has arisen, leading them to abandon the polytheistic customs and festivals which they shared with their Hindu fellow-villagers. In the Punjab, besides the Pathán immigrants from across the frontier, Islam has taken a strong hold of the native population. The census returned upwards of 1,300,000 Játs, 700,000 Rájputs, and 424,000 Gujars among the Musalmáns. Here, again, the Mahometans are not strongly distinguished from their Hindu brethren. Baluchis from beyond the frontier number 235,000 in the Punjab, and 145,000 in Sind. Bombay possesses three peculiar classes of Musalmáns, each of which is specially devoted to maritime trade,—the *Memons*, numbering 49,000, chiefly in Sind; the *Borahs*, 86,000, mainly in Guzerat; the *Khojahs*, nearly 18,000, of whom half live in the island of Bombay. In southern India the majority are known as Dakhani Musalmáns, being descendants of the armies led by the kings and nawábs of the Deccan. But the two peculiar races of the south are the *Moplas* (613,000) and the *Labbays* (312,000), both of which are seated along the coast and follow a seafaring life. They are descended from the Arab traders who settled there in very early times, and have been recruited partly by voluntary adhesions and partly by forcible conversions during the persecutions of Hyder Alí and Tipú Sultán. The Moplas of Malabar are notorious for repeated outbreaks of bloody fanaticism.

The Mahometans are most numerous, as might be expected, along the valley of the Indus, from Karáchi (Kurrachee) to Peshawar. In the Bombay province of Sind they number 78 per cent. of the total population. In the Punjab generally the proportion is 53 per cent., rising to 93 per cent. in the frontier district of Peshawar. In the North-Western Provinces and also in Oudh the proportion of Mahometans nowhere exceeds 23 per cent., though that part of the country was the seat of successive Musalmán empires for many centuries. In Lower Bengal, on the other hand, the faith of Islam has exercised a more permanent effect upon the population, especially in the valley of the Brahmaputra. The average of Mahometans in the whole province is 33 per cent., rising to 80 per cent. in the deltaic districts of Bográ and Rájsháhí. Here, again, it is found that the Mahometans are not most numerous in the neighbourhood of the great Musalmán capitals, Gaur, Rájmahál, Dacca, and Murshidábád, but in the densely populated agricultural tracts, where the semi-aboriginal tribes appear to have willingly embraced Islam in preference to remaining outcasts beyond the exclusive pale of Hinduism.

Sikhs. The Síkhs are almost entirely confined to the Punjab, where they number only 6·50 per cent. of the population. Their stronghold is the country between the rivers Rávi and Sutlej (Satlaj), including the historical cities of Lahore, Amritsar, Ambála (Umballa), and Jalandhar. In no district do they form more than 17 per cent.

Christians. Of the total number of 897,682 Christians, about 250,000 are believed to be Europeans or to have European blood in their veins. The south of India is the only part where the exertions of the missionaries can be said to be visible in the statistics of population. In the Madras presidency generally, Christians number 533,760, or 1·71 per cent. of the total. Of these, about 416,000 are returned as Roman Catholics, and about 118,000 as Protestants. Nearly one-fifth of all the Christians are found in the single district of Tinnevelli, and they are numerically next strongest in Madura, Tanjore, Trichinopoli, South Kánara, and Malabar. Christianity has been known in southern India for many centuries. A Pehlevi inscription in the ancient church of the St Thomas' Mount near Madras city indicates a settlement of Manichæans or Persian Christians on the eastern coast, as well as on the west; and tradition speaks of the preaching of the apostle St Thomas in Madras, Tinnevelli, and Malabar. The adherents of the Syrian church in Malabar, Travancore, and Cochin are the most ancient Christian community in the south. After these come the Roman Catholics, who trace their origin to the teaching of St Xavier and the Madura Jesuits. The Protestant churches date only from about the beginning of the present century, but their progress since that time has been considerable. In Bombay there are 126,063 Christians, of whom nearly 83,000, chiefly Indo-Portuguese, are returned as Roman Catholics. In Bengal the Christians number only 90,763, but since the date of the census missionary effort has been very successful among the hill tribes of Chutiá Nágpur. In the North-Western Provinces there are 22,196 Christians, in the Punjab 22,154, in the Central Provinces 10,477, in Mysore 25,676, in Coorg 2410, and the remainder are scattered over Assam, Berar, and Ajmír. In British Burmah the Christians are proportionately more numerous than in any other province, amounting to 52,299, or 1·90 per cent., chiefly converts from the hill tribe of Karens. It should be remembered that the above figures are exclusive of the native states, in which the Christians amount to about 700,000, making a total in round numbers of 1½ millions for all India.

Occupations. An attempt was made at the time of the census to ascertain the professions and occupations of the male adults, but the results cannot be accepted as even approximately accurate. The totals, however, are here given for what they may be worth. Out of a classified total of about 62,000,000 adult males, 2,232,000, or 3·6 per cent., were returned as professional or in Government service; 3,844,000, or 6·2 per cent., as in domestic service; 34,844,000, or 56·2 per cent., as agricultural; 3,224,000, or 5·2 per cent., as commercial; 8,122,000, or 13·1 per cent., as industrial; 7,626,000, or 12·3 per cent., as labourers; and 2,108,000, or 3·4 per cent., as independent and non-productive.

ecific firmi- s. An attempt was also made to collect statistics of persons afflicted with certain specific infirmities, but here again the results possess little value. The number of insane persons and idiots was returned at 67,000, or 1 in 2700 of the population, being less than ⅓th of the rate prevailing in England. The deaf and dumb numbered 134,000, or 1 in 1340, a proportion about half as great again as in England; the blind numbered 354,000, or rather less than 1 in 500, which is double the English rate; the lepers numbered 96,000, or 1 in 1875.

al sta- ics. Returns of both births and deaths are now regularly collected over almost the entire area under British administration. In towns the returns are furnished through the municipalities, while in the rural tracts the agency employed is the police. The figures thus obtained are for the most part so evidently inadequate that it would only be misleading to reproduce them in this place. Suffice it to say that the sanitary commissioner accepts as approximately correct a calculation which estimates the average duration of life in India at thirty years and eight months, which is equivalent to an annual death-rate of 32·57 per thousand. During 1877, the year of famine, the ascertained death-rate in Madras rose to 53·2, while the ascertained birth-rate fell to 16·3 per thousand. Both these rates are, of course, mere approximations to the truth, but they serve to indicate how famine attacks a people from two sides. In 1877 the death-rate among European troops in India was 12·71 per thousand, being the lowest ever recorded; among native troops, 13·38 per thousand; and in the public jails, 61·95 per thousand, rising to 176·01 per thousand in the jails of Madras.

AGRICULTURE.

The cultivation of the soil is the occupation of the Indian people, in a sense which is difficult to realize in England, and which cannot be adequately expressed by figures. As the land tax forms the mainstay of the imperial revenue, so the *ráyat* or cultivator constitutes the unit of the social system. The organized village community contains many other members besides the cultivators, but they all exist for his benefit, and all alike are directly maintained from the produce of the village fields. Even in considerable towns, the traders and handicraftsmen almost always possess plots of land of their own, on which they raise sufficient grain to supply their families with food. The operations of rural life are familiar to every class. They are enveloped in a cloud of religious sanctions, and serve to mark out by their recurring periods the annual round of common life. According to the returns of the general census of 1872, the number of adult males engaged in agriculture amounts to nearly 35 millions, or 56·2 per cent. of the total. To these ought to be added almost all the labourers, an additional 7½ millions, or 12·3 per cent.,—thus raising the grand total of persons directly supported by the land to more than two-thirds of the entire number of adult males, besides those indirectly or incidentally connected with it.

But though agriculture thus forms the staple industry of the country, its practice is pursued in different provinces with infinite variety of detail. Everywhere the same perpetual assiduity is found, but the inherited experience of generations has taught the cultivators to adapt their simple methods to differing circumstances. For irrigation, native patience and ingenuity have devised means which compare favourably with the colossal projects of Government. Manure is copiously applied to the more valuable crops whenever manure is available, its use being limited by poverty and not by ignorance. The rotation of crops is not adopted as a principle of cultivation; but in practice it is well known that a succession of exhausting crops cannot be taken in consecutive seasons from the same field, and the advantage of fallows is widely recognized. The periodicity of the seasons usually allows two, and sometimes three, harvests in the year, but not necessarily, nor indeed usually, on the same fields. For inexhaustible fertility, and for retentiveness of moisture in a dry year, no soil in the world can surpass the *regar* or "black cotton-soil" of the Deccan. In the broad river basins, the inundations deposit annually a fresh top-dressing of silt, thus superseding the necessity of manures.

The name of rice has from time immemorial been so closely associated with Indian agriculture, that it is difficult to realize how comparatively small an area is planted with this crop. If we except the deltas of the great rivers and the long strip of land fringing the western coast, rice may be called an occasional crop throughout the remainder of the peninsula. But where rice is grown, it is grown to the exclusion of all other crops. In British Burmah, out of a total cultivated area of 2,833,520 acres in 1877–78, as many as 2,554,853 acres, or 90 per cent., were under rice. Independent Burmah, on the other hand, grows no rice, but imports largely from British territory. For Bengal, unfortunately, no general statistics are available. But taking Rangpur as a typical district, it was there found that 1½ million acres, out of a classified total of a little over 1¾ million acres, or 88 per cent., were devoted to rice. Similar proportions hold good for the province of Orissa, the deltas of the Godávari, Kistna, and Káveri (Cauvery), and the lowlands of Travancore, Malabar, Kánara, and the Concan. For the North-Western Provinces and Oudh, again, no agricultural statistics are available; but though rice, grown in damp localities, or with the help of irrigation, forms a favourite food for the upper classes, the local supply requires to be supplemented by importation from Bengal. Throughout the remainder of the country, except in Assam, which is agriculturally a continuation of the Bengal delta, the cultivation of rice occupies but a subordinate place. The average out-turn per acre in Bengal has been estimated at 15 *maunds*, or 1200 lb, of cleaned rice. In the years 1877–78, when famine was raging in southern India, the total exports of rice from Calcutta amounted to more than 16 million cwts. In British Burmah there is but a single rice harvest in the year, corresponding to the *áman* of Bengal. The grain is reddish in colour and of a coarse quality; but the out-turn is much higher than in Bengal, reaching in some places an average of 2000 and 2500 lb per acre. The annual exports of rice from Burmah amount to about 12 million cwts. Besides being practically the sole crop grown in the deltaic swamps, rice is raised in patches in all the hill-valleys, from Coorg to the Himálayas. Rice.

Wheat is grown to some extent in almost every district; but, broadly speaking, it may be said that wheat does not thrive where rice does, nor, indeed, anywhere south of the Deccan. The great wheat-growing tract of India is the Punjab, where, in 1877–78, nearly 7 million acres, or 37 per cent. of the total cultivated area, were under this crop. For the North-Western Provinces and Oudh, in default of actual statistics, it has been estimated that the total area under wheat is as large as in the Punjab, though the relative proportion is less. Wheat is also grown in Behar and in the districts of Bengal that lie south of the Ganges. In the Central Provinces, in 1877–78, wheat was grown on 23 per cent. of the cultivated area, being the chief crop in the districts of Hoshangábád, Narsinhpur, and Ságar. In Bombay the corresponding proportion was less than 5 per cent., and in Sind 12 per cent. It has been conjectured that the total area under wheat in India is equal to the area under the same crop in the United States. Nor is the general out-turn contemptible, averaging about 13 bushels per acre in the Punjab, as compared with an average of 15½ bushels for the whole of France. The quality, also, of the grain is high enough to satisfy the demands of English millers; and "Calcutta Club No. 1" commands a price in Mark Lane not much below that of the Wheat.

finest Australian or Californian produce. Unfortunately, when a prosperous trade with Europe seemed on the point of establishing itself, the terrible year 1877–78 supervened, and India will now have to fight against the position of vantage occupied by the United States. According to the system of classification in Upper India, wheat ranks as a *rabí* or spring crop, being reaped at the close of the cold weather in April and May. Wherever possible, it is irrigated; and the extension of canals through the Gangetic Doáb has largely contributed to the substitution of wheat for inferior cereals.

Millet. Taking India as a whole, it may be affirmed that the staple food grain is neither rice nor wheat, but millet, which is probably the most prolific grain in the world, and the best adapted to the vicissitudes of a tropical climate. Excluding the special rice-growing tracts, varieties of millet are grown more extensively than any other crop from Madras, in the south, at least as far as Rájputána, in the north. The two most common kinds are great millet (*Holcus Sorghum* or *Sorghum vulgare*), known as *joár* or *jawárí* in the languages derived from the Sanskrit, as *jonna* in Telugu, and as *cholam* in Tamil; and spiked millet (*Holcus spicatus* vel *Penicillaria spicata*), called *bájra* in the north and *kambu* in the south. In Mysore and the neighbouring districts *rágí* (*Eleusine coracana*), called *náchani* in Bombay, takes the first place. According to the Madras system of classification, these millets all rank as "dry crops," being watered only by the local rainfall, and sown under either monsoon; farther north, they are classed with the *kharíf* or autumn harvest, as opposed to wheat. Indian corn is cultivated to a limited extent in all parts of the country; barley, in the upper valley of the Ganges, throughout the Punjab, and in Himálayan valleys; oats, only as an experimental crop by Europeans. *Joár* and *rágí*, but not *bájra*, are invaluable as fodder for cattle.

Oil-seeds. Oil-seeds also form an important crop in all parts of the country, being perhaps more universally grown than any other, as oil is necessary, according to native customs, for application to the person, for food, and for burning in lamps. In recent years the cultivation of oil-seeds has received an extraordinary stimulus owing to the demand for export to Europe, especially to France; but as they can be grown after rice, &c., as a second crop, this increase has hardly at all tended to diminish the production of food grains. The four chief varieties grown are mustard or rape seed, linseed, *tíl* or gingelly (sesamum), and castor-oil. Bengal and the North-Western Provinces are at present the chief sources of supply for the foreign demand, but gingelly is largely exported from Madras, and, to a smaller extent, from Burmah.

Vegetables. Vegetables are everywhere cultivated in garden plots for household use, and also on a larger scale in the neighbourhood of great towns. Among favourite native vegetables, the following may be mentioned:—the egg-plant, called *brinjal* or *baigan* (*Solanum Melongena*), potatoes, cabbages, cauliflower, radishes, onions, garlic, turnips, yams, and a great variety of cucurbitaceous plants, including *Cucumis sativus*, *Cucurbita maxima*, *Lagenaria vulgaris*, *Trichosanthes dioica*, and *Benincasa cerifera*. Of these, potatoes, cabbages, and turnips are of recent introduction. Almost all English vegetables can be raised by a careful gardener. Potatoes thrive best on the higher elevations, such as the Khásí hills, the Nílgiris, the Mysore uplands, and the slopes of the Himálayas; but they are also grown even in lowland districts. They were first introduced into the Khásí hills in 1830, and they now constitute the principal crop, the annual export to the Calcutta market being more than 7000 tons, valued at £50,000.

Fruits. Among cultivated fruits are the following:—Mango (*Mangifera indica*), plantain (*Musa paradisiaca*), pine-apple (*Ananassa sativa*), pomegranate (*Punica Granatum*), guava (*Psidium pomiferum* et *P. pyriferum*), tamarind (*Tamarindus indica*), jack (*Artocarpus integrifolia*), custard-apple (*Anona squamosa*), papaw (*Carica Papaya*), shaddock (*Citrus decumana*), and several varieties of fig, melon, orange, lime, and citron. According to the universal verdict of Europeans, no native fruits can compare with those of England. But the mangoes of Bombay, of Múltán, and of Maldah in Bengal, and the oranges of the Khásí hills, enjoy a high reputation; while the guavas of Madras are made into an excellent preserve.

Spices. Among spices, for the preparation of curry and other hot dishes, turmeric and chillies hold the first place, being very generally cultivated. Next in importance come ginger, coriander, aniseed, black cummin, and fenugreek. Pepper proper is confined to the Malabar coast, from Kánara to Travancore. Cardamoms are a valuable crop in the same locality, and also in the Nepálese Himálayas. *Pán* or betel-leaf is grown by a special caste in most parts of the country. Its cultivation requires constant care, but is highly remunerative. Betel-nut or areca is chiefly grown in certain favoured localities, such as the deltaic districts of Bengal and the highlands of southern India.

Palms. Besides betel-nut (*Areca Catechu*), the palms of India include the cocoa-nut (*Cocos nucifera*), the bastard date (*Phœnix sylvestris*), the palmyra (*Borassus flabelliformis*), and the true date (*Phœnix dactylifera*). The cocoa-nut, which loves a sandy soil and a moist climate, is found in greatest perfection along the strip of coast-line that fringes the west of the peninsula, where it ranks next to rice as the staple product. The bastard date, grown chiefly in the country round Calcutta and in the north-east of the Madras presidency, supplies both the jaggery sugar of commerce and intoxicating liquors for local consumption. Spirit is also distilled from the palmyra, especially in the neighbourhood of Bombay and in the south-east of Madras. The true date is almost confined to Sind.

Sugar. Sugar is manufactured both from the sugar-cane and from the bastard date-palm, but the total production is inadequate to the local demand. The best cane is grown in the North-Western Provinces, on irrigated land. It is an expensive crop, requiring much attention, and not yielding a return within the year; but the profits are proportionately large. In Bengal the manufacture of sugar for exportation has declined during the century; but in Jessor district the preparation of date-sugar is a thriving and popular industry. The manufacture of sugar is everywhere in the hands of natives, except in the case of the Aska factory in the Madras district of Ganjám, and the Ashtagrám factory in Mysore. Both these factories, which use sugar-cane and not date, have received honourable notice at exhibitions in Europe.

Cotton. Cotton holds the first place among agricultural products grown for export. From the earliest times, cotton has been grown in sufficient quantities to meet the local demand, and even in the last century there was some slight export which was carefully fostered by the East India Company. But the present importance of the crop dates only from the crisis in Lancashire caused by the American War. Prior to 1860 the exports of raw cotton from India used to average less than 3 millions sterling a year; but after that date they rose by leaps, until in 1866 they reached the enormous total of 37 millions. Then came the crash, caused by the restoration of peace in the United States, and the exports fell, until they now average little more than 8 millions a year. The fact is that Indian cotton has a short staple, and cannot compete with the best American cotton for spinning the finer qualities of yarn. But while the cotton famine was at its height, the cultivators were intelligent enough to make the most of their opportunity. The area under cotton increased enormously, and the growers managed to retain in their own hands a fair share of the profit.

Cotton-growing tracts. The principal cotton-growing tracts are the plains of Guzerat and Káthiáwár, whence Indian cotton has received in the Liverpool market the historic name of Surat; the highlands of the Deccan; and the deep valleys of the Central Provinces and Berar. The best native varieties are found in the Central Provinces and Berar, passing under the trade names of Hinganghát and Amráoti. These varieties have been successfully introduced into the Bombay district of Khándesh. Experiments with seed from New Orleans have been conducted for several years past on the Government farms in many parts of India; but it cannot be said that they have resulted in success except in the Bombay district of Dhárwár, where exotic cotton has now generally supplanted the indigenous staple. In 1875–76 the total area under cotton in the Bombay presidency, including Sind and the native states, amounted to 4,516,587 acres, with a yield of 2,142,835 cwts. Of this total, 583,854 acres, or 13 per cent., were sown with exotic cotton, including that from the Central Provinces and also that from New Orleans, with a yield of 248,767 cwts. The average yield was about 53 lb of cleaned cotton per acre, the highest being in Sind and Guzerat, and the lowest in the southern Marhattá country. In the same year the total exports were 3,887,808 cwts., valued at £10,673,761. In 1877–78 the area under cotton in the Central Provinces was 837,083 acres, or 5 per cent. of the total cultivated area, chiefly in the districts of Wárdhá, Nágpur, and Ráipur. The average yield was about 59 lb per acre. The total exports to Bombay, including re-exports from Berar, were about 300,000 cwts., chiefly in compressed bales, valued at £672,000. In the same year the area under cotton in Berar was 2,078,273 acres, or 32 per cent. of the total cultivated area, chiefly in the two districts of Akola and Amráoti. The average yield was as high as 67 lb of cleaned cotton per acre. The total export was valued at £2,354,946, almost entirely railway-borne. In Madras the average area under cotton is about 1,500,000 acres, chiefly in the upland districts of Bellary and Karnúl, and the low plains of Kistna and Tinnevelli. The total exports in 1875–76 were 733,420 cwts., valued at £1,652,849. In Bengal the cultivation of cotton is on the decline. The local demand is satisfied by imports from the North-Western Provinces and from the bordering hill tracts, where a very short-stapled variety of cotton is extensively cultivated. The total area under cotton in Bengal is estimated at only 162,000 acres, yielding 138,000 cwts. of cleaned cotton. Of this, 31,000 acres were in Sáran, 28,000 in the Chittagong hill tracts, and 20,000 in Cuttack. Throughout the North-Western Provinces, and also the Punjab, sufficient cotton is grown to meet the wants of the village weavers. The total exports of raw cotton from Indian ports in 1878–79 were 2,966,569 cwts., valued at £7,914,091, besides cotton twist and yarn to the value of £937,698, and cotton manufactures valued at £1,644,125.

Jute. Jute ranks next after cotton as a fibre crop. The extension of its cultivation has been equally rapid, and it is yet more limited in its area, being confined to northern and eastern Bengal. In this tract, which extends from Purniah to Goálpárá, north of the Ganges for the most part, and along both banks of the Brahmaputra, jute is grown on almost every variety of soil. The chief characteristic of the cultivation is that it remains entirely under the control of the cultivator. Practically a peasant proprietor, he increases or diminishes his cultivation according to the state of the market, and keeps the profits in his own hands. The demand for jute in Europe has contributed more than any administrative reform to raise the average standard of comfort throughout eastern Bengal. In 1872, when speculation was briskest, it is estimated that about 1 million acres were under jute, distributed over sixteen districts, which had a total cultivable area of 23 million acres. The total export from Calcutta in that year was about 7 million cwts., valued at £4,142,548. Both quantities and prices have since somewhat declined, but the business remains on a stable footing. In 1878–79 the total export of raw jute from India was 6,021,382 cwts., valued at £3,800,426, besides jute manufactures to the value of £1,098,434.

Indigo. Indigo, though relatively of less importance than formerly, is still the foremost staple grown by European capital. In Bengal Proper its cultivation has greatly declined since the early years of this century. English planters have abandoned the districts of Húglí (Hooghly), the Twenty-four Parganás, Dacca, Farídpur, Rangpur, and Pabná, which are dotted with the sites of ruined factories. In Nadiyá, Jessor, Murshidábád, and Maldah, the industry is still carried on, but it has not recovered from the depression caused by the indigo riots of 1860, and the emancipation of the peasantry by the Land Act of 1859. Dye of superior quality is manufactured in Midnapur, along the frontier of the hill tracts. But indigo cultivation on the old scale still flourishes in North Behar, from which is derived one-half of the total exports from Calcutta. No accurate statistics of area are available; but in Tirhut alone there are fifty-six principal concerns, with seventy outworks, producing annually about 20,000 *maunds* of dye; in Sáran, thirty principal concerns and twenty-five outworks, producing about 12,000 *maunds*; in Champáran, seven large concerns, producing also 12,000 *maunds*.[1] It has been estimated that the total amount of money annually distributed by the planters of North Behar cannot be less than 1 million sterling. Across the border, in the North-Western Provinces, indigo is grown and manufactured to a considerable extent by native cultivators. In the Punjab, also, indigo is an important crop, especially in the districts of Múltán, Muzaffargarh, and Derá Ghází Khán. In Madras, where it is grown and manufactured entirely by the natives, the total area under indigo is about 300,000 acres, chiefly in the north-east of the presidency, extending along the coast from Kistna to South Arcot, and inland to Karnúl and Cuddapah. The exports of indigo from all India in 1878–79 amounted to 105,051 cwts., of the value of £2,960,463.

Opium. The opium of commerce is grown and manufactured in two special tracts,—(1) the valley of the Ganges round Patná and Benares, and (2) a fertile table-land in Central India, corresponding to the old kingdom of Máwá, for the most part still under the rule of native chiefs, among whom Sindhia and Holkar rank first. In the latter of these two regions the cultivation of poppy is free, and the duty is levied as the opium passes through the British presidency of Bombay; in the former, the cultivation is a strict Government monopoly. Opium is also grown for local consumption throughout Rájputána, and to a very limited extent in the Punjab and the Central Provinces. Throughout the rest of India it is absolutely prohibited. In the Ganges valley, the cultivation is supervised from two agencies, with their headquarters at Patná and Gházípur, at which two towns alone the manufacture is conducted. In 1872 the total area under poppy was 560,000 acres; the number of chests of opium sold was 42,675; and the sum realized was £6,067,701, giving a net revenue of £4,259,376. The whole of this was exported from Calcutta to China and the Straits Settlements. The amount of opium grown in native states and exported from Bombay is about equal, thus raising the average exports of opium to about 12 millions sterling, of which about 7½ millions represent net profit to Government. In 1878–79, 91,200 chests of opium were exported, of the value of £12,993,985, of which £7,700,000 represented the net profit to Government.

Bengal system. Under the Bengal system annual engagements are entered into by the cultivators to sow a certain quantity of land with poppy; and it is a fundamental principle that they may agree or refuse to engage as they please. As with most other Indian industries, a pecuniary advance is made to the cultivator before he commences operations, which is balanced when he delivers over the opium at the subordinate agencies. He is compelled to deliver his whole produce, being paid at a fixed rate according to quality. In the beginning of April the cultivators bring in their opium to the subordinate Government agencies, where it is examined and weighed, and the accounts are settled. The final process of preparing the drug in balls for the Chinese market is conducted at the two central Government agencies at Patná and Ghazípur. This generally lasts until the end of July, but the balls are not dry enough to be packed in chests until October.

[1] The factory *maund* of indigo weighs 74 lb 10 oz.

Tobacco. Tobacco is grown in every district of India for local consumption. The soil and climate are favourable; but up to the present time the quality of native-cured tobacco is so inferior that it finds no market in Europe. The principal tobacco-growing tracts are Rangpur and Tirhut in Bengal, Kaira in Bombay, and the delta of the Godávari and Coimbatore and Madura districts in Madras. The two last-mentioned districts supply the raw material for the well-known "Trichinopoli cheroot," almost the only form of Indian tobacco that finds any favour with Europeans; the produce of the *lánkás* or alluvial islands in the Godávari is manufactured into "coconadas." The tobacco of northern Bengal is largely exported to British Burmah, for the Burmese, who are great smokers, do not grow sufficient for their own needs. In the year 1876–77 the total registered imports of tobacco into Calcutta were 400,000 cwt., valued at £261,000, of which more than half came from the single district of Rangpur. Tobacco is also grown for export in the hill tracts of Chittagong. The tobacco of Tirhut is chiefly exported towards the west. The total area under tobacco in that district is estimated at 40,000 acres, the best quality being grown in *parganá* Saressa of the Tájpur subdivision.

Since 1875 a private firm of capitalists, backed by Government support, has begun to grow tobacco and manufacture it for the European market. The scene of operations is two abandoned stud-farms at Gházípur in the North-Western Provinces, and at Pusa in the Bengal district of Tirhut. In the year 1878–79 about 240 acres in all were cultivated with tobacco, and the total crop was about 160,000 lb. No less than five English or American curers were employed. Some of the produce was exported to England as "cured leaf"; but the larger part was put upon the Indian market in the form of "manufactured smoking mixture." This mixture is in demand at regimental messes and canteens, and has already found its way to Australia. The enterprise may now be said to have passed beyond the stage of experiment, and has probably opened a new sphere alike for Indian agriculture and European capital. The one essential condition of success is skilled supervision in the delicate processes of tobacco-curing. Tobacco to the value of £128,239 was exported from India in 1878–79.

Coffee. The cultivation of coffee is confined to southern India, though attempts have been made to introduce the plant both into British Burmah and into the Bengal district of Chittagong. The coffee tract may be roughly defined as a section of the landward slope of the Western Gháts, extending from Kánara in the north to Travancore in the extreme south. That tract includes almost the whole of Coorg, the districts of Kádur and Hassan in Mysore, and the Nílgiri hills, enlarged by the recent annexation of the Wainád. Within the last few years the cultivation has extended to the Shevaroy hills in Salem district, and to the Palni hills in Madura.

Unlike tea, coffee was not introduced into India by European enterprise; and even to the present day its cultivation is largely followed by the natives. The Malabar coast has always enjoyed a direct commerce with Arabia, and at an early date gave many converts to Islám. One of these converts, Bába Budan by name, is said to have gone on a pilgrimage to Mecca and to have brought back with him the coffee berry, which he planted on the hill range in Mysore still called after him. According to local tradition this happened about two centuries ago. The shrubs thus sown lived on, but the cultivation did not spread until the beginning of the present century. The state of Mysore and the Bába Budan range also witnessed the first opening of a coffee-garden by an English planter about 1840. The success of this experiment led to the extension of coffee cultivation into the neighbouring tract of Manjarábád, also in Mysore, and into the Wainád subdivision of the Madras district of Malabar. From 1840 to 1860 the enterprise made slow progress; but since the latter date it has spread with great rapidity along the whole line of the Western Gháts, clearing away the primæval forest, and opening a new era of prosperity to the labouring classes. The following statistics show the area under coffee for the year 1877–78:—in Mysore, 128,438 acres, almost confined to the two districts of Hassan and Kádur; in Madras, 58,988 acres, chiefly in Malabar, the Nílgiris, and Salem; in Coorg, 45,150 acres; total, 232,576 acres, exclusive of Travancore. The average rate of produce is estimated at about 3 cwts. per acre of mature plant. The total export of coffee in 1878–79 was 342,268 cwts., valued at £1,548,481.

Tea. The cultivation of tea in India commenced within the memory of men still living in 1881, and the industry now rivals indigo as a field for European capital. Unlike coffee-planting the enterprise owes its origin to the initiation of Government, and has never attracted the attention of the natives. Early travellers reported that the tea-plant was indigenous to the southern valleys of the Himálayas; but they were mistaken in the identity of the shrub, which was the *Osyris nepalensis*. The real tea (*Thea viridis*), a plant akin to the camellia, grows wild in Assam, being commonly found throughout the hilly tract between the valleys of the Brahmaputra and the Bárak. There it sometimes attains the dimensions of a large tree; and from that, as well as from other indications, it has been plausibly inferred that Assam is the original home of the plant, which was thence introduced at a prehistoric date into China. The real progress of tea-planting in Assam dates from about 1851, and was greatly assisted by the promulgation of the Waste-land Rules of 1854. By 1859 there were already fifty-one gardens in existence, owned by private individuals; and the enterprise had extended from its original headquarters in Lakhimpur and Síbságar as far down the Brahmaputra as Kámrúp. In 1856 the tea-plant was discovered wild in the district of Cáchár in the Bárak valley, and European capital was at once directed to that quarter. At about the same time tea-planting was introduced into the neighbourhood of the sanatorium of Dárjíling (Darjeeling), among the Sikkim Himálayas. The success of these undertakings engendered a wild spirit of speculation in tea companies both in India and at home, which reached its climax in 1865. The industry recovered but slowly from the effects of this disastrous crisis, and did not again reach a stable position until 1869. Since that date it has rapidly but steadily progressed, and has been ever opening new fields of enterprise. At the head of the Bay of Bengal in Chittagong district, side by side with coffee on the Nílgiri hills, on the forest-clad slopes of Chutiá Nágpur, amid the low-lying jungle of the Bhután Dwars, and even in Arakan, the energetic pioneers of tea-planting have established their industry. Different degrees of success may have rewarded them, but in no case have they abandoned the struggle. The market for Indian tea is practically inexhaustible. There is no reason to suppose that all the suitable localities for its growth have yet been tried; and we may look forward to the day when India shall not only rival but supersede China in her staple product. (Tea-growing tracts.)

The following statistics, unless it is otherwise stated, refer to the year 1877–78:—

The total area taken up for tea cultivation in Assam, including both the Brahmaputra and the Bárak valleys, was 736,082 acres, of which 538,961 acres were fit for cultivation; the total number of separate estates was 1718; the total out-turn was 23,352,298 lb, at the average rate of 286 lb per acre under mature plant. In Bengal, the area taken up was 62,642 acres, of which 20,462 acres were under mature plant, including 18,120 acres in the single district of Dárjíling; the number of gardens was 221; the out-turn was 5,768,654 lb, at the rate of 282 lb per acre under mature plant. In the North-Western Provinces, there were, in 1876, 25 estates in the districts of Kumáun and Garhwál, with an out-turn of 578,000 lb, of which 350,000 lb were sold in India to Central Asia merchants; and in 1871, 19 estates in Dehra Dún, with 2024 acres under tea, and an out-turn of 297,828 lb. In the Punjab, there were 10,046 acres under tea, almost entirely confined to Kángrá district, with an out-turn of 1,113,106 lb, or 111 lb per acre. In Madras, the area under tea on the Nílgiris was 3160 acres; the exports from the presidency were 183,178 lb, valued at £19,308. Excluding the figures just given for Madras, the whole of the Indian tea is shipped from the port of Calcutta, and almost the whole is sent to the United Kingdom. The total exports for 1878–79 were 34,800,027 lb, valued at £3,170,118. Of the total supply, about 26,000,000 lb came from Assam, about 8,000,000 lb from Bengal, 787,000 lb from the North-Western Provinces, and 684,000 lb from the Punjab. In the previous year the exports of tea from the Punjab to Central Asia were returned at 1,217,840 lb, valued at £181,634, being a considerable decrease on the year before. (Area and out-turn of tea.)

Approximate Area in Acres occupied by the Principal Crops in some Indian Provinces in 1877-1878.

	Madras.	Bombay (exclud. Sind).	Sind.	Punjab.	Central Provinces.	British Burmah.	Mysore.	Berar.
Rice	4,600,000	1,195,000	512,000	400,000	4,550,000	2,555,000	540,000	31,000
Wheat	16,000	561,000	354,000	7,000,000	3,600,000	...	11,000	525,000
Millets and inferior grains	10,600,000	5,800,000	934,000	6,000,000	} 5,140,000	...	3,400,000	} 2,760,000
Pulses	1,600,000	830,000	115,000	3,200,000				180,000
Oil-seeds	800,000	628,000	180,000	800,000	1,360,000	15,000	130,000	460,000
Cotton	1,000,000	1,350,000	70,000	660,000	840,000	10,000	15,000	2,080,000
Tobacco	60,000	35,000	6,000	80,000	48,000	17,000	19,000	17,000
Indigo	120,000	14,000	10,000	110,000	...	700	...	...
Sugar-cane	21,000	50,000	4,000	380,000	100,000	4,000	13,000	5,000

The introduction of the quinine-yielding cinchona into India is a remarkable example of success rewarding the indefatigable exertions of a single man. When Mr Clements Markham undertook the task of transporting the seedlings from South America in 1860, cinchona had never before been reared artificially. But the novel experiment in arboriculture has not only been successfully conducted, but has proved remunerative from a pecuniary point of view. A cheap febrifuge has been provided, in the form of the mixed cinchona alkaloids, for the fever-stricken population of the Indian plains, while the surplus bark sold in Europe more than repays interest upon the capital expended. These results have been produced from an expenditure of about £100,000. The headquarters of cinchona cultivation are on the Nílgiri hills, where Government owns several plantations covering an aggregate of about 1000 acres, with about 570,000 full-grown plants. From the Government plantations cinchona seeds and plants are annually distributed to the public in large quantities; and there are now several private plantations rivalling the Government estates in area, and understood to be very valuable properties. The varieties of cinchona most commonly cultivated are *C. officinalis* and *C. succirubra*; but experiments are being conducted with *C. Calisaya*, *C. pubescens*, *C. lanceolata*, and *C. pitayensis*. When the success of the enterprise was secure, Government somewhat curtailed the extent of its own operations. No fresh land was taken up, but the plantations were kept free from weeds. The quinologist's department was abolished, and the bark sold in its raw state. From the central establishment on the Nílgiris cinchona has been introduced into the Palni hills in Madura district, into the Wainád, and into the state of Travancore. Plantations have also been successfully opened by Government near Merkara in Coorg, on the Bába Budan hills in Mysore, and in Sitang district in British Burmah. Failure has attended the experiments made at Mahábaleshwar in the Bombay presidency, and at Nongklao in the Khásí hills, Assam. But the success of the Government plantation at Dárjíling, in northern Bengal, rivals that of the original plantation on the Nílgiris. The area has been gradually extended to more than 2000 acres, and the bark is manufactured into quinine on the spot by a Government quinologist. The species mostly grown is *C. succirubra*, which supplies a red-coloured bark, rich in its total yield of alkaloids but comparatively poor in quinine proper. Efforts are being made to increase the cultivation of *C. Calisaya*, which yields the more valuable bark, but is difficult to propagate.

The following are the financial results of the two Government plantations in 1877–78. On the Nílgiris the crop was 138,808 ℔, of which 132,951 ℔ were shipped to England, and the rest supplied to the Madras and Bombay medical departments. The total receipts were £35,875, and the total expenditure £6977, thus showing a net profit of £28,898. At Dárjíling the crop amounted to 344,225 ℔ of bark, which was all handed over to the quinologist, and yielded 5162 ℔ of the febrifuge. The total receipts were £9707, of which £6188 represents the amount debited to Government departments for the sale of febrifuge and bark, while £3519 was derived from sales to the public. The total expenditure was £8554, of which £5790 was expended upon the plantation, and £2764 on the quinologist's department. The net profit, therefore, was £1153, which is expected shortly to rise to £4000 a year, as more of the young plants come into bearing.

Silk.—Sericulture in India is a stationary, if not a declining, industry. The large production in China, Japan, and Silk. the Mediterranean countries controls the European markets, and on an average of years the imports of raw silk into India now exceed the exports. The East India Company from the first took great pains to foster the production of silk. As early as 1767, two years after the grant of the financial administration of Bengal had been conferred upon the Company, we find the governor, Mr Verelst, personally urging the *zamíndárs*, gathered at Murshidábád for the ceremony of the *púnyá*, "to give all possible encouragement to the cultivation of mulberry." In 1769 a colony of reelers was brought from Italy to teach the system followed in the filatures at Novi. The first silk prepared in the Italian method reached England in 1772, and Bengal silk soon became an important article of export. Similar efforts started at Madras in 1793 were abandoned after a trial of five years. Sericulture is said to have been introduced into Mysore by Tipú Sultán, and for many years continued to prosper. But recently the worms have been afflicted by a mysterious epidemic; and despite the enterprise of an Italian gentleman who imported fresh broods from Japan, the business has dwindled to insignificance. Bengal has always been the chief seat of mulberry cultivation. When the trading operations of the Company ceased in 1833, they owned eleven head factories in that province, each supplied by numerous filatures to which the cultivators brought in their cocoons. The annual export of raw silk from Calcutta was then about 1 million ℔. But in those days the weaving of silk formed a large portion of the business of the factories. In 1779 Rennel wrote that at Kasímbázár (Cossimbazar) alone about 400,000 ℔ were consumed in the several European factories. In 1802 Lord Valentia describes Jangipur as "the greatest silk station of the Company, with 600 furnaces, and giving employment to 3000 persons."

When the Company abandoned trade on its own account, sericulture was forthwith taken up by private enterprise, and it still clings to its old headquarters. At the present time the cultivation of the mulberry is mainly confined to the Rájsháhí and Bardwán divisions of Lower Bengal. That branch of agriculture, together with the rearing of the silk-worms, is conducted by the peasantry themselves, who are free to follow or abandon the business. The destination of the cocoons is twofold. They may either be sent to small native filatures, where the silk is roughly wound before being consumed in the hand-looms of the country; or they may be brought to the great European factories, which generally use steam machinery and consign their produce direct to Europe.

The cultivation of the mulberry is chiefly carried on in the districts of Rájsháhí, Bográ, Maldah, Murshidábád, Bírbhúm, Bardwán, and Midnapur. No accurate statistics are available, but in Rájsháhí alone the area under mulberry is estimated at 80,000 acres. The variety grown as food for the silk-worms is not the fruit-tree that is common in England, but a comparatively small shrub.

Silk-worms.

Besides the silk-worm proper (*Bombyx mori*), fed upon the mulberry, several other species of silk-yielding worms abound in the jungles of India, and are utilized, and in some cases domesticated, by the natives. Throughout Assam especially, an inferior silk, produced in this way, has from time immemorial furnished the common dress of the people. These "wild silks" are known to commerce under the generic name of *tasar* or *tusser*, but they are really the produce of several distinct varieties of worm, fed on many different trees. The worm that yields *tasar* silk in Chutiá Nágpur has been identified as the caterpillar of *Antheræa paphia*. When wild, it feeds indiscriminately upon the *sál* (*Shorea robusta*), *baer* (*Zizyphus Jujuba*), and other forest trees; but in a state of semi-domestication it is exclusively reared upon the *ásan* (*Terminalia alata*), which grows conveniently in clumps. The cocoons are sometimes collected in the jungle, but more frequently bred from an earlier generation of jungle cocoons. The worms require constant attention while feeding to protect them from crows and other birds. They give three crops in the year—in August, November, and May—of which the second is by far the most important. The *tasar* silk-worm is also found and utilized throughout the Central Provinces, in the hills of the Bombay presidency, and along the southern slope of the Himálayas. During the past twenty years repeated attempts have been made to raise this industry out of its precarious condition, and to introduce *tasar* silk into the European market. That the raw material abounds is certain, but the great difficulty is to obtain it in a state that will be acceptable to European manufacturers. Native spun silk is only fit for native hand-looms. In Assam two distinct qualities of silk are made, known as *eriá* and *mugá*. The former is obtained from the cocoons of *Phalæna cynthia*, and the worm is fed, as the native name implies, upon the leaves of the castor-oil plant (*Ricinus communis*). This variety may be said to be entirely domesticated, being reared indoors. *Mugá* silk is obtained from the cocoons of *Saturnia assamungis*. The moth, which is remarkable for its size, is found wild in the jungle, but the breed is so far domesticated that cocoons are brought from one part of the province to another, and the *súm* tree is artificially propagated to supply the worms with food. Raw silk was exported in 1878–79 to the extent of 1,534,715 lb, valued at £623,871, besides manufactured silk of the value of £195,897.

Lac.

The collection of lac is in a somewhat similar position to that of *tasar* silk. The lac insect abounds on certain jungle trees in every part of the country, and from time immemorial it has been collected by the wild tribes in order to be worked up into lacquered ware. European enterprise has tried, with small success, to place the industry upon a stable and remunerative basis. Though lac is to be found everywhere, the foreign exports are almost entirely confined to Calcutta, which draws its supplies from the hills of Chutiá Nágpur, and to a less degree from Assam and Mírzápur in the North-Western Provinces. Lac is known to commerce both as a gum (shellac) and as a dye. The total exports in 1879 were 91,983 cwts., valued at £300,072.

Farming.

Farming.—The efforts of Government to improve the native methods of agriculture, by the establishment of model farms under skilled European supervision, have not been generally successful.[1]

Cattle.

Stock.—Throughout the whole of India, except in Sind and the western districts of the Punjab, horned cattle are the only beasts used for ploughing. The well-known humped breed of cattle predominates everywhere, being divided into many varieties. Owing partly to unfavourable conditions of climate and soil, partly to the insufficiency of grazing ground, and partly to the want of selection in breeding, the general condition of the cattle is miserably poor. As cultivation advances, the area of waste land available for grazing steadily diminishes, and the prospects of the poor beasts are becoming worse rather than better. Their only hope lies in the introduction of fodder crops as a regular stage in the agricultural course. There are, however, some fine breeds in existence. In Mysore the *amrit mahál*, a breed said to have been introduced by Hyder Alí for military purposes, is still kept up by Government. In the Madras districts of Nellore and Karnúl the indigenous breed has been greatly improved under the stimulus of cattle shows and prizes, founded by British officials. In the Central Provinces there is a peculiar breed of trotting bullocks which is in great demand for wheeled carriages. The large and handsome oxen of Guzerat in Bombay and of Hariáná in the Punjab are excellently adapted for drawing heavy loads in a sandy soil. The worst cattle are to be found always in the deltaic tracts, but there their place is to a large extent taken by buffaloes. These last are Buf more hardy than ordinary cattle; their character is maintained by crossing the cows with wild bulls, and their milk yields the best *ghí*, or clarified butter. In British Burmah, the returns show that the total number of buffaloes is just equal to that of cows and bullocks, being about 700,000. Along the valley of the Indus, and in the sandy desert Can which stretches into Rájputána, camels supersede cattle for agricultural operations. In the Punjab, the total estimated number of camels is 170,000. The breed of Hor horses has generally deteriorated since the demand for military purposes has declined with the establishment of British supremacy. In Bengal Proper, and also in Madras, it may be broadly said that horses are not bred. The chief breeds in Bombay are those of the Deccan and of Káthiáwár, in both of which provinces Government maintains establishments of stallions. The Punjab, however, is the chief source of remounts for the cavalry regiments, the total number of horses in that province being returned at 80,000, in addition to 50,000 ponies. About the beginning of the present century, a stud department was organized to breed horses for the use of the Bengal army, but this system was abolished as extravagant and inefficient under the governor-generalship of Lord Mayo. Remounts are now obtained in the open market; but the Government of the Punjab still maintains about 130 stallions, including 60 imported from England and 40 Arabs. The best horses are bred by the Baluchí tribes along the western frontier. The best ponies come from Burmah, Manipur (the original home of the now well-known game of polo), and Bhután. Four great horse fairs are held in the year—at Ráwal Pindí, Derá Ghází Khán, Jhang, and Derá Ismáil Khán—at which about 4500 horses were exhibited in 1877–78, and a total sum of about £1300 was awarded in prizes; the average price given for native cavalry remounts was only £17. In recent years much attention has been paid in the Punjab to the breeding of mules for military purposes; and the value of Mul these animals was conspicuously proved in the course of

[1] Model farms have been abandoned in Bengal, in Assam, and in the Punjab. In the North-Western Provinces valuable experiments are prosecuted. In Bombay there are three model farms, and in the Central Provinces one, on which the common crops of the country are raised at a loss. The Saidapet farm, near the city of Madras, is the only establishment at which important experiments have been conducted on a scale and with a perseverance sufficient to yield results of value. This farm was started by the governor, Sir William Denison, in 1865, and has been for the past nine years under the management of Mr Robertson. It now (1881) covers an area of 250 acres in a ring fence. Many important experiments have been made, of which some have produced encouraging results, indicating the general direction in which improvements may be effected in the agricultural practice of the presidency. It has been proved that many of the common "dry crops" can be profitably cultivated for fodder at all seasons of the year. Those most strongly recommended are yellow cholam (*Sorghum vulgare*), guinea grass (*Panicum jumentaceum*), and horse-gram (*Dolichus uniflorus*). Sugar-cane and rice also yield excellent fodder when cut green. Attention has also been given to subsoil drainage, deep ploughing, the fertilizing powers of various manures, and the proper utilization of irrigation water. It has been decided to establish a school of agriculture at Saidapet in connexion with the model farm, with subordinate branches in the districts, so as to diffuse as widely as possible the agricultural lessons that have been already learned. In the year 1877–78 the total expenditure at Saidapet on both farm and school of agriculture was about £6000.

the operations in Afghánistán in 1879–80. Government maintains about fifty donkey stallions, of which four were imported from Spain, twenty-eight from Arabia, and twelve from Bokhara. Some of the mules bred reach the height of 15 hands. The catching of elephants is now a Government monopoly or under Government supervision, except in Malabar and Travancore where the old proprietors retain the right. The chief source of supply is the north-east frontier, especially the range of hills running between the valleys of the Brahmaputra and the Bárak (see *ante*, p. 742). Sheep and goats are commonly reared in the wilder parts of the country for the sake of their wool. Both their weight for the butcher and their yield of wool are exceedingly low. In Mysore, and with considerable success at the Saidapet farm, attempts have been made to improve the breed of sheep by crossing with merino rams. Pigs of great size and most repulsive appearance are reared, and eaten by the lowest of out-castes.

Sheep and goats.

Approximate Numbers of Agricultural Stock and Implements in some Indian Provinces in 1877–1878.

	Madras	Bombay and Sind.	Punjab.	Central Provinces.	British Burmah.	Mysore.	Berar.
Bullocks	3,500,000	3,300,000	6,570,000	5,200,000	714,000	2,300,000	1,400,000
Cows	3,000,000	2,380,000					
Buffaloes	1,332,000	1,630,000			662,000		
Horses	21,500	150,000	85,000	12,000	5,800	4,900	6,500
Ponies	18,000		52,000	82,000		14,000	26,000
Donkeys	128,000	90,000	290,000	22,000	...	37,000	17,000
Camels	45	...	170,000	7	...	...	...
Elephants	604	...	...	...	1,324	...	...
Sheep	4,600,000	3,300,000	3,850,000	641,000	20,000	1,590,000	386,000
Goats	2,700,000						
Pigs	250,000	...	...	132,000	102,000	32,000	2,700
Carts	284,000	380,000	98,000	286,000	194,000	83,000	89,000
Ploughs	2,023,000	1,080,000	1,747,000	764,000	293,000	558,000	115,000

The forests of India, both as a source of natural wealth and as a department of the administration, are beginning to receive their proper share of attention. Up to a recent date the destruction of forests by timber cutters, by charcoal burners, and above all by nomadic cultivation, was allowed to go on everywhere unchecked. The extension of cultivation was considered as the chief care of Government, and no regard was paid to the improvident waste going on on all sides. But as the pressure of population on the soil became more dense, and the construction of railways increased the demand for fuel, the question of forest conservation forced itself into notice. It was recognized that the inheritance of future generations was being recklessly sacrificed to satisfy the immoderate desire for profit. And at the same time the importance of forests as affecting the general meteorology of a country was being learned from bitter experience in Europe. On many grounds, therefore, it became necessary to preserve what remained of the forests in India, and to repair the mischief of previous neglect even at considerable expense. In 1844 and 1847 the subject was actively taken up by the Governments of Bombay and Madras. In 1864 Dr Brandis was appointed inspector-general of forests to the Government of India, and in the following year an act of the legislature was passed (No. VII. of 1865). The regular training of candidates for the Forest Department in the schools of France and Germany dates from 1867. In the short interval that has since elapsed, sound principles of forest administration have been gradually extended. Indiscriminate timber-cutting has been prohibited, the burning of the jungle by the hill tribes has been confined within bounds, large areas have been surveyed and demarcated, plantations have been laid out, and, generally, forest conservation has become a reality.

From the point of view of administration, the forests are classified as "reserved" or "open." The reserved forests are those under the immediate control of officers of the Forest Department; they are managed as the property of the state, with a single eye to conservancy and their future development as a source of national wealth. Their limits are demarcated after survey, nomadic cultivation by the hill tribes is prohibited, cattle are excluded from grazing, destructive creepers are cut down, and the hewing of timber, if permitted at all, is placed under stringent regulations. The open forests are less carefully guarded; but in them also certain kinds of timber-trees are preserved. A third class of forest lands consists of plantations, on which large sums of money are spent annually. It is impossible to present in a single view the entire result of the labours of the Forest Department. In 1872–73 the total area of reserved forests in India was estimated at more than 6,000,000 acres; and the area has probably been doubled since that date. In the same year the total forest revenue was £477,000, as compared with an expenditure of £295,000, thus showing a surplus of £182,000. By 1877–78 the revenue had increased to £664,102, of which £160,308 was derived from British Burmah, and £126,163 from Bombay. The forest exports in that year included—teak, valued at £406,652; lac and lac-dye, £362,008; caoutchouc, £89,381; and gums, £183,685. But no figures that can be given exhibit adequately the labour and the benefits of the Forest Department, which is gradually winning back for the country the fee-simple of her forest wealth, when it was on the point of being squandered beyond possibility of redemption.

Nomadic cultivation.

The practice of nomadic cultivation by the hill tribes may conveniently be described in connexion with forest conservation, of which it is the most formidable enemy. In all the great virgin forests of India, in Arakan, on the north-east frontier of Assam and Chittagong, throughout the Central Provinces, and along the line of the Western Gháts, the aboriginal tribes raise their crops of rice, cotton, &c., in this manner. A similar system has been found to prevail in Madagascar; and indeed, from its simplicity and its appropriateness it may fairly be called the most primitive mode of agriculture known to the human race. Known as *toungya* in Burmah, *júm* on the north-east frontier, *dahya* in Central India, *kil* in the Himálayas, and *kumárí* in the Western Gháts, it is practised, without any material differences, by tribes of the most diverse origin. Its essential features are the burning down of a patch of forest, and sowing the crop with little or no tillage on the clearing thus formed. The tribes of the western coast break up the cleared soil with a sort of hoe-pick and spade or even with the plough; in other parts the soil is merely scratched with a knife, or the seed is scattered on its surface without any cultivation at all. In some cases a crop is taken off the same clearing for two or even three years in succession, but more usually the tribe moves off every year to a fresh field of operations. To these nomad cultivators the words rhetorically used by Tacitus of the primitive Germans are strictly applicable—*Arva per annos mutant; et superest ager.* The wanton destruction thus wrought in the forests is simply incalculable. In addition to the timber-trees deliberately burned down to clear the soil, the fire thus started not unfrequently runs wild through the forest, and devastates many square miles. Wherever timber has any value from the proximity of a market, the first care of the Forest Department is to prohibit these fires, and to assign heavy penalties for any infringement of its rules. The success of a year's operations is mainly estimated by the degree in which the reserves have been saved from the flame.

But vast tracts of country yet remain in which it would be equally useless and impossible to place restraint upon nomad cultivation, which is admitted to yield a larger profit than ordinary cultivation with the plough. A virgin soil, manured many inches deep with ashes and watered by the full burst of a tropical rainfall, returns forty and fifty-fold of rice, which is the staple grain thus raised. In addition to rice, Indian corn, millet, oil-seeds, and cotton are sometimes grown in the same clearing, the seeds being all thrown into the ground together, and each crop ripening in succession at its own season. Except to the eyes of a forest officer, a patch of *júm* cultivation is a very picturesque sight. Men, women, and children all work together with a will, for the trees must be felled and burned, and the seed sown, before the monsoon breaks.

Irrigation. Irrigation is everywhere dependent upon the two supreme considerations of water supply and land level. The sandy desert that extends from the hills of Rájputána to the basin of the Indus is more absolutely closed to irrigation than the confused system of hill and valley in Central India. Farther west, in the Indus valley, irrigation becomes possible, and in no part of India has it been conducted with greater perseverance and success. The entire province of Sind, and hardly less the lower districts of the Punjab, are absolutely dependent upon the floods of the Indus. Sind has been compared to Egypt, and the Indus to the Nile; but, in truth, the case of the Indian province is the less favourable of the two. In Sind the average rainfall is barely 10 inches in the year, the soil is a thirsty sand, and, above all, the river does not run in confined banks, but wanders at its will over a wide valley. The rising of the Nile is a beneficent phenomenon, whose effects can be calculated with tolerable precision, and which the industry of countless generations has brought under control for the purposes of cultivation. In Sind the inundation is an uncontrolled torrent, which oftentimes does as much harm as good. Broadly speaking, no crop can be grown in Sind except under irrigation, and therefore the total cultivated area of about 3 million acres may be regarded as entirely dependent upon artificial water-supply. The supply is derived from the river by two main classes of canals —(1) inundation channels, which only fill when the Indus is in flood, and (2) perennial channels, which carry off water by means of dams at all seasons of the year. The former are for the most part the work of ancient rulers of the country, or of the cultivators themselves; the latter have been constructed since the British conquest. In both cases care has been taken to utilize abandoned channels of the river. It is impossible to present a complete view of the results of irrigation, for in some provinces, as in Sind, it is treated as a department of land administration, while in others it is almost entirely conducted by private enterprise.

In 1876–77 about 900,000 acres in Sind were returned as irrigated from works for which capital and revenue accounts are kept, the chief being the Ghár, Eastern and Western Nárá, Sakhar (Sukkur), Phuleli, and Pinyari; the total receipts were about £190,000, almost entirely credited under the head of land revenue. In the same year about 445,000 acres were irrigated from works of which revenue accounts only are kept, yielding about £75,000 in land revenue. Throughout the remainder of the Bombay presidency irrigation is conducted on a comparatively small scale, and mainly by private enterprise. In the Concan, along the coast, the heavy local rainfall and the annual flooding of the numerous small creeks permit rice to be grown without artificial aid. In Guzerat the supply is drawn from wells, and in the Deccan from tanks; but both these are liable to fail in years of deficient rainfall. Government has now undertaken a few comprehensive schemes of irrigation, which mostly conform to a common type—damming up the end of a hill valley so as to form an immense reservoir, and then conducting the water over the fields by channels, which are in some cases of considerable length. In 1876–77 the total area in Bombay (excluding Sind) irrigated from Government works was about 180,000 acres, yielding a revenue of about £42,000. In the same year the total expenditure on irrigation (inclusive of Sind) was £235,000,—£65,000 under the head of extraordinary and £170,000 of ordinary outlay.

In some parts of the Punjab irrigation is only one degree less necessary than in Sind, but the sources of supply are more numerous. In the northern tract, under the Himálayas, and in the upper valleys of the rivers, water can be obtained by digging wells from 10 to 30 feet below the surface. In the south, towards Sind, inundation channels are usual; while the upland tracts that rise between the basins of the main rivers are now in course of being supplied by the perennial canals of the Government. According to the returns for 1877–78, out of a grand total of 22,640,894 acres under cultivation, 5,000,481 were irrigated by private individuals and 1,618,854 by public channels, giving a total under irrigation of 6,619,335 acres, or 29 per cent of the cultivated area. The principal Government works are the Western Jumna canal, the Barí Doáb canal, and the Sirhind, the last of which, with the largest expenditure of all, is still incomplete. Up to the close of 1877–78 the total outlay had been £3,645,189; the total income in that year was £263,053, of which £171,504 was classified as direct and £91,549 as indirect; the total revenue charges on works in operation were £224,316, of which £146,419 was for maintenance and £77,897 for interest, thus showing a surplus of £38,737. On the Western Jumna canal alone the net profit was £83,112.

The North-Western Provinces present in the great *doáb*, or high land between the Ganges and the Jumna, a continuation of the physical features to be found in the Upper Punjab. The local rainfall, indeed, is higher, but before the days of artificial irrigation occasional deficiency repeatedly resulted in terrible famines. It is in this tract that the British Government has been perhaps most successful in averting the calamity of drought. In Sind irrigation is an absolute necessity; in Lower Bengal it may be regarded almost as a luxury; but in the great river basins of Upper India it serves the twofold object of saving the population from the vicissitudes of the season and of introducing more valuable crops and a higher stage of agriculture. Concerning private irrigation from wells in the North-Western Provinces no information is available. The great Government works are the Ganges canal, the Eastern Jumna canal, the Agra canals, and the Lower Ganges canal, the last of which is not yet complete. Up to the close of 1877–78 the total outlay had been £5,673,401. The gross income in that year was £438,136, of which £337,842 was derived from water rates and £100,294 from enhanced land revenue; the working expenses amounted to £143,984, leaving £294,152 for surplus profits, or 6·77 per cent. on the total capital expended on works in operation. The total area irrigated was 1,461,428 acres, of which more than two-thirds were supplied by the Ganges canal. Of the total area, 415,659 acres were under wheat and 139,374 under sugar-cane.

Into Oudh no irrigation works have yet been introduced by Government. A tolerable local rainfall, the annual overflow of the rivers, and an abundance of low-lying swamps combine to furnish a water supply that is ample in all ordinary years. According to the settlement returns, out of a total cultivated area of 8,276,174 acres, 2,957,397 acres, or nearly 36 per cent., are irrigated by private individuals; but this figure must include low lands watered by natural overflow.

Throughout the greater part of Bengal there is no demand for artificial irrigation, but the solicitude of Government has undertaken to construct works in those exceptional tracts where experience has shown that occasional drought is to be feared. In the lower valleys of the Ganges and the Brahmaputra, and along the deltaic seaboard, flood is a more formidable enemy than drought, and embankments there take the place of canals. The Public Works Department has altogether about 2800 miles of embankments under its charge, upon which £79,105 was expended in 1877–78, either as direct outlay or in advances to landowners. The broad strip of northern Bengal and Behar, stretching between the Himálayas and the Ganges, is also rarely visited by drought; though, when drought does come, the excessive density of the population brings the danger of famine very near. In Sáran alone it has been found necessary to carry out a comparatively small scheme for utilizing the discharge of the river Gandak. The great irrigation works in Bengal are two in number, and belong to two different types. (1.) In the delta of Orissa an extensive system of canals has been constructed on the pattern of those lower down on the Coromandel coast, which are intended to avert the danger of both drought and flood, and also to be useful for navigation. In average seasons, *i.e.*, in five years out of six, the local rainfall is sufficient for the rice crop, which is there the sole staple of cultivation; and therefore it is not to be expected that these canals will be directly remunerative. But on the other hand, if they save the province from a repetition of the disastrous year 1865–66, the money will not have been expended in vain. (2.) In South Behar the flood discharge of the Son has been intercepted, after the system of engineering followed in the North-West, so as to irrigate a comparatively thirsty strip of land extending along the south bank of the Ganges, where distress has ere now been severely felt. In this case also, the expenditure must be regarded rather as an insurance fund against famine than as reproductive outlay. The works are not yet complete, but the experience already gained proves that irrigation is wanted even in ordinary seasons. Up to the close of 1877-78 the total expenditure on capital account for all the irrigation works in Bengal was £4,653,903; the gross income for the year was £49,477; the working expenses were £70,286; and the estimated interest on capital, at 4½ per cent., amounted to £203,971, thus showing a net deficit of £224,780. The area irrigated was about 400,000 acres.

In the Madras presidency, and generally throughout southern India, facilities for irrigation assume a decisive importance in determining the character of agriculture. Crops dependent on the rainfall are distinguished as "dry crops," comprehending the large class of millets. Rice can only be grown on "wet land," which means land capable of being irrigated. Except on the Malabar or western coast, the local rainfall is nowhere sufficiently ample or sufficiently steady to secure an adequate water supply. Everywhere else water has to be brought to the fields from rivers, from tanks, or from wells. Out of the total cultivated area of Madras, only 15 per cent. is classified as "wet land;" the rest is at the mercy of the monsoons. From time immemorial an industrious population has made use of all the means available to store up the rainfall and direct the river floods over their fields. The upland areas are studded with tanks, which sometimes cover square miles of ground; the rivers are crossed by innumerable anicuts, or dams by which the floods are diverted into long aqueducts. Most of these works are now the property of Government, which annually expends large sums of money in maintenance and repairs, looking for remuneration only to the augmented land revenue. The average rate of assessment is 9s. 6d. per acre on irrigated land, as compared with only 2s. 3d. per acre on unirrigated land. It is, therefore, not only the duty but the manifest advantage of Government to extend the facilities for irrigation wherever the physical aspect of the country will permit. The deltas of the Godávari, the Kistna, and the Káveri (Cauvery) have within recent years been traversed by a network of canals and thus guaranteed against any risk of famine. Smaller works of a similar nature have been carried out in other places; while a private company, with a Government guarantee, has undertaken the more difficult task of utilizing on a grand scale the waters of the Tungabhadra amid the hills and vales of the interior. According to the latest statistics, the total irrigated area of the presidency is about 5 million acres, yielding a land revenue of about 2 millions sterling. Of this total, 1,680,178 acres, with a revenue of £739,778, are irrigated by eight great systems, for which revenue and capital accounts are kept. The minor works consist of about 35,000 tanks and irrigation canals, and about 1140 anicuts or dams across streams.

In Mysore, tanks, anicuts, and wells dug in the dry beds of rivers afford the means of irrigation, but wet cultivation is there even rarer than in Madras. After the disastrous famine of 1876-78 some comprehensive schemes of throwing embankments across river valleys were undertaken by Government. In the Central Provinces irrigation still remains a matter of private enterprise. According to the settlement returns, out of a total cultivated area of 13,610,503 acres, 804,370 acres, or 6 per cent., are irrigated by private individuals. The only Government work is a tank in the district of Nimár. In British Burmah, as in Lower Bengal, embankments take the place of canals, being classed as "irrigation works" in the annual reports. Within the last few years Government has spent about £318,000 under this heading, in order to save the low rice-fields along the Irawadi from destructive inundation.

The following figures, applying to India as a whole, partially show how the Government has performed its duty as a landlord in undertaking productive public works. During the ten years ending March 1878 a total sum of £10,457,702 was expended on irrigation under the budget heading of "extraordinary," as compared with £18,636,321 expended on state railways in the same period. In the twelve months ending at the same date irrigation yielded a gross income of £495,142, as compared with £548,528 derived from state railways; while £370,747 was charged to revenue account against irrigation and £420,754 against state railways.

Internal Communication.

Railways.—The existing system of railway communication in India dates from the administration of Lord Dalhousie, who brought to bear upon this question an experience gained at the Board of Trade when railway speculation in England was at its height. The first Indian line was projected in 1843 by Sir Macdonald Stephenson, who was afterwards active in forming the East India Railway Company; but that premature scheme was blighted by the financial panic that followed soon afterwards in England. Bombay, the city that has most benefited by railway enterprise, saw the first sod turned in 1850, and the first line of 3 miles to Tháná (Tanna) opened in 1853. The elaborate minute drawn up by Lord Dalhousie in the latter year still faithfully represents the railway map of India at the present day, though modified in detail by Lord Mayo's reform of 1869. Lord Dalhousie's scheme consisted of a few trunk lines, traversing the length and breadth of the peninsula, and connecting all the great cities and military cantonments. These trunk lines were to be constructed by private companies, to whom Government should guarantee a minimum of 5 per cent. interest on their capital expended, and from whom it should demand in return a certain measure of subordination. The system thus sketched out was promptly carried into execution, and by 1871 Bombay was put into direct railway communication with the sister presidencies of Calcutta and Madras. The task Lord Mayo had to undertake was the development of traffic by means of feeders which should tap the districts of production and thus open up the entire country. The means he determined to adopt was the construction of minor lines by the direct agency of the state, on a narrower gauge, and therefore at a cheaper rate, than the existing guaranteed railways. Railways

The guaranteed lines, including the East Indian, which was transferred to Government in 1879 in accordance with terms applicable to all alike, comprise the following:—the East Indian, running up the valley of the Ganges from Calcutta (Howrah) as far as Delhi, with a branch to Jabalpur; the Great Indian Peninsular, which starts from Bombay and sends one arm north-east to Jabalpur, with a branch to Nágpur, and another south-east to the frontier of Madras; the Madras line, with its terminus similarly at Madras city, and two arms running respectively to the Great Indian Peninsular junction at Ráichur and to Beypur on the opposite coast, with branches to Bangalore and Bellary; the Oudh and Rohilkhand, connecting Lucknow and Moradábád with Cawnpur and Benares; the Bombay, Baroda, and Central India, which runs due north from Bombay through the fertile plain of Guzerat, and is destined ultimately to be extended across Rájputána to Delhi; the Sind, Punjab, and Delhi, consisting of three sections, one in Lower Sind, another from Delhi to Lahore, and the third from Lahore to Múltán; the South Indian (the only one on the narrow gauge), in the extreme south, from Cape Comorin to Madras city; and the Eastern Bengal, traversing the richest portion of the Gangetic delta. The state lines are too numerous to be described singly. They include the extension from Lahore to Peshávar on the north-west frontier, which at present stops short at Jhelum; the "missing link," from Múltán to Hyderabad, thus bringing the Punjab into direct connexion with its natural seaport at Karáchi (opened throughout in 1878); the line up the valley of the Irawadi from Rangoon to Prome; and several short lines which have been constructed entirely at the expense of native states.

Statistics of Indian Railways for 1878.

	Miles. Open.	Capital Expended.	Number of Passengers.	Tons of Goods and Minerals.	Head of Live Stock.	Gross Receipts.	Gross Expenses.	Net Earnings.
Guaranteed railways	6044	£95,430,863	32,206,570	7,166,205	...	£9,503,721	£4,501,693	£5,002,028
State railways	2171	19,628,591	6,289,173	1,005,412	...	901,032	705,245	195,787
Totals	8215	£115,059,454	38,495,743	8,171,617	594,249	£10,404,753	£5,206,938	£5,197,815

These figures show 1 mile of railway to every 109 square miles of the area of British India, or to every 179 square miles of the area of the entire peninsula. The average cost of construction per mile is almost exactly £14,000. The guaranteed railways, embracing the great trunk lines throughout India, are on the "broad gauge" of 5 feet 6 inches; the state lines follow as a rule the narrow or metre gauge of 3·281 feet.

Roads.—As the railway system of India approaches its completion, the relative importance of the roads naturally

Roads. diminishes. From a military point of view, rapid communication by rail has now superseded the old marching routes as completely as in any European country. Like Portsmouth in England, Bombay in India has become the national harbour for the embarkation and debarkation of troops. On landing at Bombay, all troops proceed for a short rest to the healthy station of Deoláli on the plateau of the Deccan, whence they can reach their ultimate destinations, however remote, by easy railway stages. The Grand Trunk Road, running up the valley of the Ganges from Calcutta to the north-west frontier, which was first planned in the 16th century by the Afghán emperor Sher Sháh and was brought to completion under the administration of Lord George Bentinck, is now for the most part untrodden by troops. But though the railway system occupies the first place for military and commercial purposes, the actual mileage and economic importance of roads have greatly increased. They do not figure in the imperial balance-sheet, nor do they strike the popular imagination, but their construction and repair constitute two of the most important duties of the district official. A few lines, such as the continuation of the Grand Trunk Road in the Punjab, are still substitutes for the railways of the future. Others, which climb the passes of the Himálayas, the Western Gháts, or the Nílgiris, will probably never be superseded. The great majority, however, are works of local utility, serving to promote that ease and regularity of communication upon which the existence of civilization so largely depends. The substitution of the post-cart for the naked runner, and that of wheeled traffic for the pack-bullock, are silent revolutions effected under British rule.

The more important roads are all carefully metalled, the material employed in most provinces being *kankar* or calcareous limestone. In Lower Bengal and other deltaic tracts, where no kind of stone exists, bricks are roughly burnt and then broken up to supply metal for the roads. The minor streams are crossed by permanent bridges, with foundations of stone, and not unfrequently iron girders. The larger rivers have temporary bridges of boats thrown across them during the dry season, which give place to ferries in time of flood. Avenues of trees afford shade and material for timber. Most of these main lines are under the charge of the Public Works Department. The burden of maintaining the minor roads has, by a recent administrative reform, been thrown upon the local authorities, who depend for their pecuniary resources upon district committees and are often compelled to act as their own engineers. No statistics are available to show the total mileage of roads in British India, or the total sum expended on their maintenance.

River navigation. Inland navigation is almost confined to the four great rivers, the Ganges, the Brahmaputra, the Indus, and the Irawadi. These all flow through broad valleys, and from time immemorial have been the chief means of conveying the produce of the interior to the sea. South of the Gangetic basin there is not a single river that can be called navigable. Most of the streams in that tract, though mighty torrents in the rainy season, dwindle away to mere threads of water and stagnant pools during the rest of the year. The Godávari and the Narbadá, whose volume of water is ample, are both obstructed by rocky rapids which engineering skill has hitherto been unable to overcome. A total sum of 1½ millions sterling has been in vain expended upon the former river. Indeed, it may be doubted whether water carriage is able to compete, as regards the more valuable staples, with communication by rail. After the East Indian Railway was opened, steamers ceased to ply upon the Ganges; and the steam flotilla on the Indus similarly shrank to insignificance when through communication by rail became possible between Múltán and Karáchi. On the Brahmaputra and its tributary the Bárak, and on the Irawadi, steamers still run secure from competition. But it is in the Gangetic delta that river navigation attains its highest development. There the population may be regarded as half amphibious. Every village can be reached by water in the rainy season, and every family keeps its boat. The main channels of the Ganges and Brahmaputra and their larger tributaries are navigable all the year through. During the rainy months road-carriage is altogether superseded. All the minor streams are swollen by the rainfall on the hills, and the local downpour; while fleets of boats sail down with the produce that has accumulated in warehouses on the river banks. The statistics of this subject belong rather to the department of internal trade, but it may be mentioned here that the number of laden boats registered at certain of the river-stations in Bengal in the year 1877–78 was 401,729.

The great majority of the Bengal rivers require no attention from Government, but the system known as the three Nadiyá rivers is only kept open for traffic by close supervision. A staff of engineers is constantly employed to watch the shifting bed, to assist the scouring action of the current, and to advertize the trading community of the depth of water from time to time. In the year 1877–78 a total sum of £9522 was expended on this account, while an income of £32,494 was derived from tolls.

The artificial water channels of India may be divided into two classes—(1) those confined to navigation, and (2) those primarily constructed for purposes of irrigation. Of the former class the most important examples are to be found in the south of the peninsula. On both the Malabar and the Coromandel coasts the strip of lowland lying between the mountains and the sea affords natural facilities for the construction of an inland canal running parallel to the shore. In Malabar the salt-water lagoons or lakes, which form such a prominent feature in the local geography, merely required to be supplemented by a few cuttings to supply continuous water communication from the port of Calicut to Cape Comorin. On the east coast, the Buckingham canal, running north from Madras city as far as the delta of the Kistna, has been completed without any great engineering difficulties. In Bengal there are a few artificial canals of old date, but of no great magnitude, in the neighbourhood of Calcutta. The principal of these form the system known as the Calcutta and Eastern canals, which consist for the most part of natural channels, artificially deepened in order to afford a safe boat route through the Sundarbans. Up to the close of the year 1877–78 a capital sum of £360,332 had been expended by Government on these canals, and the gross income in that year was £44,120; after deducting cost of repairs, &c., charged to revenue account, and interest at the rate of 4½ per cent., a net profit was left amounting to £8748. The Hijlí tidal canal in Midnapur district, which cuts off a difficult corner of the Húglí (Hooghly) river, yielded a net revenue of £3171 in the same year.

Most of the great irrigation works, both in northern and southern India, have been so constructed as to be available also for navigation. The general features of these works have been already described. The works of the Madras Irrigation Company on the Tungabhadra were not made available for navigation until 1879. A scheme is now under the consideration of the Bengal Government for joining the Midnapur and Orissa canal systems, and extending the line of water communication farther southward through the Chilká Lake as far as Ganjám, 400 miles from Calcutta.

Commerce.

The trade of India may be considered under four heads:—(1) sea-borne trade with foreign countries; (2) coasting trade; (3) frontier trade, chiefly across the northern mountains; (4) internal traffic within the limits of the empire.

Sea-borne Trade.—With an extensive seaboard, India has but few ports. Calcutta monopolizes the commerce, not only of Lower Bengal, but of the entire basins of the Ganges and the Brahmaputra. Bombay is the sole outlet for the agricultural wealth of Guzerat, the Deccan, and the Central Provinces; while Karáchi (Kurrachee) performs a similar office for the Indus, and Rangoon for the Irawadi. The natural value of these four ports has been permanently confirmed by the construction of the main lines of railway communication. In the south of India only is sea-borne trade distributed along the coast. The western side has a succession of tolerable harbours, from Goa to Cochin. On the east there is not a single safe roadstead nor a navigable river, but ships anchor some distance off the shore at Madras, and at other points, generally near the mouths of the rivers. Of the total foreign trade of India, Calcutta and Bombay control about 40 per cent. each; Madras has 6 per cent., Rangoon 4 per cent., and Karáchi 2 per cent., leaving a balance of only 8 per cent. for all the remaining ports of the country. Calcutta and Bombay may be called the two centres of collection and distribution, to a degree without a parallel in other countries; and the growth of their prosperity is identical with the development of Indian commerce.

Foreign Trade of India for Forty Years, classified according to Quinquennial Periods, in Millions Sterling.

Periods.	Average Imports.			Average Exports.			
	Cotton Manufactures.	Total Merchandise.	Treasure.	Raw Cotton.	Total Merchandise.	Treasure.	Balance of Trade including Treasure.[1]
1840-44	3·19	7·69	2·76	2·34	14·14	0·48	+ 4·17
1845-49	3·76	9·14	3·07	1·68	15·68	1·32	+ 4·79
1850-54	5·15	11·06	4·79	3·14	19·02	1·00	+ 4·17
1855-59	6·94	15·58	11·27	3·11	24·93	0·92	− 1·00
1860-64	10·92	23·97	17·09	15·56	42·15	1·02	+ 2·11
1865-69	15·74	31·70	17·62	25·98	55·86	1·80	+ 8·34
1870-74	17·56	33·04	8·26	17·41	56·25	1·59	+16·54
1875-79	18·89	38·36	9·86	11·52	60·32	2·81	+14·91
General Average.	10·27	21·32	9·34	10·09	36·04	1·37	+ 6·75

The preceding table, which has been compiled from materials furnished by the *Parliamentary Abstract* for 1879, demands a few words of explanation. The average of quinquennial periods has been taken in order to counteract, as far as possible, accidental fluctuations. The two columns giving the imports of treasure and the exports of raw cotton both show exceptional increases between 1855 and 1869, due mainly to the effects of the Mutiny and of the American War. Far more instructive are the three columns giving the imports of cotton manufactures and of total merchandise and the exports of total merchandise. Each of these three, without exception, exhibits a progressive increase in every one of the eight quinquennial periods. In the full period of forty years the value of cotton goods imported has multiplied sixfold; the value of total merchandise imported has multiplied fivefold; and the value of total merchandise exported has multiplied more than fourfold.

Before examining in detail the history of some of the chief staples of trade, it may be convenient to give in this place the statistics of a single year,—1877-1878, which was a year of inflation, despite the incidence of famine in southern India. In 1877-78 the aggregate volume of foreign sea-borne trade exceeded 126 millions sterling in value. The transactions of Government show an import of £2,138,182 and an export of £36,615. The imports of merchandise were £39,336,003, and of treasure £17,355,460; total imports, £56,691,463. The exports of merchandise were £65,185,713, and of treasure £2,155,136; total exports, £67,340,849. These figures show an excess of exports over imports (including treasure) amounting to £8,494,250, and an excess of treasure imported to the amount of £15,200,324. The total number of vessels that entered and cleared was 12,537, with an aggregate of 5,754,379 tons, or an average of 459 tons each. Of the total tonnage 76 per cent. was British, 7 per cent. British Indian, 4 per cent. native, and 13 per cent. foreign,—American, Italian, and French being best represented in the latter class. There was also a land-borne frontier trade estimated at 7¾ millions—imports into India 4¼ millions, exports 3½ millions. The grand total of the land-borne and sea-borne foreign trade of India in 1878, was 134 millions.

The following tables give the principal items, together with the totals, of import and export for 1877-78, showing the quantities wherever possible, as well as the values:—

[1] The *plus* sign (+) stands for excess of exports, or so-called favourable balance of trade; the *minus* sign (−) stands for excess of imports.

Foreign Trade of British India in 1877-78.

Imports.

	Quantities.		Value.	
			£	£
Apparel	...	...	...	557,597
Coal and coke ... tons	...	601,159	...	1,007,932
Cotton twist and yarn ... lb	...	36,194,125	2,850,403	
Cotton piece-goods—				
Grey ... yds.	...	992,537,579	11,562,853	
White ... ,,	...	215,624,360	2,936,109	
Coloured ... ,,	...	150,548,713	2,454,103	
Other sorts	...	...	369,248	
Total cotton goods	...	...		20,172,716
Hardware and cutlery	...	...	...	448,228
Liquors—				
Ale, beer, porter ... gals.	1,328,077		313,070	
Spirits ... ,,	737,714		647,661	
Wines and liqueurs ... ,,	496,733		436,020	
Other sorts ... ,,	14,160		4,808	
Total liquors ... ,,		2,576,684		1,401,559
Machinery, &c.	...	...	...	850,997
Metals—				
Copper ... cwts.	320,103		1,498,175	
Iron ... ,,	2,437,721		1,435,561	
Other sorts ... ,,	330,789		671,728	
Total metals ... ,,		3,088,613		3,605,464
Provisions	...	...	...	858,797
Railway plant	...	...	...	907,002
Salt ... tons	...	254,231	...	401,365
Silk, raw ... lb	...	2,102,930	...	678,069
Silk, manufactured ... yds.	...	8,328,716	...	804,883
Spices ... lb	...	33,123,137	...	488,884
Sugar ... cwts.	...	475,105	...	798,036
Woollen goods ... yds.	...	7,069,693	...	782,781
Miscellaneous	...	...	...	5,571,693
Total merchandise				39,336,003
Treasure	...	...	...	17,355,460
Government stores	...	...	...	2,138,182
Grand total				58,829,645

Exports.

	Quantities		Value.	
			£	£
Coffee ... lb	...	33,300,624	...	1,338,499
Cotton, raw ... ,,	...	387,416,624	...	9,383,534
Cotton piece-goods ... yds.	...	17,546,591	...	442,286
Cotton twist ... lb	...	15,600,291	...	682,058
Indigo ... cwts.	...	120,605	...	3,494,334
Other dyes ... ,,	...	735,838	...	406,660
Grain—				
Rice ... ,,	18,428,386		6,950,276	
Wheat ... ,,	6,340,150		2,856,990	
Other sorts ... ,,	879,806		326,834	
Total grain ... ,,		25,648,342		10,134,100
Hides and skins ... no.	...	22,916,317	...	3,756,887
Jute, raw ... cwts.	...	5,450,276	...	3,518,114
Jute, manufactured	...	...	...	771,127
Lac, excepting lac-dye cwts.	...	95,075	...	333,039
Oils	...	...	...	371,552
Opium ... chests	...	92,820	...	12,374,355
Saltpetre ... cwts.	...	389,002	...	379,002
Seeds—				
Linseed ... ,,	7,198,918		4,224,429	
Rape ... ,,	3,193,488		1,918,438	
Gingelly or *til* ... ,,	1,158,802		848,226	
Other sorts ... ,,	635,812		369,191	
Total seeds ... ,,		12,187,020		7,360,284
Silk, raw ... lb	...	1,512,819	...	703,549
Silk, manufactured ... yds.	...	1,535,458	...	151,080
Spices ... lb	...	13,805,035	...	226,515
Sugar ... cwts.	...	844,125	...	745,851
Tea ... lb	...	33,459,075	...	3,044,571
Timber, teak ... tons	...	56,939	...	406,652
Tobacco ... lb	...	11,102,233	...	93,037
Wool, raw ... ,,	...	23,075,323	...	943,645
Woollen manufactures	...	...	...	207,873
Miscellaneous	...	...	...	1,874,929
Total Indian produce ...	...	...	...	63,143,533
Foreign merchandise	...	...	...	2,042,180
Treasure	...	...	...	2,155,136
Government stores	...	...	..	36,615
Grand total	...	...	...	67,377,464

Principal imports

As regards the imports, the first thing to notice is the enormous predominance of two items—cotton goods and treasure. On an average of the last forty years, cotton goods form 33 per cent., or exactly one-third of the total, and treasure an additional 30 per cent. Next in order come metals (copper, which is largely used by native smiths, slightly exceeding iron); Government stores, including munitions of war, boots, liquor, and clothing for soldiers, and railway plant; liquors, entirely for European consumption; coal, for the use of the railways and mills; railway plant for the guaranteed companies; provisions, machinery and mill-work, and manufactured silk. It will thus be seen that, with the single exception of Manchester goods, no articles of European manufacture are in demand for native consumption, but only for the needs of the civilized administration, and no raw produce, except copper, iron, and salt.

Cotton goods. Considering that England's export trade with India thus mainly depends upon piece-goods, it is curious to recollect the history of cotton manufacture. In the beginning of the 17th century the industry had not been introduced into England, and whatever demand there was for cotton in that country was satisfied by circuitous importations from India itself, where cotton-weaving is an immemorial industry. In 1641 "Manchester cottons," in imitation of Indian calicoes and chintzes, were still made of wool. Cotton is said to have been first manufactured in England in 1676. To foster the nascent industry, a succession of statutes were passed prohibiting the wear of imported cottons; and it was not until after the inventions of Arkwright and others and the application of steam as a motive power had secured to Manchester the advantage of cheap production that these protective measures were entirely removed. In the present century Lancashire has rapidly distanced her instructors. During the five years 1840–45 the annual import of cotton manufactures into India averaged a little over £3,000,000 sterling. In each subsequent quinquennial period there has been a steady increase, until in the year 1877–78 the import reached the unprecedented total of £20,000,000 sterling, or an increase of more than sixfold in less than forty years.

Treasure. The importation of treasure is perhaps still more extraordinary, when we bear in mind that it is not consumed in the using, but remains permanently in the country. During the same period of forty years the net import of treasure, deducting export, has reached the enormous aggregate of just 319 millions sterling, or more than £1, 6s. 6d. per head of the 240 million inhabitants of the peninsula. Of course, by far the larger portion of this was silver, but the figures for gold are by no means inconsiderable. During the ten years ending with 1875, when the normal value of silver in terms of gold was but little disturbed, the total net imports of treasure into India amounted to just 99 millions; of this total $62\frac{1}{2}$ millions were in silver and $36\frac{1}{2}$ millions in gold, the proportion of the latter metal being thus considerably more than one-third of the whole. On separating the re-exports from the imports, the attraction of gold to India appears yet more marked. Of the total imports of gold only 7 per cent. was re-exported, while for silver the corresponding proportion was 19 per cent. Roughly speaking, it may be concluded that India then absorbed about £3,000,000 sterling of gold a year. The supply is drawn chiefly from China, Ceylon, Great Britain, and Australia. The depreciation of silver that has since taken place has caused an enormous increase in the import of silver and a corresponding increase in the export of gold. The figures since 1876 do not show the normal state of things. But even in 1877–78, when the value of silver was at its lowest, though India drew upon its hoards of gold for export to the amount of more than 1 million sterling, it yet imported more than $1\frac{1}{2}$ millions, showing a net import of half a million of gold. It has been estimated that the gold circulation of India amounts to about 1,620,000 gold *mohars*, as compared with £158,000,000 of silver and £2,960,000 of copper. In addition, 10 million sovereigns are said to be hoarded in India, mainly in the Bombay presidency, where the impression of St George and the Dragon is valued on religious grounds.

Exports. When we turn to the exports, the changes that have taken place in relative magnitude demand notice.

In 1877–78 raw cotton for the first time for many years falls into the second place, being surpassed by the aggregate total of food grains; oil-seeds show as a formidable competitor to cotton; jute surpasses indigo, and tea comes close behind; while cotton manufactures are nearly as valuable as coffee. The imports of sugar, in value though not in quantity, exceed the exports; the trade in raw silk is about equally balanced; while spices, once the glory of Eastern trade, were exported to the value of only £226,515, as compared with imports more valuable and also twofold larger.

R co The export of raw cotton has been subject to excessive variations. At the close of the last century cotton was sent to England in small quantities, chiefly the produce of the Central Provinces, collected at Mírzápur and shipped at Calcutta, or the produce of Guzerat, despatched from Surat. In the year 1805 the total export of cotton from Surat was valued at £108,000; in the same year the English returns show only 2000 bales of East Indian cotton imported into Great Britain. But this figure was far below the average, for by 1810 the corresponding number of bales had risen to 79,000, to sink again to 2000 in 1813, and to rise to 248,000 in 1818. Bombay did not begin to participate in this trade until 1825, but has now acquired the practical monopoly, since the railway has diverted to the west the produce of the Central Provinces. In 1834, when the commerce of India was first thrown open, 33,000,000 lb were exported. Analysing the exports of cotton during the forty years since 1840, we find that in the first quinquennial period they averaged $2\frac{1}{4}$ millions sterling in value, and did not rise perceptibly until 1858, when they first touched 4 millions. From that date the increase was steady, even before the American exports were cut off by war in 1861. India then made the most of her opportunity, though quantity and quality did not keep pace with the augmented price. The highest figures of value was attained with $37\frac{1}{2}$ millions sterling in 1865, and the highest figure of quantity with 803,000,000 lb in 1866. Thenceforth the decline has been constant, though somewhat irregular, the lowest figures both of quantity and value being those of 1878–79. The most recent feature of the trade is the comparatively small amount shipped to the United Kingdom, and the even distribution of the rest among Continental ports. The export of raw cotton in 1878–79 amounted to £7,914,091, and of twist and cotton goods to £2,581,823.

J Second in importance to cotton as a raw material of British manufacture comes jute, the trade in which is a creation of less than thirty years. At the time of the London Exhibition of 1851 jute fibre was practically untried and unknown, while attention was even then actively drawn to rhea or China grass, which remains to the present day unmanageable by any cheap process. From time immemorial jute has been grown in the swamps of Eastern Bengal, and has been woven into coarse fabrics for bags and even clothing. As early as 1795 Dr Roxburgh called attention to the commercial value of the plant, which he grew in the Botanical Gardens of Calcutta and named "jute," after the language of his Orissa gardeners, the Bengalí word being *pát* or *koshta*. In 1828–29 the total exports of jute were only 364 cwts., valued at £62. From that date the trade steadily grew, until in the quinquennial period ending 1847–48 the exports averaged 234,055 cwts. The Crimean war, which cut off the supplies of Russian flax and hemp from the Forfarshire weavers, made the reputation of jute. Taking quinquennial periods, the export of jute rose from an average of 969,724 cwts. in 1858–63 to 2,628,100 cwts. in 1863–68 and 4,858,162 cwts. in 1868–73. The highest figures reached were in the year 1872–73, with 7,080,912 cwts., valued at £4,142,548. The export of raw jute in 1878–79 reached £3,800,426, and of manufactured jute £1,098,434.

Ri wl The export of grain, as already noticed, is now in the aggregate larger than that of cotton. The two chief items are rice and wheat. Rice is exported from British Burmah, from Bengal, and from Madras. From the point of view of the English produce market rice means only Burmese rice, which is annually exported to the large amount of about 12 million cwts., valued at 3 millions sterling. In the Indian tables this is all entered as consigned to the United Kingdom, though, as a matter of fact, the rice fleets from Burmah only call for orders at Falmouth, and are thence diverted to various English or Continental ports. India has a practical monopoly of the European market. An export duty is levied on rice in India at the rate of 3 *ánnás* per *maund*, or about 6d. per cwt. A similar duty on wheat was repealed in 1875, and that trade has since conspicuously advanced. In 1874–75 the export of wheat was about 1 million cwts. Forthwith it increased year by year, until in 1877–78 it exceeded $6\frac{1}{4}$ million cwts., valued at nearly 3 millions sterling. In the following year the quantity fell away to almost nothing, owing to the general failure of the harvest in the producing districts. The Punjab is the principal wheat-growing tract in India, but hitherto the chief supplies have come from the North-Western Provinces and Oudh, being collected at Cawnpur and thence despatched by rail to Calcutta. The total export of grains in 1879 was valued at £9,802,363.

Oil Oil-seeds, also, were freed in 1875, the duty previous to that date having been 3 per cent. *ad valorem*. Ten years before, the average export was only about 4 million cwts. a year; but the fiscal change, coinciding with an augmented demand in Europe, has caused an increase of threefold. In 1877-78 the total export amounted to 12,187,020 cwts., valued at more than 7¼ millions sterling. Of this Bengal contributed 7,799,220 cwts., and Bombay 3,179,475 cwts. Linseed and rape are consigned mainly to the United Kingdom, while France takes almost the entire quantity of *til* or gingelly. The export of oil-seeds in 1878-79 was valued at £4,682,512.

In actual amount, though not in relative importance, indigo holds its own in the face of competition from aniline dyes. The export of 1877-78 amounted to 120,605 cwts., valued at £3,494,334, being the highest figures on record. Of this total Bengal yielded 99,402 cwts., and Madras 16,899 cwts. In 1878-79 the export of indigo amounted to 105,051 cwts., valued at £2,960,463. The most noticeable feature in this trade is the diminishing proportion sent direct to England, and the wide distribution of the remainder. Of other dyes, safflower has greatly fallen off, being now only in demand for a rouge in China and Japan; the export in 1877-78 was 3698 cwts., valued at £14,881. The export of myrobalans, on the other hand, was greatly stimulated by the Russo-Turkish war, which interrupted the supply of valonia and galls from Asia Minor. The quantity rose from 286,350 cwts. in 1875-76 to 537,055 cwts. in 1877-78, valued in the latter year at £230,526. Practically the whole is sent to the United Kingdom. Turmeric, also, exhibits an increase to 146,865 cwts. in 1877-78, valued at £123,766, of which the United Kingdom took about one-half. Lac-dye, like other kinds of lac, shows a depressed trade, the exports in 1877-78 having been 9570 cwts., valued at £29,009.

No other export has made such steady progress as tea, which has multiplied more than fourfold in the space of ten years. In 1867-68 the amount was only 7,811,429 ℔; by 1872-73 it had reached 17,920,439 ℔; and in 1878-79, without a single step of retrogression, it had further risen to 34,800,027 ℔, valued at £3,170,118. Indian tea has now a recognized position in the London market, generally averaging about 4d. per ℔ higher in value than Chinese tea, but it has failed to win acceptance in most other countries, excepting Australia. The exports of coffee from India are stationary, if not declining. The highest amount during the past ten years was 507,296 cwts. in 1871-72, the lowest amount 298,587 cwts. in 1877-78, valued at £1,338,499. In 1878-79 the export was 342,268 cwts., valued at £1,548,481.

Of manufactured goods, cotton and jute deserve notice, though by far the greater part of the produce of the Indian mills is consumed locally. The total value of cotton goods exported in 1878-79 was £1,644,125, being an increase of nearly threefold as compared with 1874-75. The exports of twist and yarn, spun in the Bombay mills, increased from 3 million ℔ in 1874-75 to 15½ million ℔ in 1877-78, valued in the latter year at £682,058. The chief places of destination were—China, 13,762,133 ℔; Aden, 1,181,120 ℔; and Arabia, 393,371 ℔. The export of twist and yarn in 1878-79 was valued at £937,698. Piece-goods belong to two classes. Coloured goods, woven in hand-looms, are exported from Madras to Ceylon and the Straits, to the annual value of about £230,000, the quantity being about 8 million yards; while in 1877-78 grey goods from the Bombay mills were sent to Aden, Arabia, Zanzibar, and the Mekran coast, amounting to over 10 million yards, and valued at £141,509. Jute manufactures consist of gunny bags, gunny cloths, and rope and twine, almost entirely the produce of the Calcutta mills. In all of these the value of the exports is increasing faster than the quantity, having multiplied nearly fourfold in the last five years. In 1877-78 the total export of jute manufactures was valued at £771,127, and in 1878-79 at £1,098,434. Gunny bags, for the packing of wheat, rice, and wool, were exported in 1877-78 to the number of more than 26½ millions, valued at £729,669. Of this total £298,000 (including by far the most valuable bags) was sent to Australia, £162,000 to the Straits, £80,000 to the United States, £77,000 to Egypt, £32,000 to China, and £81,000 to other countries, this comprising a considerable quantity destined for England. In 1878-79 the export of gunny bags had increased to 45¾ millions, valued at a million sterling. Of gunny cloth in pieces nearly 3 million yards were exported in 1877-78, almost entirely to the United States, valued at £35,610; in 1878-79 these exports had increased to upwards of 4⅝ million yards. Of rope and twine 4428 cwts. were exported, valued at £5443.

The following tables, being taken from Indian returns, do not in all cases show the real origin of the imports or the ultimate destination of the exports, but primarily the countries with which India has direct dealings. London still retains its historical pre-eminence as the first Oriental mart in the world, whither buyers flock from the other countries of Europe to satisfy their wants. Germans go there for wool, Frenchmen for jute, and all nations alike for rare dyes, spices, and drugs. Though the opening of the Suez Canal has restored to the maritime cities of the Mediterranean some share of the business that they once monopolized, yet, on the other hand, the advantage of prior possession, the growing use of steamers, and the certainty of being able to obtain a return freight, all tend to favour trade with England carried in English bottoms. As the result of these conflicting influences, the trade of India with the United Kingdom, while in actual amount it remains pretty constant, shows a relative decrease as compared with the total trade.

Distribution of Principal Exports of Raw Produce in 1877-78, *in Cwts.*

	Cotton.	Jute.	Rice.	Wheat.	Indigo.
United Kingdom	1,440,000	4,493,483	10,488,198	5,731,349	51,641
France	611,000	...	20,117	116,674	29,999
Germany	109,000	...	68,839	...	...
Austria	407,000	...	...	...	6,618
Italy	434,000	...	...	...	1,392
United States	...	845,810	...	...	9,832
Egypt		...	...	...	12,417
Persia		...	126,824	...	4,148
Mauritius...............	.	...	1,461,931	154,888	...
China	219,000	...	...	...	...
Straits Settlements..	...	...	1,022,431	...	...

Distribution of Foreign Trade of India in 1877-1878 (*excluding treasure*).

	United Kingdom.	France.	Italy.	United States.	Australia.	China and Hong-Kong.	Straits Settlements.	Ceylon.	Mauritius.
	£	£	£	£	£	£	£	£	£
Imports..................	32,211,303	451,105	349,229	279,717	298,298	1,403,673	1,079,702	530,555	642,471
Exports..................	29,298,152	5,963,057	1,867,690	1,930,340	449,740	12,634,935	2,343,285	2,496,323	1,117,975
Total	61,509,455	6,414,162	2,216,919	2,210,057	748,038	14,038,608	3,422,987	3,026,878	1,760,446
Per cent of grand tot.	49	5	1·8	1·8	·6	13	3	2·6	1·4

The opening of the Suez Canal in 1869, while it has stimulated every department of trade into greater activity, has not materially changed its character. As might be anticipated, the imports, being for the most part of small bulk and high value, first felt the advantages of this route. In 1875-76 as much as 85 per cent. of the imports from Europe and Egypt (excluding treasure) passed through the canal, but only 29 per cent. of the exports. In 1878-79 the proportion of imports was substantially the same, while that of exports had risen to 64 per cent., showing that such bulky commodities as cotton, grain, oil-seeds, and jute were beginning to participate in the advantages of rapid traffic. The actual values of canal trade in 1877-78, the year of its greatest development, were 29 millions sterling for imports, and 23 millions for exports. It is estimated that the canal has reduced the length of the voyage from London to India by the equivalent of thirty-six days, the route round the Cape being more than 11,000 miles, that through the canal less than 3000 miles.

In 1873-74, which may be regarded as a normal year, though the figures are not altogether free from suspicion, the total number of vessels engaged in the coasting trade that cleared and entered was 294,374, with an aggregate of 10,379,862 tons; the total value of both exports and imports was returned at £34,890,445. Of the total number of vessels, 280,913, with 4,843,668 tons, were native craft. Bombay and Madras divide between them nearly all the native craft; while in Bengal and Burmah a large and increasing proportion of the coasting traffic is carried in British steamers. In 1877-78, the year of famine, the number of ships increased to 319,624, the tonnage to 15,732,246 tons, and the value to £67,814,446. By far the largest item was grain, of which a total of 1,137,690 tons, valued at 13 millions sterling, was thrown into the famine-stricken districts from the seaboard. Next in importance come raw cotton and cotton goods. The trade in raw cotton amounted to 387,438 cwts., valued at £957,900, much of which was merely transshipped from one port to another in the Bombay presidency. Cotton, twist, and yarn amounted to 17,425,993 ℔, valued at £965,038, of which the greater part was sent from Bombay to Bengal and Madras. The total value of the cotton piece-goods was £620,866, including about 24 million yards of grey goods sent from Bombay to Bengal and to Sind in nearly equal proportions, and about 2 million yards of coloured goods from Madras. Stimulated by the activity of the grain trade, the exports of gunny bags from Calcutta coastwise rose to a total value of nearly

£960,000. The trade in betel-nuts amounted to nearly 44 million lb, valued at over £500,000. Burmah consumes most of these, obtaining its supplies from Bengal; while Bombay gets considerable quantities from Madras, from the Concan and Goa, and from Bengal. Sugar (refined and unrefined) figures to the large amount of £900,000, of which the greater part came from Bengal. The movements of treasure coastwise show a total of just 5 millions sterling, being exceptionally augmented by the conveyance of silver to Burmah in payment for rice supplied to Madras.

Frontier trade. The following table exhibits the totals of the trade conducted along the landward frontier of the Indian empire, so far as figures are available:—

Registered Frontier Trade of India in 1877–1878.

	Imports.	Exports.	Total.
	£	£	£
Afghánistán and adjoining hill tribes, ...	671,000	718,000	1,389,000
Kashmír, Ladákh, and Tibet	630,000	374,000	1,004,000
Nepál	1,054,000	633,000	1,687,000
North-East Frontier tribes	77,000	30,000	107,000
Independent Burmah	1,664,000	1,762,000	3,426,000
Siam	69,000	57,000	126,000
Total..................	4,165,000	3,574,000	7,739,000

Internal trade. In any community raised above primitive barbarism the aggregate volume of its internal trade must be far greater than that of its foreign commerce; but, from the nature of the case, it is impossible to estimate its amount or even to describe adequately its general character. On the one hand, there is the wholesale business connected with foreign commerce in its earliest stages—the collection of agricultural produce from a thousand little villages, its accumulation at a few great central marts, and its despatch to the seaboard; in return for which manufactured articles are distributed by the same channels, though in the reverse direction. On the other hand, there is the interchange of commodities of native growth and manufacture, sometimes between neighbours, but also between distant provinces. With a few unimportant exceptions, free trade is the rule throughout the vast peninsula of India, by land as well as by sea. The Hindus possess a natural genius for commerce, as is shown by the daring with which they have penetrated into the heart of Central Asia, and to the east coast of Africa. Among the benefits which British rule has conferred upon them is the removal of the innumerable shackles that a short-sighted despotism had imposed upon their talents.

Trading classes. Broadly speaking, the greater part of the internal trade remains in the hands of the natives. Europeans control the shipping business, and have a share in the collection of some of the more valuable staples of exports, such as cotton, jute, oil-seeds, and wheat. But the work of distribution and the adaptation of the supply to the demand of the consumer naturally fall to those who are best acquainted with native wants. Even in the presidency towns the retail shops are generally owned by natives. The Vaisya, or trading caste of Manu, has no longer any separate existence; but its place is occupied by several well-marked classes. On the western coast the Pársis, by the boldness and extent of their operations, tread close upon the heels of the most prosperous English houses. In the interior of the Bombay presidency, business is mainly divided between two classes, the Baniyas of Guzerat and the Márwárís from Rájputána. Each of these profess a peculiar form of religion, the former being Vishnuvites of the Vallabhácharí sect, the latter Jains. In the Deccan their place is taken by Lingáyats from the south, who again follow their own form of Hinduism, which is an heretical species of Siva worship. Throughout Mysore, and in the north of Madras, Lingáyats are still found, but along the eastern sea-board the predominating classes of traders are those named Chetties and Komatis. In Bengal many of the upper castes of Súdras have devoted themselves to general trade; but there again the Jain Márwárís from Rájputána and the North-West occupy the front rank. Their head-quarters are in Murshidábád district, and their agents are to be found throughout the valley of the Brahmaputra, as far up as the unexplored frontier of China. They penetrate everywhere among the wild tribes; and it is said that the natives of the Khásí hills are the only hillmen who do their own business of buying and selling. In the North-Western Provinces and Oudh the traders are generically called Baniyas; and in the Punjab are found the Khatrís, who have perhaps the best title of any to regard themselves as descendants of the original Vaisyas. According to the general census of 1872, the total number of persons in all India returned as connected with commerce and trade was 3,224,000, or 5·2 per cent. of the adult males.

Local trade. Local trade is conducted either at the permanent *bázárs* of great towns, at weekly markets held in certain villages, at annual gatherings primarily held for religious purposes, or by means of travelling brokers and agents. The cultivator himself, who is the chief producer and also the chief customer, knows little of the great towns, and expects the dealer to come to his own door. Each village has at least one resident trader, who usually combines in his own person the functions of money-lender, grain dealer, and cloth seller. The simple system of rural economy is entirely based upon the dealings of this man, whom it is the fashion sometimes to decry as a usurer, but who is really the one thrifty person among an improvident population. Abolish the money-lender, and the general body of cultivators would have nothing to depend upon but the harvest of a single year. The money-lender deals chiefly in grain and in specie. In those districts where the staples of export are largely grown, the cultivators commonly sell their crops to travelling brokers, who re-sell to larger dealers, and so on until the commodities reach the hands of the agents of the great shipping houses. The wholesale trade thus rests ultimately with a comparatively small number of persons, who have agencies, or rather corresponding firms, at the great central marts. Buying and selling in their aspects most characteristic of India are to be seen, not at these great towns, nor even at the weekly markets, but at the fairs which are held periodically at certain spots in most districts. Religion is always the original pretext of these gatherings or *melás*, at some of which nothing is done beyond bathing in the river, or performing various superstitious ceremonies. But in the majority of cases religion has become a mere excuse for secular business. Crowds of petty traders attend, bringing all those miscellaneous articles that can be packed into a pedlar's wallet; and the neighbouring villagers look forward to the occasion to satisfy alike their curiosity and their household wants.

Provincial trade. It is, of course, impossible to express accurately in figures the extent of internal trade, but the following statistics will serve in some measure to show both its recent development and its actual amount. They are based upon the registration returns that have been collected for some years past in certain provinces. In 1863–64 the total external trade of the Central Provinces, both export and import, was estimated to amount to 102,000 tons, valued at £3,909,000. By 1868–69, after the opening of the Jabalpur through railway, it had increased to 209,000 tons, valued at £6,795,000. In 1877–78, the year of famine in southern India, the corresponding figures were 635,000 tons and £9,373,000, showing an increase in fourteen years of more than sixfold in quantity, and considerably more than twofold in value. The comparatively small increase in value is to be attributed to the exclusion from the later returns of opium, which merely passes through in transit from Málwá. In 1874–75 the total external trade of the Punjab amounted to about 600,000 tons, valued (but probably overvalued) at about £16,000,000. In 1877–78 it had increased to nearly 900,000 tons, valued at £17,500,000. The total trade of Behar in

1877–78 was valued at £16,000,000. But perhaps the significance of such enormous totals will become plainer if we take the case of a single mart, Patná, which may claim to be considered one of the most important centres of inland traffic in the world. Favourably situated on the Ganges, near the confluence of the Son and the Gogra, where the principal trade routes branch off to Nepál, it has become a great changing station for the transfer of goods from river to rail. In the year 1876–77 the total registered trade of Patná (excluding the Government monopoly of opium, and probably omitting a good deal besides) was valued in the aggregate at 7¼ millions sterling. Many articles are included twice over, both as exported and imported, but the imports alone amounted to more than 4 millions. Among the principal items on one side or the other may be mentioned—European piece-goods, £1,217,000; indigo, £789,000; oil-seeds, £557,000; salt, £389,000; sugar, £274,000; food grains, £258,000; hides, £185,000; saltpetre, £156,000.

Manufactures.

Though India may be truly described as an agricultural and not a manufacturing country, yet it would be erroneous to infer that it is destitute of the arts of civilized life. It has no swarming hives of industry to compare with the factory centres of Lancashire, nor a large mining population, living under the soil rather than on it. In short, it has not reached that modern stage of industrial development which is based upon the use of coal and the discoveries of physical science. But in all manufactures requiring manual dexterity and artistic taste India may challenge comparison with England in the last century. The organization of Hindu society demands that the necessary arts, such as those of the weaver, the potter, and the smith, should be practised in every village. The pride and display of the rival kingdoms, into which the country was formerly divided, gave birth to many arts of luxury that have not yet been entirely forgotten in the decayed capitals. When the first European traders reached the coast of India in the 16th century, they found a civilization among both "Moors" and "Gentoos" at least as highly advanced as their own. In architecture, in fabrics of cotton and silk, in goldsmith's work and jewellery, the people of India were then unsurpassed. But while the East has stood still, or rather retrograded (for, in the face of keen competition, to stand still is to retrograde), the West has advanced with a gigantic stride which has no parallel in the history of human progress. On the one hand, the downfall of the native courts has deprived the skilled workman of his chief market, while, on the other, the English capitalist has enlisted in his service forces of nature against which the village artisans in vain try to compete. The fortunes of India are bound up with those of a country whose manufacturing supremacy depends upon a great export trade. The tide of circumstances, more inexorable than artificial enactments, has compelled the weaver to exchange his loom for the plough, and has crushed out a multitude of minor handicrafts. Political economy, judging only by the single test of cheapness, may approve the result; but the philosopher will regret the increasing uniformity of social conditions, and the loss to the world of artistic tendencies which can never be restored.

Historically the most interesting, and still the most important in the aggregate, of all Indian industries are those conducted in every rural village of the land. The Hindu village system is based upon division of labour quite as much as upon hereditary caste. The weaver, the potter, the blacksmith, the brazier, the oil-presser, are each members of a community, as well as inheritors of a family occupation. On the one hand, they have a secure market for their wares, and, on the other, their employers have a guarantee that their trades shall be well learned. Simplicity of life and permanence of employment are here happily combined with a high degree of excellence in design and honesty of execution. The stage of civilization below these village industries is represented by the hill tribes, especially those on the north-east frontier, where the weaving of clothes is done by the women of the family,—a practice which also prevails throughout Burmah. A higher stage may be found in those villages or towns which possess a little colony of weavers or braziers noted for some specialty. Yet one degree higher is the case of certain arts of luxury, such as ivory carving or the making of gold lace, which chance or royal patronage has fixed at some capital now perhaps falling into decay. One other form of native industry owes its origin to European interference. Many a village in Lower Bengal and on the Coromandel coast still shows traces of the time when the East India Company and its European rivals gathered large settlements of weavers round their little forts, and thus formed the only industrial towns that ever existed in India. But when the Company abandoned its manufacturing business in 1833, these centres of industry rapidly declined; and the once celebrated muslins of India have been driven out of the market of the world by Manchester goods.

Cotton weaving.

Cotton weaving may be called the oldest indigenous industry of India. The Greek name for cotton fabrics, *sindon* (σινδών), is etymologically the same as that of India or Sind; in later days Calicut on the Malabar coast has given us "calico." Cotton cloth, whether plain or ornamented, has always been the single material of clothing for both men and women, except in Assam and Burmah, where silk is preferred, perhaps in reminiscence of an extinct trade with China. When European adventurers found the way to India, cotton and silk always formed part of the rich cargoes they brought home. The English, in especial, appear to have been careful to fix their earliest settlements amid a weaving population—at Surat, at Calicut, at Masulipatam, at Hooghly. In delicacy of texture, in purity and fastness of colour, in grace of design, Indian cottons may still hold their own against the world; but in the matter of cheapness they have been unable to face the competition of Manchester.

In 1870 the Madras Board of Revenue published a valuable report upon hand-loom weaving, from which the following local figures are taken. The total number of looms at work in that presidency, with its general population of 31 millions, was returned at 279,220, of which 220,015 were in villages and 59,205 in towns, showing a considerable increase upon the corresponding number in 1861, when the *mohtarfa* or assessed tax upon looms was abolished. The total estimated consumption of twist was 31,422,712 ℔, being at the rate of 112 ℔ per loom. Of this amount, about one-third was imported twist and the remainder country-made. The total value of the cotton goods woven was returned at 3½ millions sterling, or £12, 10s. per loom, but this was believed to be much under the truth. The export of country-made cloth in the same year was about £220,000. In the Central Provinces (population 8 millions), where hand-loom weaving is still fairly maintained, and where statistics are more trustworthy than in other parts, the number of looms is returned at 87,588, employing 145,896 weavers, with an annual out-turn valued at £828,000. In 1878–79 the export of Indian piece-goods from the Central Provinces was valued at £162,642. As regards Bengal, hand-loom weaving is generally on the decline. The average consumption of piece-goods throughout the province is estimated at about 5s. per head, and the returns of registered trade show that European piece-goods are distributed from Calcutta at the rate of about 2s. 5d. per head. In Midnapur, Nadiyá, and Bardwán the native weavers still hold their own, appears from the large imports of European twist; but in the eastern districts, which have to balance their large exports of jute, rice, and oil-seeds, the imports of European cloth rise to the high figure of 2s. 7d. per head. No part of India has suffered more from English competition than Bombay, where, however, the introduction of steam machinery is beginning to restore the balance. Twist from the Bombay mills is now generally used by the hand-loom weavers of the presidency, and is largely exported to China. But it is in the finer fabrics produced for export that the west of India has suffered most. Taking Surat alone, the export by sea of piece-goods at the beginning of the century was valued at £360,000 a year. By 1845 the value had dropped to £67,000, rising again to £134,000 in 1859; but in 1874 it was only £4188.

Silk weaving.

Silk weaving is also a common industry everywhere, silk fabrics, or at least an admixture of silk in cotton, being universally affected as a mark of wealth. Throughout British Burmah, and also in Assam, silk is the common material of clothing, being made up by the women of the household. In Burmah the bulk of the silk is imported from China, generally in a raw state; but in Assam it is obtained from two or three varieties of worms, which are generally fed on jungle trees and may be regarded as semi-domesticated. Bengal is the only part of India where sericulture, or the rearing of the silk-worm proper on mulberry, can be said to flourish. The greater part of the silk is wound in European filatures, and exported in the raw state to Europe. The native supply is either locally consumed, or sent up the Ganges to the great cities of the North-West. A considerable quantity of raw silk, especially for Bombay consumption, is imported from China. *Tasar* silk, or that obtained from the cocoons of semi-domesticated worms, does not contribute much to the supply. As compared with cotton weaving, the manufacture of silk fabrics may be called a town and not a village industry. These fabrics are of two kinds—(1) those composed of pure silk, and (2) those with a cotton warp crossed by a woof of silk. Both kinds are often embroidered with gold and silver. The mixed fabrics are known as *mashru* or *sufi*, the latter word, meaning "permitted," being used because the strict ceremonial law will not allow Mahometans to wear clothing of pure silk. They are largely woven in the towns of the Punjab and Sind, at Agra, at Hyderabad in the Deccan, and at Tanjore and Trichinopoli. Pure silk fabrics are either of simple texture, or highly ornamented in the form of *kinkhabs* or brocades. The latter are a specialty of Benares, Murshidábád, Ahmadábád, and Trichinopoli. Printed silks are woven at Surat for the wear of Pársí and Guzerati women. Quite recently mills with steam machinery have been established at Bombay, which weave silk fabrics for the Burmese market, chiefly *lúngyís*, *tamains*, and *patsoes*. The silk manufactures exported from India consist almost entirely of the handkerchiefs known as *bandannas* and *corahs*, with a small proportion of *tasar* fabrics. The trade appears to be on the decline, the total exports having decreased from 2,468,052 yards, valued at £238,000, in 1875–76 to 1,481,256 yards, valued at £147,000, in 1877–78. But in 1879 the value had again risen to £195,897; and the returns for 1874–77 were unusually high.

Embroidery. Embroidery has already been referred to in the two preceding paragraphs. The groundwork may be either silk, cotton, wool, or leather. The ornament is woven in the loom, or sewn on afterwards with the needle. Muslin is embroidered with silk and gold thread at Dacca, Patná, and Delhi. Sind and Cutch (Kachhch) have special embroideries of coloured silk and gold. Leather-work is embroidered in Guzerat. In some of the historical capitals of the Deccan, such as Gulbargah and Aurangábád, velvet (*makhmal*) is gorgeously embroidered with gold, to make canopies, umbrellas, and housings for elephants and horses, for use on state occasions. Not only the goldsmith, but also the jeweller lends his aid to Indian embroidery.

Carpet weaving. Carpets and rugs may be classified into those made of cotton and those made of wool. The former, called *satranjis* and *daris*, are made chiefly in Bengal and northern India, and appear to be an indigenous manufacture. The woollen or pile carpets known as *kalin* and *kalicha* are those which have recently attained so much popularity in England, by reason of the low price at which the outturn of the jail manufactories can be placed in the market. The art was probably introduced into India by the Mahometans. The historical seats of the industry are in Kashmír, the Punjab, and Sind, and at Agra, Mírzápur, Jabalpur, Warangal in the Deccan, Malabar, and Masulipatam. Velvet carpets are also made at Benares and Murshidábád, and silk pile carpets at Tanjore and Salem. At the London Exhibition of 1851 the finest Indian rugs came from Warangal, the ancient capital of the Andhra dynasty, about 80 miles east of Hyderabad. Their characteristic feature was the exceedingly fine count of the stitches, about 12,000 to the square foot. "They were also perfectly harmonious in colour, and the only examples in which silk was used with an entirely satisfactory effect" (Birdwood). The price was not less than £10 per square yard. The common rugs, produced in enormous quantities in the jails at Lahore, Jabalpur, Mírzápur, Benares, and Bangalore, sell in England at 7s. 6d. each.

Jewellers' work. Gold and silver and jewels, both from their colour and their intrinsic value, have always been the favourite material of Oriental ornament. Even the hill tribes of Central India and the Himálayas have developed some skill in hammering silver into brooches and torques. Imitation of knotted grass and leaves seems to be the origin of the simplest and most common form of gold ornament, the early specimens consisting of thick gold wire twisted into bracelets, &c. A second archaic type of decoration is to be found in the chopped gold jewellery of Guzerat. That is made of gold lumps, either solid or hollow, in the form of cubes and octahedrons, strung together on red silk. Of artistic jeweller's work, the best known examples come from Trichinopoli, Cuttack, Delhi, and Kashmír. Throughout southern India the favourite design is that known as *swámi*, in which the ornamentation consists of figures of Hindu gods in high relief, either beaten out from the surface or fixed upon it by solder or screws. The hammered *repoussé* silver work of Cutch (Kachhch), though now entirely naturalized, is said to be of Dutch origin. Similar work is done at Lucknow and Dacca. The goldsmith's art contributes largely to embroidery, as has already been mentioned. Gold and silver thread is made by being drawn out under the application of heat. The operation is performed with such nicety that one rupee's worth of silver will make a thread nearly 800 yards long. Before being used in the loom this metallic thread is generally twisted with silk.

Precious stones are lavishly used by Indian jewellers, who care less for their purity and commercial value than for the general effect produced by a blaze of splendour. "But nothing can exceed the skill, artistic feeling, and effectiveness with which gems are used in India both in jewellery proper and in the jewelled decoration of arms and jade" (Birdwood).

Iron work. *Iron Work.*—The chief duty of the village smith is, of course, to make the agricultural implements for his fellow-villagers. But in many towns in India, often the sites of former capitals, iron work, especially in the manufacture of arms, still retains a high degree of artistic excellence.

Cutlery and arms. *Cutlery.*—The blade of the Indian *talwár* or sword is sometimes marvellously watered, and engraved with date and name, sometimes sculptured in half-relief with hunting scenes, sometimes shaped along the edge with teeth or notches like a saw. Matchlocks and other firearms are made at several towns in the Punjab and Sind, at Monghyr in Bengal, and at Vizianágaram in Madras. Chain armour, fine as lacework and said to be of Persian origin, is still manufactured in Kashmír, Rájputána, and Cutch (Kachhch). Ahmadnagar in Bombay is famous for its spear-heads. Both firearms and swords are often damascened in gold, and covered with precious stones. In fact, the characteristic of Indian arms, as opposed to those of other Oriental countries, is the elaborate goldwork hammered or cut upon them and the unsparing use of gems. Damascening on iron and steel, known as *kuft*, is chiefly practised in Kashmír, and at Guzerat and Siálkot in the Punjab. Damascening in silver, which is chiefly done upon bronze, is known as *bidari* work, from the ruined capital of Bidar in the nizám's dominions, where it is still chiefly carried on.

Brass and copper work.

Brass and Copper.—The village brazier, like the village smith, manufactures the necessary vessels for domestic use. Chief among these vessels is the *lota*, or globular bowl, universally used in ceremonial ablutions. The form of the *lota*, and even the style of ornamentation, has been handed down unaltered from the earliest times. Benares enjoys the first reputation in India for work in brass and copper. In the south, Madura and Tanjore have a similar fame; and in the west, Ahmadábád, Poona, and Násik. At Bombay itself large quantities of imported copper are wrought up by native braziers. The temple bells of India are well known for the depth and purity of their note. In many localities the braziers have a special repute either for a peculiar alloy or for a particular process of ornamentation. Silver is sometimes mixed with the brass, and in rarer cases gold. The brass or rather bell-metal ware of Murshidábád, known as *khágraí*, has more than a local reputation, owing to the large admixture of silver in it.

Pottery.

Pottery is made in almost every village, from the small vessels required in cooking to the large jars used for storing grain, and occasionally as floats to ferry persons across a swollen stream. But, though the industry is universal, it has hardly anywhere risen to the dignity of a fine art. Sind is the only province of India where the potter's craft is pursued with any regard to artistic considerations; and there the industry is said to have been introduced by the Mahometans. Sind pottery is of two kinds, encaustic tiles and vessels for domestic use. In both cases the colours are the same,—turquoise blue, copper green, dark purple, or golden brown, under an exquisitely transparent glaze. The usual ornament is a conventional flower pattern, pricked in from paper and dusted along the pricking. The tiles, which are evidently of the same origin as those of Persia and Turkey, are chiefly to be found in the ruined mosques and tombs of the old Musalmán dynasties; but the industry still survives at the little towns of Saidpur and Bubri. Artistic pottery is made at Hyderabad, Karáchi, Tatta, and Hála, and also across the border, at Lahore and Múltán in the Punjab. The Madura pottery also deserves mention from the elegance of its form and the richness of its colour. The North-Western Provinces have, among other specialties, an elegant black ware with designs in white metal worked into its surface.

Sculpture and carving.

Carving and Inlaying.—Stone sculpture is an art of the highest antiquity in India, as may be seen in the early memorials of Buddhism. Borrowing an impulse from Greek exemplars, the Buddhist sculptors at the commencement of our era freed themselves from the Oriental tradition which demands only the gigantic and the grotesque, and imitated nature with some success. But with the revival of Bráhmanism Hindu sculpture again degenerated; and so far as the art can still be said to exist, it possesses a religious rather than an æsthetic interest. In the cities of Guzerat, and in other parts of India where the houses are built of wood, their fronts are ornamented with elaborate carving. Wood-carving, an important industry in Western India, is said, perhaps erroneously, to owe its origin to Dutch patronage, though the models of the carvers are evidently taken from their own temples. The favourite materials are blackwood, sandal-wood, and jack-wood. The supply of sandal-wood comes from the forests of the Western Gháts in Kánara and Mysore, but some of the finest carving is done at Surat and Ahmadábád. Akin to sandal-wood carving is the inlaying of the miscellaneous articles known as "Bombay boxes." This art is known to be of modern date, having been introduced from Shiraz in Persia towards the close of the last century. It consists of binding together in geometrical patterns strips of tin-wire, sandal-wood, ebony, ivory, and stag's horn. At Vizagapatam, in Madras, similar articles are made of ivory and stag's horn, with scroll-work edged in to suit European taste. At Máinpuri, in the North-Western Provinces, wooden boxes are inlaid with brass wire. The chief seats of ivory-carving are Amritsar, Benares, Murshidábád, and Travancore, where any article can be obtained to order, from a full-sized palanquin to a lady's comb. Human figures in clay, dressed to the life, are principally made at Krishnagar in Bengal, Lucknow, and Poona.

Cotton mills.

It remains to give some account of those manufactures proper, conducted by steam machinery and under European supervision, which have rapidly sprung up in certain parts of India during the past few years. These comprise cotton, jute, silk, and beer.

The first mill for the manufacture of cotton yarn and cloth by machinery worked by steam was opened at Bombay in 1854. The enterprise grew with scarcely a check, until by 1879 the total number of mills throughout India was 58, with about 1½ million spindles and 12,000 looms, giving employment to upwards of 40,000 persons—men, women, and children. Of this total, 30 mills, or more than half, were in the island of Bombay, which now possesses a busy manufacturing quarter with tall chimney stalks, recalling the aspect of a Lancashire town; 14 were in the cotton-growing districts of Guzerat, also in the Bombay presidency; 6 were in Calcutta and its neighbourhood; 3 at Madras; 2 at Cawnpur in the North-Western Provinces; 1 at Nágpur in the Central Provinces; 1 at Indore, the capital of Holkar's dominions; and 1 at Hyderabad, the residence of the nizám. Like the jute mills of Bengal, the cotton factories of Bombay have suffered of late years from the general depression of trade.

The Indian mills are, almost without exception, the property of joint-stock companies, the shares in which are largely taken up by natives. The overlookers are skilled artisans brought from England, but natives are now beginning to qualify themselves for the post. The operatives are all paid by the piece; and, as compared with other Indian industries, the rate of wages is high. In 1877, at Bombay, boys earned from 14s. to £1 a month; women, from 16s. to £1; and jobbers, from £3 to £6, 10s. Several members of one family often work together, earning among them as much as £10 a month. The hours of work are from six in the morning to six at night, with an hour allowed in the middle of the day for meals and smoking. A Factory Act, to regulate the hours of work for children and young persons and to enforce the fencing of dangerous machinery, &c., is now (1881) under the consideration of the legislative council.

Besides supplying the local demand, these mills are gradually beginning to find a market in foreign countries, especially for their twist and yarn. Between 1872-73 and 1878-79 the export of twist from Bombay increased from 1,802,863 lb, valued at £97,162, to 21,271,059 lb, valued at £883,665, or an increase of nearly twelvefold in quantity and ninefold in value. Within the same period of eight years the export of grey piece-goods increased from 4,780,834 yards, valued at £75,495, to 14,993,336 yards, valued at £198,380. The twist and yarn are mostly sent to China and Japan, the piece-goods to the coast of Arabia and Africa. The figures for the coasting trade also show a corresponding growth, the total value of twist carried from port to port in 1878-79 having been £804,996, and of piece-goods (including hand-loom goods) £654,553. Mr O'Conor, who has devoted much attention to the matter, thus summarizes his opinion regarding the future of the Indian cotton mills in his *Review of Indian Trade for* 1877-78:—"Whether we can hope to secure an export trade or not, it is certain that there is a sufficient outlet in India itself for the manufactures of twice fifty mills; and, if the industry is only judiciously managed, the manufactures of our mills must inevitably, in course of time, supersede Manchester goods of the coarser kinds in the Indian market."

Jute mills.

The jute mills of Bengal have sprung up to rival Dundee, just as Bombay competes with Manchester; but in the former case the capital is mostly supplied by Europeans. They cluster thickly round Calcutta, extending across the river into Hooghly district; and one has been planted at Sirájganj, far away up the Brahmaputra in the middle of the jute-producing country. In 1879 the total number of jute mills in India was 21, of which all but two were in Bengal, and the number is annually increasing. The weaving of jute into gunny cloth is an indigenous industry throughout northern Bengal, chiefly in the district of Purniah and Dinájpur. The gunny is made by the semi-aboriginal tribe of Koch, Rájbansí or Páli, both for clothing and for bags; and, as with other industries practised by non-Hindu races, the weavers are the women of the family, and not a distinct caste. In 1877-78 just three million bags were imported into Calcutta from Pábná district, being the product of the Sirájganj mills. The total exports by sea and land of both power-loom and hand-made bags numbered 80 millions, of which not more than 6 millions were hand-made. The East Indian Railway took 20 millions for the grain marts of Behar and the North-Western Provinces (chiefly Patná and Cawnpur); and 1 million went as far as Ludhiána in the Punjab. The total exports by sea exceeded 57 millions, of which 32 millions represent interportal, and 25 millions foreign trade. Bombay took as many as 16 millions, and British Burmah 12 millions. In fact, Calcutta supplies bagging for the whole of India. The foreign trade may be given in greater detail, for gunny weaving is perhaps the single Indian industry that aims at a foreign market. The total export of jute manufactures (both bags and cloth) in 1872–73 was valued at £200,669. By 1878–79 the value had risen to £1,098,434, or an increase of fivefold in six years. Within the same period the exports to the United Kingdom alone increased from 21,200 bags, valued at £585, to 7 million bags, valued at £184,400. The other countries which take Indian gunny bags are the following, with the values for 1877–78:—Australia, £298,186; Straits Settlements, £161,772; United States, £79,795; Egypt, £76,726; China, £32,121.

Brewing. Brewing has recently become established as a prosperous business at the large hill stations on the Himálayas. There are now about twelve breweries in India, including five in the Punjab and North-Western Provinces, at Mari (Murree), Simla, Kasauli, Masuri (Mussoorie), and Náini Tál, and two in the Madras presidency, at Utakamand and Bellary. The total quantity of beer brewed was returned at 2,162,888 gallons in 1877 and 1,522,769 gallons in 1878, the diminution being due to the termination of a contract between the Commissariat Department and one of the Masuri breweries. The total quantity of beer imported in 1878–79 was 2 million gallons by Government and 1 million gallons on private account, so that the Indian breweries now satisfy just one-third of the entire demand. At Simla imported beer sells at over 18s. per dozen, while that from the local brewery can be obtained for 11s. per dozen. The hops are entirely imported, for the experimental plantation of 100 acres established by the rájá of Kashmír has not yet proved a practical success. The imports of hops show a steady increase from 1529 cwts. in 1875–76 to 1807 cwts. in 1876–77, and 2135 cwts. in 1877–78.

Paper. The steam paper-mills established in the neighbourhood of Calcutta and at Bombay have almost entirely destroyed the local manufactures of paper which once existed in many parts of the country. The hand-made article, which was strong though coarse, and formed a Mahometan specialty, is now no longer used for official purposes. Besides manufacturing munitions of war, the

Leather. Government possesses a large leather factory at Cawnpur, which turns out saddlery, &c., of excellent quality. Indeed, leather manufactures are an important local industry in Oudh and the North-Western Provinces, and are conducted on such a scale as to preclude the import from England, except in the case of *articles de luxe*.

Minerals.

The Indian peninsula, with its wide area and diversified features, supplies a great store of mineral wealth, characterized both by variety and unusual richness. In utilizing this wealth, English enterprise has met with many rebuffs. Much capital has been expended with no other result in many cases than disappointment. But the experience has not been thrown away; and the mining industry, now established on a sure basis, is rising into an important position in a country which ought gladly to welcome any employment other than the universal pursuit of agriculture.

Iron. *Iron.*—In purity of ore, and in antiquity of working, the iron deposits of India probably rank first in the world. They are to be found in every part of the country, from the northern mountains of Assam and Kumáun to the extreme south of the Madras presidency. Wherever there are hills, iron is found and worked to a greater or less extent. The indigenous methods of smelting the ore, which are everywhere the same, and have been handed down unchanged through countless generations, yield a metal of the finest quality in a form well suited to native wants. But they require an extravagant supply of charcoal; and even with the cheapness of native labour the product cannot compete in price with imported iron from England. European enterprise, attracted by the richness of the ore and the low rate of wages, has repeatedly tried to establish ironworks on a large scale; but hitherto every one of these attempts has ended in failure, alike in Madras, in the Central Provinces, in the Ráníganj coal-field, and in Kumáun. At the present time iron is manufactured only by peasant families of smelters, each working on a very small scale; and even this industry is languishing under the competition of English imports. The initial difficulty in India is to find the three elements of iron working—namely, the ore, the flux, and the fuel—sufficiently near to each other; the second difficulty is the choking of the furnaces from the excessive quantity of ash in the coal.

Coal. Coal has been known to exist in India since 1774, and is said to have been worked as far back as 1775. There are now altogether fifty-eight collieries in the country, with an annual out-turn of about 1 million tons. In India, as elsewhere, coal-mining and railway extension have gone hand in hand. Coal is comparatively worthless unless it can be brought to market by rail; and the price of coal is the chief element in determining the expenses of railway working. The history of coal in India has, on the whole, been one of continual progress. The first mine, at Ráníganj, dates from 1820, and has been worked regularly up to the present time. In 1878 its output was 50,000 tons. For twenty years no new mine was opened; but the commencement of the East India Railway in 1854 gave a fresh impetus to the industry, and since that date collieries have been opened at the rate of two or three every year. The largest number of additions was seven, in 1874. By 1878 the total number of collieries in connexion with the East Indian system was fifty-six. From these are supplied, not only the railway itself, but also the jute mills of Calcutta, and the river steamers of Lower Bengal. In 1877–78 the railway used 308,000 tons of coal from its own collieries at Karharbárí and Srirámpur, and sent exactly the same quantity to Calcutta. In that year the imports of coal into Calcutta by sea were only 80,000 tons, so that Calcutta now uses about 80 per cent. of Indian to 20 per cent. of foreign coal. Bombay, on the other hand, and also Madras are entirely supplied with coal from England. The collieries in the Central Provinces, which are the only others worked on a large scale, are limited to the supply of the Great Indian Peninsula Railway. They are two in number,—(1) the Warora colliery, under the management of the Public Works Department, and (2) the Mohpání colliery, which has been leased to the Narbadá Coal Company. The total area of the Ráníganj coal-field has been estimated at 500 square miles. In this "black country" of India, which is dotted with tall chimney-stalks, six European companies are at work, besides many native firms. At first coal was raised from surface quarries, but regular mining is now carried on, according to the system of "pillar and stall." The seams are entirely free from gas, so that the precautions usual in England against explosion are found unnecessary. The miners are all drawn from the aboriginal low-castes, chiefly Santáls and Baurís, who are noted for their endurance and docility. Baurís work with the pick, but Santáls will consent to use no other tool than the crowbar. Wages are high, and the men look well-fed, though they waste their surplus earnings in drink. The great drawback of Indian coal is its large proportion of ash, varying from 14 to 20 per cent., as against 3 to 6 per cent. in English coal. This places it at a great disadvantage alike for iron-smelting and locomotive purposes. But it has been proved that, with efficient fire-grates and proper manipulation, 135 lb of Warora coal will do the work of 100 lb of English coal.

Salt. Salt, an article of supreme necessity to the Indian peasant who eats no meat, is derived from three main sources, exclusive of importation from Europe:—(1) by evaporation from sea-water along the entire double line of seaboard from Bombay to Orissa, but especially in Guzerat and on the Coromandel coast; (2) by evaporation from inland lakes, of which the Sámbhar Lake in Rájputána affords the chief example; (3) by quarrying solid hills of salt in the north-east of the Punjab. The last is the only case in which salt can be said to exist as a mineral. It occurs in solid cliffs, which for extent and purity are stated to have no rival elsewhere in the world. The chief of these has given its name to the Salt Range, running across the districts of Jhelum (Jhílam) and Shábpur, from the bank of the Jhelum river to Kálábágh in Bannu district. Similar deposits are found beyond the Indus in Kohát district, where the salt is of two kinds, red and green, and in the hill state of Mandi bordering on Kángrá district. The salt is found in the red marls and sandstones of the Devonian group. In some cases it can be obtained from open quarries; but more generally it is approached by regular mining by pick and blasting, through wide galleries. The principal mine is at Keora in Jhelum district, now called after Lord Mayo. The total annual out-turn in the Punjab is returned at about 50,000 tons, yielding a revenue to Government of more than £400,000. In 1877–78 the actual figures of revenue were—(1) from the Salt Range, £426,000, (2) from Kohat, £8000, (3) from Mandi, £6000.

Rock-salt.

In southern India salt made by evaporation is almost universally consumed. Lower Bengal, especially eastern Bengal, uses salt imported from Cheshire at low rates of freight, and paying the excise duty at Calcutta or other port of entry. In Orissa and south-western Bengal both imported salt and salt made by solar evaporation are consumed, the latter being alone considered pure for religious purposes or for the priests.

Saltpetre.

Saltpetre.—At one time India had almost a monopoly of the supply of saltpetre upon which Europe depended for its gunpowder. In combination with other saline substances it occurs as a white efflorescence upon the surface of the soil in many parts of the country, especially in the upper valley of the Ganges. Its preparation leaves common salt as one of the residuary products; and consequently fiscal reasons have tended to limit the manufacture to the most remunerative region, which is found in North Behar. The manufacture is simple, and entirely in the hands of a special caste of natives, called Nuniyás, who are conspicuous for their capacity of enduring hard work. As is the case with most Indian industries, they work under a system of money advances from middle-men, who are themselves sub-contractors under the large houses of business. In former times the East India Company engaged in the manufacture on its own account; when it abandoned all private trade, its works were taken over by European firms, but these have in their turn retired from the business, which is now in a state of decline, partly owing to the general fall in price, and partly to the restrictions imposed by the salt preventive department. The exports of saltpetre from Calcutta are fairly constant, averaging about 450,000 cwts. a year, of which one-half goes to the United Kingdom. More than two-thirds of the total comes from Behar, chiefly from the districts of Tirhút, Sáran, and Champáran, though Patná is the railway station for despatch to Calcutta. Cawnpur, Gházípur, Allahábád, and Benares, in the North-Western Provinces, send small quantities, while a little comes from the Punjab.

Gold.

Gold exists in many parts and probably in considerable quantities. Herodotus affirms that the Indians were the only nation who paid their tribute to Darius in gold; and there is some reason for believing that the "Ophir" of King Solomon is to be identified with the Malabar coast. Nearly every hill stream is washed for gold, whether in the extreme south, in the central plateau, or on the north-east and north-west frontiers. It is true that gold-washing is everywhere a miserable business, affording the barest livelihood; but yet the total amount of gold obtained in this way cannot be insignificant. In recent years attention has been prominently drawn to the possibility of extracting gold from the quartz formation of southern India, which bears many points of resemblance to the auriferous quartz reefs of Australia. The principal localities are in the Wainád (Wynaad) subdivision of the Nílgiri district and in Kolár district of Mysore. Gold-washing has always been practised there; and the remains of old workings show that at some unknown period operations have been conducted on a large scale.

From about 1875 to 1880 individual pioneers were prospecting in that region. Crushing the quartz by rude native methods, they proved that it contained a larger proportion of gold than is known to yield a profit in Australia. These experiments on the southern ends of six reefs yielded an average of 7 dwts. per ton of quartz, rising in one case to 11 dwts. The best assay of the gold showed a fineness of slightly over 20 carats. In 1879 Government summoned a practical mining engineer from Australia, whose report was eminently hopeful. He described the quartz reefs as of great extent and thickness and highly auriferous. One reef in Kolár, laid bare 100 feet longitudinally, gave an average of 1 oz. of gold per ton. In order to attract capital, Government proposed to grant mining leases at a dead rent of Rs. 5 (10s.) per acre, subject to no royalty or further tax. Up to 1880 the enterprise had scarcely passed beyond the stage of laboratory experiments. If the results of actual working with elaborate machinery realize the promise held out by competent investigators, gold-mining will be established as an important industry in southern India.

Copper.

Copper is known to exist in many parts of the country in considerable quantities. The richest mines are in the lower ranges of the Himálayas, from Dárjíling westward to Kumáun. The ore occurs in the form of copper pyrites, often accompanied by mundic, not in true lodes, but disseminated through the slate and schist. The miners are almost always Nepálís, and the remoteness of the situation has deterred European capital. The extent of abandoned workings proves that these mines have been known and worked for many years. The best seams show a proportion of copper slightly above the average of Cornish ore, but the ordinary yield is not more than about 4 per cent. The mines resemble magnified rabbit-holes, meandering passages being excavated through the rock with little system. The tools used are an iron hammer and chisel, and sometimes a small pick. After extraction, the ore is pounded, washed, and smelted on the spot. The price obtained for the metal is Rs. 2.8.0 per 3 *sers*, or at the rate of about 10d. a pound. Copper-ore, of fair purity and extending over a considerable area, also occurs in Singbhúm district of Chutiá Nágpur, where there are many deserted diggings and heaps of scoriæ. In 1857 a company was started to re-open the workings at these mines; but, though large quantities of ore were produced, the enterprise did not prove remunerative, and was finally abandoned in 1864. A similar attempt to work the copper found in Nellore district of Madras also ended in failure.

Lead.

Lead occurs in the form of sulphuret or galena along the Himálayas on the Punjab frontier, and has been worked at one place by an English company.

Tin.

Tin is confined to the Burmese peninsula. Very rich deposits, yielding about 70 per cent. of metal, occur over a large extent of country in Mergui and Tavoy districts of the Tenasserim region. The ore is washed and smelted, usually by Chinese, in a very rough and unscientific way. Recent experiments made by a European firm seem to show that the deposits, though rich and extensive, are not sufficiently deep to repay more elaborate processes.

Antimony.

Antimony, in the form of *surmá*, which is largely used by the natives as a cosmetic, is chiefly derived from the hill states of the Punjab. It is also found in Mysore and Burmah. The minerals of Rájputána, which have not yet been thoroughly ascertained, include an ore of cobalt used for colouring enamel.

Mineral oil.

Petroleum is produced chiefly in Independent Burmah, but it has also been found on British territory in Pegu, in

Assam, and in the Punjab. Near the village of Ye-nang-yaung in Upper Burmah, on the banks of the Irawadi, there are upwards of one hundred pits or wells with a depth of about 250 feet, from which petroleum bubbles up in inexhaustible quantities. The annual yield is estimated at 11,000 tons, of which a considerable quantity is exported. Petroleum wells are also found in the British districts of Akyab, Kyouk-hpyu, and Thayet-myo, which first attracted British capital with most promising results in 1877. In Assam petroleum occurs in the neighbourhood of the coal-fields in the south of Lakhimpur district, and was worked in conjunction with the coal by a European capitalist in 1866. In the Punjab petroleum is worked by the Public Works Department at two spots in Ráwal Pindí district. In 1873–74 the total yield was only 2756 gallons.

Lime-stone. *Stone.*—The commonest and also the most useful stone of India is *kankar*, a nodular form of impure lime, which is found in almost every river valley, and is used universally for metalling the roads. Lime for building is derived from two sources,—(1) from burning limestone and *kankar*, and (2) from the little shells so abundantly found in the marshes. Calcutta derives its chief supply from the quarries of the Khásí hills in Assam, known as "Sylhet lime," and from the Susunia quarries in Bankura district. The Gangetic delta is destitute of stone, nor does the alluvial soil afford good materials for brick-making or pottery. But a European firm has recently established large pottery-works at Ráníganj in Bardwán, which employ about five hundred hands, and carry out contracts for drainage pipes and stoneware. Other stones. The centre of the peninsula and the hill country generally abound in building-stone of excellent quality, which has been used locally from time immemorial. Among the finest stones may be mentioned the pink marble of Rájputána, of which the historical buildings at Agra were constructed, the trap of the Deccan, the sandstone of the Godávari and the Narbadá, and the granite of southern India. Quarries of slate are scattered through the peninsula, and are sometimes worked by European capital. Mica and talc are also quarried to make ornaments. Among the hills of Orissa and Chutiá Nágpur household vessels and ornaments are skilfully carved out of an indurated variety of potstone.

Diamonds. *Precious Stones.*—Despite its legendary wealth, which is really due to the accumulations of ages, India cannot be said to be naturally rich in precious stones. Under the Mahometan rule diamonds were a distinct source of state revenue; and Akbar is said to have received a royalty of £80,000 a year from the mines of Panna. But at the present day the search for them, if carried on anywhere in British territory, is an insignificant occupation. The name of Golconda has passed into literature; but that city, once the Musalmán capital of the Deccan, was rather the home of diamond-cutters than the source of supply. It is believed that the far-famed diamonds of Golconda actually came from the sandstone formation which extends across the south-east borders of the nizám's dominions into the Madras districts of Ganjám and Godávari. A few worthless stones are still found in that region. Sambalpur, on the upper channel of the Mahánadi river in the Central Provinces, is another spot once famous for diamonds. So late as 1818 a stone is said to have been found there weighing 84 grains and valued at £500. The river valleys of Chutiá Nágpur are also known to have yielded a tribute of diamonds to their Mahometan conqueror. At the present day the only place where the search for diamonds is pursued as a regular industry is the native state of Panna (Punnah) in Bundelkhand. The stones are found by digging down through several strata of gravelly soil and washing the earth. Even there, however, the pursuit is understood to be unremunerative, and has failed to attract European capital. About other gems little information is available. Other gems. Turquoises are said to be found near Múltán in the Punjab, though far inferior to the Persian stones. Independent Burmah yields many valuable gems; and some excitement has been caused by the discovery of sapphire mines just across the Siamese frontier. Poor pearl fisheries exist off the coast of Madura district in the extreme south, and in the Gulf of Cambay; but the great majority of Indian pearls come either from Ceylon or from the Persian Gulf. In the year 1700 the Dutch obtained a lease of all the pearl fisheries along the Madura coast, and sublet the right of fishing to native boatmen, of whom seven hundred are said to have taken licences annually at the rate of 60 *écus* per boat. The town of Cambay in Guzerat is celebrated for its carving in carnelian, agate, and onyx. The stones come from the neighbourhood of Ratanpur, in the state of Rájpípla. They are dug up by Bhíl miners, and subjected to a process of burning before being carved. The most valued colour for carnelians is red, but they are also found white and yellow. Lapis lazuli is found in the mountains of the north, and freely used in the decoration of temples and tombs.

FAMINES.

As the agriculture of India is mainly dependent upon the bounty of nature, so is it peculiarly exposed to the vicissitudes of the seasons. In any country where the population is dense and the means of communication backward, the failure of a harvest, whether produced by drought, by flood, by blight, by locusts, or by war, must always cause much distress. Whether that shall develop into famine is merely a matter of degree, depending upon a combination of circumstances—the comparative extent of the failure, the density of the population, and the practicability of imports.

Causes of famine. Drought, or an inadequate supply of rain, is undoubtedly the great cause of wide-spread famine. No individual foresight, no compensating influences, can entirely prevent those recurring periods of continuous drought with which large provinces of India are afflicted. An average rainfall, if irregularly distributed, may affect the harvest to a moderate degree, as also may flood or blight. The total failure of a monsoon may result in a general scarcity, sufficiently severe to arouse the solicitude of Government. But famine proper, or wide-spread starvation, is caused only by a succession of years of drought. The cultivators of India are not dependent upon a single harvest or upon the crops of one year. In the event of a partial failure, they can draw for their food supply either upon their own grain pits or upon the stores of the village merchants. The first sufferers, and those who suffer most in the end, are the class who live by daily wages. But small is the number that can hold out, either in capital or credit, against a second year of insufficient rainfall; and not impossibly a third season may prove adverse. All the great famines in India of which we have record have been caused by drought, and usually by drought repeated over a series of years.

Water supply. This being so, it becomes necessary to inquire into the water supply, which varies extremely in different parts of the country. It can be derived only from three sources—(1) local rainfall, (2) natural inundation, and (3) artificial irrigation from rivers, canals, tanks, or wells. Any of these sources may exist separately or together. In only a few parts of India can the rainfall be entirely trusted, as both sufficient in its amount and regular in its distribution. Those favoured tracts include the whole strip of coast beneath the Western Ghâts, from Bombay to Cape Comorin; and the greater part of the provinces of Assam and Burmah, together with the deltaic districts at the head of the Bay of Bengal. There the annual rainfall rarely, if ever, falls below 100 inches; artificial irrigation and famine are alike unknown. The whole of the rest of the peninsula may be described as liable, more or less, to drought. In Orissa, the scene of one of the most severe famines of recent times, the average rainfall exceeds 60 inches a year; in Sind, which has been exceptionally free from famine under British rule, the average falls to less than 10 inches. The local rainfall, therefore, is not the only element to be considered. Broadly speaking, artificial irrigation has protected, or is now in course of protecting, certain fortunate regions, such as the eastward deltas of the Madras rivers and the upper valley of the Ganges. The rest, and by far the greater portion, of the country is still exposed to famine. Nor is it easy to see any remedy. Meteorological science may teach us to foresee what is coming; but it may be doubted whether it is in our power to do more than alleviate. Lower Bengal and Oudh are watered by natural inundation as much as by the local rainfall; Sind derives its supplies mainly from canals filled by the floods of the Indus; the Punjab and the North-West Provinces are dependent largely upon wells; the Deccan with the entire south is the land of tanks and reservoirs. But in all these cases, when the rainfall has failed over a series of years, the artificial supply must likewise fail after no long interval, so that irrigation becomes a snare rather than a benefit. Water works on a scale adequate to guarantee the whole of India from drought are not only above the possibilities of finance; they are also beyond the reach of engineering skill.

[Fa]mine [of 18]76-78. Taking the example of the famine of 1876-78, the most wide spread and the most prolonged that India has yet known, we may say that the drought commenced in Mysore by the failure of the monsoon in 1875, and that all fear of distress in the North-West Provinces did not pass away until 1879. But it will always be known in history as the great famine in the south. Over the entire Deccan, from Poona to Bangalore, the south-west monsoon failed to bring its usual rainfall in the summer of 1876. In the autumn of the same year the north-east monsoon proved deficient in the south-eastern districts of the Madras presidency. The main food crop, therefore, entirely perished throughout an immense tract of country; and, as the harvest of the previous year had also been short, prices rapidly rose to famine rates. In November 1876 it was first officially recognized that starvation was abroad in the land, and that Government must adopt measures to keep the people alive. From that time until the middle of 1878, a period of more than eighteen months, the campaign against famine was strenuously conducted, with various vicissitudes. The summer monsoon of 1877 proved a failure; some relief was brought in October of that year by the autumn monsoon; but all anxiety was not removed until the arrival of a normal rainfall in June 1878. Meanwhile the wave of drought had reached northern India, where it found the stocks of grain much depleted to meet the famine demand in the south. Bengal, Assam, and Burmah were the only provinces that escaped scot free in that disastrous year. The North-West Provinces, the Punjab, Rájputána, and the Central Provinces alike suffered from drought through all the summer of 1877, and from its consequences well into the following year. When once famine gets ahead of relief operations, all is over. The flood of distress bursts through the embankment. Starvation and all the attendant train of famine diseases sweep away their thousands. The total expenditure of Government upon famine relief on this occasion may be estimated at about 8 millions sterling, not including the indirect loss of revenue nor the amount debited against the state of Mysore. For this large sum of money there is but little to show in the way of works constructed. The largest number of persons in receipt of relief at one time in Madras was 2,591,900 in September 1877; of these only 634,581 were nominally employed on works, while the rest were gratuitously fed. From cholera alone the deaths were returned at 357,430 for Madras, 58,648 for Mysore, and 57,252 for Bombay. Dr Cornish, the sanitary commissioner of Madras, well illustrated the effects of the famine by contrasting the returns of births and deaths over a series of years. In 1876, when famine with its companion cholera was already beginning to be felt, the births registered in Madras numbered 632,113 and the deaths 680,381. In 1877, the year of famine, the births fell to 477,447, while the deaths rose to 1,556,312. In 1878 the results of the famine showed themselves by a still further reduction of the births to 348,346, and by the still high number of 810,921 deaths. In 1879 the births recovered to 476,307, still considerably below the average, and the deaths diminished to 548,158. These figures are, of course, not accurate; but they serve to show how long the results of famine are to be traced in the vital statistics of a people.[1]

Previous famines. The first great famine of which we have any trustworthy record is that which devastated the lower valley of the Ganges in 1769-70. One-third of the population is credibly reported to have perished. The previous season had been bad; and, as not uncommonly happens, the break-up of the drought was accompanied by disastrous floods. Beyond the importation into Calcutta and Murshidábád of a few thousand *maunds* of rice from the fortunate districts of Bákarganj and Chittagong, it does not appear that any public measures for relief were taken or proposed. The next great famine was that which afflicted the Carnatic from 1780 to 1783, and has been immortalized by the genius of Burke. It was primarily caused by the ravages of Hyder Ali's army. A public subscription was organized by the Madras Government, from which sprang the "Monegar Choultry," or permanent institution for the relief of the native poor. In 1783-84 Hindustan Proper suffered from a prolonged drought, which stopped short at the frontier of British territory. Warren Hastings, then governor-general, advocated the construction of enormous granaries, to be opened only in times of necessity. One of these granaries or *golás* stands to the present day in the city of Patná, but it was never used until the scarcity of 1874. In 1790-92 Madras was again the scene of a two years' famine, which is memorable as being the first occasion on which the starving people were employed by Government on relief works. No useful lesson of administrative experience is to be learned from the long list of famines and scarcities which afflicted the several provinces of India at recurring periods during the first half of the present century. In 1860-61 a serious attempt was made to alleviate an exceptional distress in the North-Western Provinces. About half a million persons are estimated to have been relieved at an expenditure by Government of about three quarters of a million sterling. Again, in 1865-66, which will ever be known as the year of the Orissa famine, the Government attempted to organize relief works and distribute charitable funds. But on neither of these occasions can it be said that the efforts were successful. In Orissa, especially, the admitted loss of one-fourth of

[1] With regard to the deaths caused by the famine and the diseases connected with it, the Famine Commissioners thus report:—"It has been estimated, and in our opinion on substantial grounds, that the mortality which occurred in the provinces under British administration during the period of famine and drought extending over the years 1877 and 1878 amounted, on a population of 197 millions, to 5¼ millions in excess of the deaths that would have occurred had the seasons been ordinarily healthy; and the statistical returns have made certain what has long been suspected, that starvation and distress greatly check the fecundity of the population. It is probable that from this cause the number of births during the same period has been lessened by 2 millions; the total reduction of the population would thus amount to about 7 millions. Assuming the ordinary death roll, taken at the rate of 35 per *mille*, on 190 millions of people, the abnormal mortality of the famine period may be regarded as having increased this total by about 40 per cent." But when estimated over a period of years the effect of famine as a check upon the population is small. The Famine Commissioners calculate that, taking the famines of the past thirty years, as to which alone an estimate of any value can be made, the abnormal deaths caused by famine and its diseases have been less than 2 per *mille* of the Indian population per annum. As a matter of fact cultivation quickly extended after the famine of 1877-78, and there were in Bombay and Madras 120,000 more acres under tillage after the long protracted scarcity than before it.

the population proves the danger to which an isolated province is exposed. The people of Orissa died because they had no surplus stocks of grain of their own, and because importation was absolutely impracticable. Passing over the prolonged drought of 1868-70 in the North-West Provinces and Rájputána, we come to the Behar scarcity of 1873-74, which first attracted the interest of England. Warned by the failure of the rains, and watched and stimulated by the excited sympathy of the public at home, the Government carried out in time a comprehensive scheme of relief. By the expenditure of 6½ millions sterling, and the importation of one million tons of rice, all risk even of the loss of life was prevented. The comparatively small area of distress, and the facilities of communication by rail and river, alone permitted the accomplishment of the feat, which remains unparalleled in the annals of famine. During the recent famine in southern India the authorities worked with no less energy, and charitable bounty was far more conspicuous, yet the conditions of the case predestined failure. The stricken tract was many times larger than Behar. No early warning was given. The rainfall failed, not once, but for three successive seasons, and, above all, adequate importation and distribution of grain were physical impossibilities. The people were dying while the grain that could have kept them alive was rotting on the beach of Madras or on the railway sidings of Upper India. What administrative enterprise can accomplish where the circumstances are within the compass of human control may be learned from the case of Bombay. In that presidency the famine affected about 34,000 square miles of country, with a population of about 5,000,000 souls. The highest number of persons in receipt of relief at one time was 529,000 in June 1877, of whom the great majority were employed on remunerative works. The importation of grain was left entirely free; and within twelve months 268,000 tons were brought by rail and 166,000 tons by sea into the distressed districts. The total gross cost to Government was estimated at 1½ millions, of which about 1 million will be returned.

ADMINISTRATION.

The supreme authority over all British India, both for executive and legislative purposes, is vested by a series of Acts of Parliament [1] in the viceroy or governor-general-in-council, subject to the ultimate sanction of the secretary of state in England. Every executive order and every legislative statute runs in the name of the "Governor-General-in-Council"; [2] but in certain exceptional classes of cases [3] a power is reserved to the viceroy to act independently of his council. This council is twofold. First, there is the ordinary or executive council, [4] usually composed of about six official members besides the viceroy, which may be compared with the cabinet of a constitutional country. It meets regularly at short intervals, discusses and decides upon questions of foreign policy and domestic administration, and prepares measures for the legislative council. Its members divide among themselves the chief departments of state, such as those of foreign affairs, finance, war, public works, &c.; while the viceroy combines in his own person the duties both of constitutional sovereign and prime minister. Secondly, there is the legislative council, [5] which is constituted by the same members as the preceding, with the addition of the governor of the province in which it may be held, and official delegates from Madras and Bombay, together with certain nominated members representing the non-official native and European communities. The meetings of the legislative council are held when and

Executive council.

Legislative council.

[1] The chief of these Acts are 13 Geo. III. c. 63; 33 Geo. III. c. 52; 3 and 4 Will. IV. c. 85; 21 and 22 Vict. c. 106; and 24 and 25 Vict. c. 67.

[2] A style first authorized by 33 Geo. III. c. 52, § 39.

[3] "Cases of high importance and essentially affecting the public interest and welfare" (33 Geo. III. c. 52, § 47); "when any measure is proposed whereby the safety, tranquillity, or interests of the British possessions in India may in the judgment of the governor-general be essentially affected" (3 and 4 Will. IV. c. 85, § 49); "cases of emergency" (24 and 25 Vict. c. 67, § 23).

[4] The lineal descendant of the original council organized under the charters of the Company, first constituted by parliamentary sanction in 1773 (13 Geo. III. c. 63, § 7).

[5] Originally identical with the executive council, upon which legislative powers were conferred by 13 Geo. III. c. 63, § 36. The distinction between the two councils was first recognized in the appointment of "the fourth member" (3 and 4 Will. IV. c. 85, § 40).

as required. They are open to the public; and a further guarantee for publicity is insured by the proviso that draft bills must be published a certain number of times in the *Gazette*. As a matter of practice, these draft bills have usually been first subjected to the criticism of the several provincial governments. In regard to the supreme judicial authority there is no such uniform system. The presidencies of Madras and Bombay, and also two of the three great provinces which have been created out of the old presidency of Bengal, and are now known as the lieutenant-governorships of Bengal and the North-Western Provinces, have each a high court, [6] supreme both in civil and criminal business, with an ultimate appeal to the judicial committee of the privy council in England. Of the subordinate provinces, the Punjab has a chief court, with three judges; the Central Provinces, Oudh, Mysore, and Berar have each a judicial commissioner, who sits alone; while in Assam and British Burmah the chief commissioner, or supreme executive officer, is also the highest judicial authority.

The law administered in the Indian courts consists mainly of (1) the enactments of the Indian legislative councils above described and of the bodies which preceded them, (2) statutes of the British parliament which apply to India, (3) the Hindu and Mahometan laws on domestic inheritance or other cases affecting the Hindus and Mahometans, and (4) the customary law affecting particular castes and races. Much has been done towards consolidating individual sections of the Indian law; and in the Indian penal code, together with the codes of civil and criminal procedure, we have memorable examples of such efforts.

But, though the governor-general-in-council is theoretically supreme over every part of India alike, [7] his actual authority is not everywhere exercised in the same direct manner. For ordinary purposes of administration British India is partitioned into provinces, each with a government of its own; and certain of the native states are attached to those provinces with which they are most nearly connected geographically. These provinces, again, enjoy various degrees of independence, in accordance with the course of their historical development. The two sister presidencies of Madras and Bombay still retain many marks of their original equality with Bengal. They each have an army and a civil service of their own. They are each administered by a governor appointed direct from England, with an executive and a legislative council, whose functions are analogous to those of the councils of the governor-general. [8] They thus possess a domestic legislature; and in administrative matters, also, the interference of the viceroy is a somewhat remote contingency. Of the other provinces, Bengal, or rather Lower Bengal, occupies a peculiar position. Like the North-Western Provinces and the Punjab, it is administered by a single official, with the style of lieutenant-governor, who is controlled by no executive council; but, unlike those two provinces, Bengal has a legislative council, so far preserving a sign of its early pre-eminence. The remaining provinces, whether ruled by a lieutenant-governor or by a chief commissioner, may be regarded from an historical point of view as fragments of the original Bengal presidency, which as thus defined would be co-extensive with all British India that is not appropriated either to Madras or to Bombay. The lieutenant-governors and most of the chief commissioners are chosen from the covenanted civil service. In executive matters they are the practical rulers; but, excepting the lieutenant-governor of Bengal, they have no legislative authority. To com-

[6] First constituted out of the Supreme Courts and the Sudder (Sadr) Courts in 1861 (24 and 25 Vict. c. 104).

[7] 3 and 4 Will. IV. c. 85, §§ 39 and 65.

[8] 24 and 25 Vict. c. 67, § 42.

plete the total area of territory under British administration, it is necessary to add certain *quasi*-provinces, under the immediate control of the viceroy. These consist of Ajmír (Ajmere), transferred from Rájputána; Berar, or the districts assigned by the nizám of Hyderabad; the state of Mysore, to be restored in 1881 upon terms to its native rájá; and the tiny territory of Coorg, in the extreme south.

Another difference of administration, though now of less importance than in former times, derives its name from the old regulations, or uniform rules of law and practice which preceded the present system of acts of the legislature. These regulations, originally intended to be universal in their application, have been from time to time withdrawn so far as regards certain tracts of country which from their backward state of civilization or other causes seemed to require exceptional treatment. In non-regulation territory, broadly speaking, a larger measure of discretion is allowed to the officials, both in the collection of revenue and in the administration of civil justice; strict rules of procedure yield to the necessities of the case, and the judicial and executive departments are to a great extent combined in the same hands. Closely connected with this indulgence in favour of the personal element in administration, a wider field is also permitted for the selection of the administrative staff, which is not confined to the covenanted civil service, but includes military officers on the staff and also uncovenanted civilians. The title of the highest authority in a non-regulation district is not that of collector-magistrate, but deputy commissioner; and the supreme authority in a non-regulation province is usually styled, not lieutenant-governor, but chief commissioner. The Central Provinces and British Burmah are examples of non-regulation provinces; but non-regulation districts are to be found also in Bengal and the North-Western Provinces, where their existence can always be traced by the office of deputy commissioner

Non-regulation territory.

Alike in regulation and in non-regulation territory the unit of administration is the district,—a word of very definite meaning in official phraseology. The district officer, whether known as collector-magistrate or as deputy commissioner, is the sole responsible head of his jurisdiction

Upon his energy and character rests ultimately the efficiency of the Indian Government. Not only are his own special duties so numerous and so vast as to be bewildering to the outsider, but the work of his subordinates, European and native, largely depends upon the stimulus of his personal example. His position has been compared to that of the French *préfet*; but such a comparison is unjust in many ways to the Indian district officer: he is not a creature of the Home Office, who takes his colour from his chief and represents only officialism, but an active worker in every department of popular well-being, with a large measure of individual initiative. As the very name of collector-magistrate implies, his main functions are twofold. He is a fiscal officer, charged with the collection of the revenue from land and other sources; and he is a civil and criminal judge of first instance. But this explanation of his title by no means exhausts his multifarious duties. He does in his local sphere all that the home secretary is supposed to do in England, and a great deal more; for he is the representative of a paternal and not of a constitutional government. Police, jails, education, municipalities, roads, sanitation, dispensaries, are all to him matters of daily concern; while, in addition, he is expected to make himself acquainted with every phase of the social life of the natives and with each natural aspect of the country. Besides being a lawyer, an accountant, and a clerk, he ought also to possess no mean knowledge of agriculture, political economy, and engineering.

Districts and sub-districts.

The total number of districts in British India is two hundred and thirty-eight. They vary greatly in size and in number of inhabitants. The average area is 3778 square miles, ranging from an average of 6612 square miles in Madras to an average of 1999 square miles in Oudh. The average population is 802,927, similarly ranging from an average of 1,508,219 in Madras to an average of 161,597 in Burmah. The Madras districts are thus both the largest and the most populous. In every province but Madras, the districts are grouped into larger areas, known as divisions, each under the charge of a commissioner. But these divisions are not properly units of administration, as the districts are. They are aggregates of units, formed only for convenience of supervision, so that an intermediate authority may exercise the universal watchfulness which would be impossible for a distant lieutenant-governor. The districts are again partitioned out into lesser tracts, which are strictly units of administration, though subordinate ones. The system of partitioning, and also the nomenclature, vary in the different provinces; but generally it may be said that the subdivision or *tahsíl* is the ultimate unit of administration. The double name indicates the twofold principle of separation: the subdivision is properly the charge of an assistant magistrate or executive officer, the *tahsíl* is the charge of a deputy-collector or fiscal officer; and these two offices may or may not be in the same hands. Broadly speaking, the subdivision is characteristic of Bengal, where revenue duties are in the background, and the *tahsíl* of Madras, where the land settlement requires attention year by year. There is no administrative unit below the subdivision or *tahsíl*. The *thána*, or police division, only exists for police purposes. The *parganá*, or fiscal division under native rule, has now but an historical interest. The village still remains as the agricultural unit, and preserves its independence for revenue purposes in certain parts of the country. The township is peculiar to Burmah.

The judicial jurisdictions coincide for the most part with the magisterial and fiscal boundaries. But, except in Madras, where the districts are large, a single civil and sessions judge, *i.e.*, the supreme judicial officer under the high court, sometimes exercises jurisdiction over more than one district. As has been already mentioned, in non-regulation territory judicial and executive functions are combined in the same hands.

The preceding sketch of Indian administration would be incomplete without a reference to the secretariat, or central office, which in some sense controls and gives life to the whole. From the secretariat are issued the orders which regulate or modify the details of administration; into the secretariat come all the multifarious reports from the local officers, to be there digested for future reference. But though the secretaries may enjoy the advantages of life at the presidency capitals, with higher salaries and better prospects of promotion, it is recognized that the efficiency of the empire rests ultimately upon the shoulders of the district officers, who bear the burden and heat of the day, with few opportunities of winning fame or reward.

Land settlement.

Land Settlement.—As the land furnishes the main source of Indian revenue, so the assessment of the land tax is the main work of Indian administration. No technical term is more familiar to Anglo-Indians, and none more strange to the English public, than that of land settlement. No subject has given rise to more voluminous controversy. It will be enough in this place to explain the general principles upon which the system is based, and to indicate the chief differences of application in the several provinces. That the state should appropriate to itself a direct share in the produce of the soil is a fundamental maxim of Indian finance, that has been recognized throughout the East from time immemorial. The germs of rival systems can be traced in the old military and other service tenures of Assam, and in the poll tax of Burmah, &c. The exclusive development of the land system is due to two conditions,—a comparatively high state of agriculture and an organized plan of administration,—both of which are supplied by the primitive village community. During the lapse of untold generations, despite domestic anarchy and foreign conquest, the Hindu village has in many parts preserved its simple customs, written in the imperishable tablets of tradition. The land was not held by private owners, but by occupiers under the petty corporation; the revenue was not due from individuals, but from the community represented by its head-man. The aggregate harvest of the village fields was thrown into a common fund, and before the general distribution the head-man was bound to set aside the share of the state. No other system of taxation could be theoretically more just, or in practice less obnoxious to the people. Such is an outline of the land system as it may be found at the present day throughout large portions of India both under British and native rule; and such we may fancy it to have been universally before the Mahometan conquest. The Musalmáns brought with them the avarice of conquerors, and a stringent system of revenue collection. Under the Mughal empire, as organized by Akbar the Great, the share of the state was fixed at one-third of the gross produce of the soil; and a regular army of tax-collectors was permitted to intervene between the cultivator and the supreme government. The entire vocabulary of the present land system is borrowed from the Mughal administration. The *zamíndár* himself is a creation of the Mahometans, unknown to the early Hindu system. He was originally a mere tax-collector, or farmer of the land revenue, who agreed to furnish a lump sum from the tract of country assigned to him. If the Hindu village system may be praised for its justice, the Mughal farming system had at least the merit of efficiency. Sháh Jáhán and Aurangzeb extracted a larger land revenue than the British do. When the government was first undertaken by the East India Company, no attempt was made to understand the social system upon which the land revenue was based. The *zamíndár* was conspicuous and useful; the village community and the cultivating *ráyat* did not force themselves into notice. The *zamíndár* seemed a solvent person, capable of keeping a contract; and his official position as tax-collector was confused with the proprietary rights of an English landlord. The superior stability of the village system was overlooked, and in the old provinces of Bengal and Madras the village organization has gradually been suffered to fall into decay. The consistent aim of the British authorities has been to establish private property in the soil, so far as is consistent with the punctual payment of the revenue. The annual Government demand, like the succession duty in England, is universally the first liability on the land; when that is satisfied, the registered landholder has powers of sale or mortgage scarcely more restricted than those of a tenant in fee-simple. At the same time the possible hardships, as regards the cultivator, of this absolute right of property vested in the owner have been anticipated by the recognition of occupancy rights or fixity of tenure, under certain conditions. Legal rights are everywhere taking the place of unwritten customs. Land, which was before merely a source of livelihood to the cultivator and of revenue to the state, has now become the subject of commercial speculation. The fixing of the revenue demand has conferred upon the owner a credit which he never before possessed, by allowing him a certain share of the unearned increment. This credit he may use improvidently, but none the less has the land system of India been raised from a lower to a higher stage of civilization.

The means by which the land revenue is assessed is known as settlement, and the assessor is styled a settlement officer. In Bengal the assessment has been accomplished once and for all, but throughout the greater part of India the process is continually going on. The details vary in the different provinces; but, broadly speaking, a settlement may be described as the ascertainment of the agricultural capacity of the land. Prior to the settlement is the work of survey, which first determines the area of every village and frequently of every field also. Then comes the settlement officer, whose duty it is to estimate the character of the soil, the kind of crop, the opportunities for irrigation, the means of communication and their probable development in the future, and all other circumstances which tend to affect the value of the produce. With these facts before him, he proceeds to assess the Government demand upon the land according to certain general principles, which may vary in the several provinces. The final result is a settlement report, which records, as in a Domesday Book, the entire mass of agricultural statistics concerning the district.

Lower Bengal and a few adjoining districts of the North-Western Provinces and of Madras have a permanent settlement, *i.e.*, the land revenue has been fixed in perpetuity. When the Company obtained the *díwání* or financial administration of Bengal in 1765, the theory of a settlement, as described above, was unknown. The existing Mahometan system was adopted in its entirety. Engagements, sometimes yearly, sometimes for a term of years, were entered into with the *zamíndárs* to pay a lump sum for the area over which they exercised control. If the offer of the *zamíndár* was not deemed satisfactory, another contractor was substituted in his place. But no steps were taken, and perhaps no steps were possible, to ascertain in detail the amount which the country could afford to pay. For more than twenty years these temporary engagements continued, and received the sanction of Warren Hastings, the first titular governor-general of India. Hastings's great rival, Francis, was among those who urged the superior advantages of a permanent assessment. At last, in 1789, a more accurate investigation into the agricultural resources of Bengal was commenced, and the settlement based upon this investigation was declared perpetual by Lord Cornwallis in 1793. The *zamíndárs* of that time were raised to the status of landlords, with rights of transfer and inheritance, subject always to the payment in perpetuity of a rent-charge. In default of due payment, their lands were liable to be sold to the highest bidder. The aggregate assessment was fixed at *sikká* Rs. 26,800,989, equivalent to Co.'s Rs. 28,587,722, or say $2\frac{3}{4}$ millions sterling. By the year 1871–72 the total land revenue realized from the same area had increased to Rs. 35,208,866, chiefly owing to the inclusion of estates which had escaped the original assessment for various reasons. While the claim of Government against the *zamíndárs* was thus fixed for ever, it was intended that the rights of the *zamíndárs* over their own tenants should be equally restricted. But no detailed record of tenant-right was inserted in the settlement papers, and, as a matter of fact, the cultivators lost rather than gained in security of tenure. The same English prejudice which made a landlord of the *zamíndár* could recognize nothing but a tenant-at-will in the *ráyat*. By two stringent regulations of 1799 and 1812 the tenant was practically put at the mercy of a rack-renting landlord. If he failed to pay his rent, however excessive, his property was rendered liable to distraint and his person to imprisonment. At the same time the operation of the revenue sale law had introduced a new race of *zamíndárs*, who were bound to their tenants by no traditions of hereditary sympathy, but whose sole object was to make a profit out of their newly purchased property. The rack-rented peasantry found no protection in the law courts until 1859, when an Act was passed which restricted the landlord's powers of enhancement in certain specified cases. The *zamíndár* is the only person recognized by the revenue law; but in a large number of cases the *zamíndár* has in effect parted with all his interest in the land by means of the creation of perpetual leases or *patnis*. These leases are usually granted in consideration of a premium or lump sum paid down, and there is nothing to prevent the *patnidár* from creating an indefinite series of sub-tenures beneath his own. The permanent settlement was not preceded by any systematic survey. But in the course of the past thirty years the whole of Bengal has been subject to a professional survey, which determined the boundaries of every village, and issued maps on the scale of 4 inches to the mile.

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This survey, however, has only a topographical value. No statistical inquiries were made, and no record obtained of rights in the soil. Even the village landmarks then set up have fallen into decay.

The permanent settlement was confined to the three provinces of Bengal, Behar, and Orissa, according to their boundaries at that time. Orissa Proper, which was conquered from the Marhattás in 1803, is subject to a temporary settlement, of which the current term of thirty years will not expire until 1897. The assessment is identical with that fixed in 1838, which was based upon a careful field measurement and upon an investigation into the rights of every landholder and under-tenant. The settlement, however, was made with the landholder, and not with the tenant, and in practice the rights of the cultivators are no more secure than in Bengal. In Assam Proper, or the valley of the Brahmaputra, the system of settlement is simple and effective. The cultivated area is artificially divided into *mauzás* or blocks, over each of which is placed a native official or *mauzádár*. Every year the *mauzádár* ascertains the area actually under cultivation, and then assesses the fields according to their character, at a certain prescribed rate.

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The prevailing system throughout the Madras presidency is the *ráyatwárí*, which takes the cultivator or peasant proprietor as its rent-paying unit, somewhat as the Bengal system takes the *zamíndár*. This system cannot be called indigenous to the country, any more than the *zamíndárí* of Bengal. If any system deserves that name, it is that of village assessment, which still lingers in the memories of the people in the south. When the British declared themselves heir to the nawáb of the Carnatic at the opening of the present century, they had no adequate experience of revenue management. The authorities in England favoured the *zamíndárí* system already at work in Bengal, which appeared at least calculated to secure punctual payment. The Madras Government was accordingly instructed to enter into permanent engagements with *zamíndárs*, and, where no *zamíndárs* could be found, to create substitutes out of enterprising contractors. The attempt resulted in failure in every case, except where the *zamíndárs* happened to be the representatives of ancient lines of powerful chiefs. Several of such chiefs exist in the extreme south and in the north of the presidency. Their estates have been guaranteed to them on payment of a *peshkash* or permanent tribute, and are saved by the custom of primogeniture from the usual fate of subdivision. Throughout the rest of Madras there are no *zamíndárs* either in name or fact. The influence of Sir Thomas Munro afterwards led to the adoption of the *ráyatwárí* system, which will always be associated with his name. According to this system, an assessment is made with the cultivating proprietor upon the land taken up for cultivation year by year. Neither *zamíndár* nor village officer intervenes between the cultivator and the state, which takes directly upon its own shoulders all a landlord's responsibility. The early *ráyatwárí* settlements in Madras were based upon insufficient experience. They were preceded by no survey, but adopted the crude estimates of native officials. Since 1858 a department of revenue survey has been organized, and the old assessments have been everywhere revised.

Nothing can be more complete in theory and more difficult of exposition, than a Madras *ráyatwárí* settlement. First, the entire area of the district, whether cultivated or uncultivated, and of each field within the district is accurately measured. The next step is to calculate the estimated produce of each field, having regard to every kind of both natural and artificial advantage. Lastly, a rate is fixed upon every field, which may be regarded as roughly equal to one-third of the gross and one-half of the net produce. The elaborate nature of these inquiries and calculations may be inferred from the fact that as many as thirty-five different rates are sometimes struck for a single district, ranging from 6d. to £1, 4s. per acre. The rates thus ascertained are fixed for a term of thirty years; but during that period the aggregate rent-roll of a district is liable to be affected by several considerations. New land may be taken up for cultivation, or old land may be abandoned; and occasional remissions are permitted under no less than eighteen specified heads. Such matters are discussed and decided by the collector at the *jamabandi* or court held every year for definitely ascertaining the amount of revenue to be paid by each *ráyat* for the current season. This annual inquiry has sometimes been mistaken by careless passers-by for an annual reassessment of each *ráyat's* holding. It is not, however, a change in the rates for the land which he already holds, but an inquiry into and record of the changes in his former holding or of any new land which he may wish to take up.

In the early days of British rule no system whatever prevailed throughout the Bombay presidency; and even at the present time there are tracts where something of the old confusion survives. The modern "survey tenure," as it is called, dates from 1838, when it was first introduced into one of the *tálukas* of Poona district, and it has since been gradually extended over the greater part of the presidency. As its name implies, the settlement is preceded by survey. Each field is measured, and an assessment placed upon it according to the quality of the soil and the crop. This assessment holds good, without any possibility of modification, for a term of thirty years. The average rate varies from a maximum of 4s. 6d. an acre in the rich black soil lands of Guzerat to a minimum of 10d. an acre in the barren hills of the Concan.

The primary characteristic of the Bombay system is its simplicity. The field is the unit, and its actual occupier is the only person recognized by the revenue law. He knows exactly what he will have to pay, and the state knows what it will receive, during the currency of the term. The assessment is, in fact, a rent-charge liable to be modified at intervals of thirty years. Secondly, the system is characterized by its fairness to the tenant. He possesses "a transferable and heritable property, continuable without question at the expiration of a settlement lease, on his consenting to the revised rate." To borrow a metaphor from English law, his position has been raised from that of a villein to that of a copyholder. In exchange for the mere leave to exist and till the soil he has received a right of property in the soil he tills, and he stands forth a free man. If the Bombay peasants have not reaped all the advantages from this system that might have been hoped for, the fault rests, not with the system, but with themselves. They were unequal to the responsibilities of property which they had not won by their own exertions, but which the state (perhaps prematurely) cast upon them.

The North-Western Provinces and the Punjab have a similar land system. In that part of India the village community has preserved its integrity more completely than elsewhere. Government therefore recognizes the village, and not the *zamíndár's* estate or the *ráyat's* field, as the unit of land administration. Throughout the North Western Provinces, indeed, the village is commonly owned by proprietors with the title of *zamíndár*, whereas in the Punjab the community is still the proprietor. But this is a distinction of tenure rather than of administration. In both cases alike the state recognizes only the village, and makes its arrangement with the owners of the village, whether they be one or many, whether they be individuals, a corporation, or a *bháyáchára* (brotherhood). The survey there becomes a more comprehensive undertaking than in Madras or Bombay. In addition to measurement, and agricultural appraisement and calculation, it includes the duty of drawing up an exhaustive record of all rights and sub-tenures existing in every village. The proprietors are alone responsible for the revenue; but, when the state limits its claims against them, it is no less careful to define at the same time the rights of other parties interested in the soil. The term of settlement both in the North-Western Provinces and in the Punjab is thirty years. The principle of assessment is that the Government revenue shall be equal to one-half of the improved rent, leaving the other half as the share of the landlord, who is liable for due payment, and has the trouble of collecting it from the cultivators. The average rate of assessment is about 2s. 11d. per acre in the North-Western Provinces, and 1s. 4d. in the Punjab.

The Oudh *tálukdárs* resemble English landlords even more closely than do the *zamíndárs* of Bengal. In origin the majority were not revenue-farmers, but territorial magnates, whose influence was derived from feudal authority as much as from mere wealth. Their present legal status dates from the pacification that followed on the mutiny of 1857. The engagement then entered into has been described as a political treaty rather than a revenue assessment. The great *tálukdárs* were invited to become responsible each for a gross sum payable from the territory over which he exercised feudal rights. This sum was fixed in perpetuity; and the exceptional position of the *tálukdárs* was recognized by conferring upon them, not only the right of succession by primogeniture, but also the privilege of bequest,—a privilege unknown alike to Hindu and Mahometan law. Land not comprised in *tálukdárí* estates was settled in the ordinary way with its proprietors or *zamíndárs* for a term of thirty years. The whole of Oudh has since been accurately surveyed.

The Central Provinces contain many varieties of land tenure, from the feudatories, who pay only a light tribute, to the village communities, who are assessed in the usual manner after survey. Population is sparse and agriculture backward, so that the incidence of land revenue is everywhere low. The survey was conducted generally on the Punjab system, adopting the village and not the field as the unit of measurement. The current settlement for a term of thirty years will expire in 1897.

Land revenue.

In 1873–74 the total land revenue realized from territory under British administration in India amounted to £20,919,256, which is raised to £22,768,144 by the inclusion of certain local rates and cesses levied on land. This latter figure shows an average of 9·4d. per acre of gross area and 2s. 4·7d. per head of total population. The highest rate of assessment appears to be that in Bombay, which is 3s. 10·4d. per head; the lowest, 1s. 2·7d. per head in Bengal and Assam.

Salt administration.

Salt Administration.—Next to land, salt contributes the largest share to the Indian revenue; and, where salt is locally manufactured, its supervision becomes an important part of administrative duty. Up to within quite recent times the tax levied upon salt varied extremely in different parts of the country, and a strong preventive staff was required to be stationed along a continuous barrier hedge, which almost cut the peninsula into two fiscal sections. The reform of Sir J. Strachey in 1878, by which the higher rates were reduced and the lower rates raised, with a view to their ultimate equalization over the whole country, effectually abolished this old engine of oppression. Communication is now free; and it has been found that prices are absolutely lowered by thus bringing the consumer nearer to his market, even though the rate of taxation be increased. In the Punjab and Rájputána salt administration has thus become, as in Lower Bengal, a simple matter of weighing quantities and levying a uniform tax. In Bombay, also, the manufacture is now conducted with a minimum of expense at large central depôts in Guzerat under a thorough system of excise supervision. Along the western coast, however, from Orissa to Cape Comorin, the process of evaporating sea-water is everywhere carried on as a private industry, though on Government account. As with poppy cultivation in Bengal, the manufacture of salt is a monopoly, which can only be defended by the peculiar circumstances of the case. No one is compelled to manufacture, and rights of property in a salt-pan are strictly respected, while the state contrives, by means of a careful staff of supervisors, to obtain the maximum of profit with a minimum of interference. The system as at present carried on has been gradually developed out of the experience of nearly a century. The manufacturers belong to the same class as ordinary cultivators; and, as a rule, their condition is somewhat more prosperous, for they possess an hereditary privilege with a commercial value. They do not work upon a system of advances, as is the case with so many other Indian industries; but they are paid at a certain rate when they bring their salt to the Government depôt. This rate of payment, known as *kudivaram*, is at present fixed at an average of 1 *ánná* 5·8 *pies* per *maund* of $82\frac{2}{7}$ lb; the other expenses of the salt department, for supervision, &c., raise the total cost to 3 *ánnás* 5·6 *pies* per *maund*. The price now charged to the consumer by the Madras Government is Rs. 2.8.0 per *maund*, the balance being net profit. The equal rate of salt duty which will ultimately prevail throughout all India is Rs. 2.8.0 per *maund*, or 7s. a cwt. This rate is already (1881) levied in Madras, Bombay, the North-Western Provinces, and the Punjab, but in Bengal a higher rate is provisionally in force of Rs. 2.14.0 per *maund*, or 8s. a cwt. In British Burmah only 3 *ánnás* per *maund*, or 6d. a cwt., is charged for local consumption, and a transit duty of 1 per cent. *ad valorem* for salt sent across the frontier.

Excise.—Excise, like salt, is not only a department of revenue collection, but also to a great extent a branch of the executive. In other words, excise duties in India are not a mere tax upon the consumer, levied for convenience through the manufacturer and retail dealer, but a species of Government monopoly. The only excisable articles are intoxicants and drugs; and the avowed object of the state is to check consumption not less than to raise revenue. Details vary in the different provinces, but the general plan of administration is the same. The right to manufacture and the right to retail are both monopolies of Government permitted to private individuals only upon terms. Distillation of country spirits is allowed according to two systems,—either to the highest bidder under strict supervision, or only upon certain spots set apart for the purpose. The latter is known as the *sadr* or central distillery system. The right of sale is also usually farmed out to the highest bidder, subject to regulations fixing the minimum quantity of liquor that may be sold at one time. The brewing of beer from rice and other grains, which is universal among the hill tribes and other aboriginal races, is practically untaxed and unrestrained. The European breweries recently established at several hill stations pay a tax at the rate of 6d. a gallon. Apart from spirits, excise duties are levied upon the sale of a number of intoxicating or stimulant drugs, of which the most important are opium and *gánjá* or *bhang*. Opium is issued for local consumption in India from the Government manufactories at Patná and Benares, and sold through private retailers at a monopoly price. This drug is chiefly consumed in Assam, Burmah, and the Punjab. *Gánjá* is an intoxicating preparation made from the flowers and leaves of Indian hemp (*Cannabis sativa*, var. *indica*). The cultivation of hemp for this purpose is almost confined to a limited area in Rájsháhí district, Bengal, and to the farther valleys of the Himálayas, whence the drug is imported under the name of *charas*. Its abuse is sometimes a cause, not only of crime, but also of insanity. Government attempts to check consumption—first, by fixing the retail duty at the highest rate that will not encourage smuggling, and, secondly, by continually raising that rate as experience allows. Scientifically speaking, *gánjá* consists of the flowering and fruiting heads of the female plant; *bhang* or *siddhi*, of the dried leaves and small stalks, with a few fruits; while *charas* is the resin itself, collected in various ways as it naturally exudes. No duty whatever is now levied upon tobacco in any part of India. The plant is universally grown by the cultivators for their own smoking, and, like everything else, was subject to taxation under native rule; but the impossibility of accurate excise supervision has caused the British Government to abandon the impost.

Municipals.

The municipalities at present existing in India are a creation of the legislature and a branch of the general system of administration. Their origin is to be traced, not in the native *pancháyat*, but in the necessity for relieving the district officer of some of the details of his work. The *pancháyat* or elective council of five is one of the institutions most deeply rooted in the Hindu mind. By it the village community was governed, the head-man being only the executive official, not the legislator or judge; by it all caste disputes were settled; by it traders and merchants were organized into powerful guilds, to the rules of which even European outsiders have had to submit; by it the Síkh army of the *khálsá* was despotically governed, when the centralized system of Ranjít Sinh fell to pieces at his death. But the Hindu village organization had been greatly broken up under Mughal rule. The modern municipal committee is a body appointed by Government, on the nomination of the collector, to assist him in the discharge of his local duties, and to assess new modes of taxation. Police, roads, and sanitation are the three main objects for which a municipality is constituted. Outside a municipality these objects are (in different provinces) the care of the collector, of some member of his subordinate staff, or of a local fund board. Within municipal limits they are delegated to a committee, who practically derive their authority from the collector's sanction, implied or expressed. Except in the great towns, the municipalities cannot be said to enjoy any of the attributes of corporate life. However, as education advances, and with it the desire and capacity of self-government, the municipal committee will doubtless form the germ from which free local institutions will in the future be developed. In 1876-77, excluding the three presidency capitals, there were altogether 894 municipalities in British India, with 12,381,059 inhabitants, or just 7 per cent. of the total population. Out of an aggregate number of 7519 members of municipal committees concerning whom information is available, 1794 were Europeans and 5725 natives; 1863 were *ex-officio*, 4512 nominated, and 1144 elected,—the last class being almost confined to the North-Western and Central Provinces. The financial statistics of these municipalities are given in a subsequent section.

Finance.

Imperial Finance.—It is impossible to present a concise view of Indian finance, such as shall be at once accurate and intelligible. In the first place, the aggregate figures of revenue and expenditure are officially returned according to a system which, though necessary for purposes of account, usually misleads the English financier. The whole system of administration is based upon the view that the British power is a paternal despotism, which owns, in a certain sense, the entire soil of the country, and whose duty it is to perform the various functions of a wealthy and enlightened proprietor. In addition, it takes on itself the business of a manufacturer and trader on a grand scale, as in the case of opium and salt. All these considerations tend to swell the totals on both sides of the balance-sheet with large items, which, on strict analysis, ought to be eliminated as mere matters of account. The actual taxation on the people of British India for 1878, as will be shown below, was 34⅞ millions, or under 3s. 8d. per head of the population. In the second place, the methods of keeping the public accounts have been subjected to frequent changes during recent years, to such an extent as to render comparative statements of totals valueless.

The following table, which has been compiled from the *Parliamentary Abstract for* 1877-78, exhibits the gross imperial revenue and expenditure of India for that year, according to the system of accounts adopted at the time. For the reasons already given, it is practically impossible to analyse these statements in such a way as to show the actual amount raised by taxation, and the actual amount returned in protection to person and property. It is equally impossible to compare the totals with those for previous years. The only profitable plan is to take some of the items and explain their real meaning.

Gross Revenue.

Land revenue	£20,026,036
Tributes and contributions	675,120
Forest	664,102
Excise	2,457,075
Assessed taxes	86,110
Provincial rates	238,504
Customs	2,622,296
Salt	6,460,082
Opium	9,182,722
Stamps	2,993,483
Mint	443,859
Post office	847,694
Telegraph	358,430
Law and justice	813,221
Public works (ordinary)	371,539
Irrigation	495,142
State railways	548,528
Guaranteed railways (net)	6,129,765
Miscellaneous	3,555,593
Total	£58,969 301
Deficiency of gross revenue as compared with gross expenditure	£3,543,087

Gross Expenditure.

Collection—Land	£2,531,325
" Salt	539,858
" Opium	2,661,266
" Miscellaneous	2,330,902
Allowances under treaties	1,646,093
Interest on debt	5,028,318
Administration	1,805,368
Law and justice	3,319,673
Marine and inland navigation	542,202
Ecclesiastical	158,039
Medical	611,819
Political agencies	468,975
Police	2,158,237
Education	738,020
Stationery and printing	425,644
Loss by exchange	1,653,377
Army	16,639,761
Famine relief	5,345,775
Provincial payments	247,034
Public works (ordinary)	3,676,274
Productive public works—	
Maintenance	791,601
Interest and surplus profits	6,572,955
Miscellaneous	2,619,872
Total	£62,512,388

Revenue.

Revenue.—It will be seen from the above statement that the larger portion of the gross revenue is not derived from taxation at all. Public works, including railways, alone yield about 7½ millions sterling, or nearly 13 per cent. of the total. If we add the items of post office and telegraphs, which also represent payment for work done or services supplied, the proportion rises to nearly 14 per cent. Then the sum of 9 millions gross, or 6½ millions net, derived from opium, being somewhat more than an additional 15 per cent. of the gross revenue, is admitted to be no charge upon the native tax-payer, but a voluntary contribution to the Indian exchequer by the Chinese consumer of the drug. Nearly one-third of the total gross revenue is thus accounted for. The land revenue, amounting to just 20 millions in an exceptionally bad year, cannot be passed over so lightly. Whether it should be properly regarded as a tax, or only as rent, is an abstruse problem for political economists to settle; but, in any case, it is paid without question, as an immemorial perquisite of the state. It yields 34 per cent., or more than one-third of the gross revenue. The importance of the land tax from the point of view of administration has been considered in a previous section. Setting aside provincial rates and assessed taxes as insignificant in their amount and variable in their incidence, we are left with four principal headings,—excise, customs, salt, and stamps,—which together constitute the indisputable taxation of the people. The total amount yielded by these four items is just 14½ millions, being nearly 25 per cent., or one-fourth of the whole. Salt alone yields 6½ millions, or 11 per cent. On the total population of 191 millions, the gross revenue of 59 millions shows an incidence of 6s. 2⅛d. per head. The land tax alone shows an incidence of 2s. 1⅛d. per head, the four taxes proper of 1s. 6¼d. per head. The whole revenue of British India of the nature of actual taxation, including land revenue, excise, assessed taxes, provincial rates, customs, salt, and stamps, amounted in 1878 to £34,883,586, or 3s. 7⅝d. per head. The rate was about 4s. per head in 1880.

Of the four items, excise and stamps are both almost entirely creations of British rule. Excise is simply a tax upon intoxicating liquors and deleterious drugs, levied both on the manufacture and on the sale, according to different systems in different provinces. Like the corresponding duty in England, it is voluntarily incurred, and presses hardest upon the lowest classes. But, unlike the English excise, it can hardly be called an elastic source of revenue, for the rate is intentionally kept so high as to discourage consumption. No duty whatever is levied upon tobacco. Stamps, as in England, is an ambiguous item. The greater part is derived from fees on litigation, and only a comparatively trifling amount from stamps proper on deeds of transfer, &c. Customs are divided into import and export duties, both of which have been so greatly lightened in recent years that their permanent maintenance must be considered doubtful. At the present time (1881) import duties, usually at the rate of 5 per cent. *ad valorem*, are levied upon a comparatively long list of commodities, of which the chief are cotton goods above a certain degree of fineness. All duties on exports have now been removed, with the single exception of that on rice, which brings in about £500,000 a year. That is levied at the rate of 3 *ánnás* a *maund*, or about 6d. per cwt., being equivalent to an *ad valorem* rate of about 10 per cent. India, including Burmah, possesses a practical monopoly of the supply of rice to Europe, and therefore the tax falls upon the consumer rather than upon the native producer. The salt tax is a matter of more importance and of greater difficulty. As an impost upon an article of prime necessity, and as falling with greatest severity upon the lowest classes, it violates the elementary rules of political economy. On the other hand, it may be urged that this tax is familiar to the people, and levied in a manner which arouses no discontent, and that it is the only means available of spreading taxation proper over the community. Recent reforms have tended to equalize the incidence of the salt tax over the entire country, with the immediate result of abolishing arbitrary and vexatious customs lines, and with a view to its ultimate reduction.

Expenditure.

Expenditure.—Putting aside the cost of collection and civil administration, which explain themselves, the most important items of expenditure are army, interest on debt, famine relief, loss by exchange, and public works, to which may be added the complex item of payments in England. Military expenditure averages fully 16 millions a year, being thus considerably more than the whole amount obtained from taxation proper. Of this total, about 12 millions represent payments in India, and 4 millions payments in England. On non-effective services nearly 2 millions are expended in England and less than £700,000 in India. Regimental pay accounts for nearly 7 millions, the commissariat for about 2 millions in India, and stores for another million in England. In 1877-78 the total capital of the Indian debt was returned at over 146½ millions sterling, being just 15s. 4d. per head of the population. The total charge for interest was 5 millions, being at the rate of £3, 14s. 4d. per cent.; but this excludes the interest to be credited against expenditure on reproductive public works, which is entered under another heading. In 1840 the debt amounted to only 30 millions, but it gradually increased to 52 millions in 1857. Then came the Mutiny, which added 42 millions of debt in four years. The rate of increase was again gradual but slow till about 1874, when famine relief conspired with public works to cause a rapid augmentation, which has continued to the present time. The most significant feature in that augmentation is the larger proportion of debt contracted in England. During the last ten years the silver debt has risen only 10 millions, whereas the gold debt has risen 28 millions. No charge has recently pressed harder upon the Indian exchequer than that of famine relief. Apart from loss by reduced revenue, the two famines of 1874 and 1877-78 have caused a direct expenditure on charitable and relief works, amounting in the aggregate to nearly 15 millions. Loss by exchange is an item which has only lately taken its place in the accounts, and is due to the circumstance that large payments in gold require to be made in England by means of the depreciated rupee. It is, of course, not a matter of expenditure proper, but merely the result of a peculiar mode of book-keeping, which estimates the rupee at the arbitrary value of 2s. In 1869-70 the loss by exchange was more than balanced by an equally nominal entry of gain by exchange on the other side of the ledger. In 1876-77 this item attained its maximum of nearly $1\frac{3}{4}$ million net. The expenditure on public works is provided from three sources—(1) the capital of private companies, with a Government guarantee, (2) loans for the construction of railways and canals, (3) current revenue applied towards such works as are considered to be not directly remunerative. In 1877-78 the total capital raised by the guaranteed railway companies was $95\frac{1}{2}$ millions, and the net earnings were 5 millions, thus showing on the average a satisfactory balance-sheet. In the ten years ending with 1878 29 millions were expended under the second head upon works classed as reproductive or extraordinary, of which 19 millions were appropriated to state railways and 10 millions to irrigation. The amount spent from revenue upon ordinary public works in 1877-78 was nearly $3\frac{3}{4}$ millions. The division of the expenditure into that paid in India and that paid in England becomes of importance when it is remembered that the latter portion requires to be provided in gold. In 1877-78, out of the total expenditure of $62\frac{1}{2}$ millions, $48\frac{1}{2}$ millions, or 78 per cent., were paid in India, and 14 millions, or 22 per cent., in England, including the guaranteed interest of the railway.companies.

Local Finance.—Independent of imperial finance, and likewise independent of certain sums annually transferred from the imperial exchequer to be expended by the provincial governments, there is another Indian budget for local revenue and expenditure. That consists of an income derived mainly from cesses upon land, and expended to a great extent upon minor public works. In 1877-78 local revenue and expenditure were each returned at about $3\frac{1}{2}$ millions.

Municipal Finance.—Yet a third budget is that belonging to the municipalities. The three presidency towns of Calcutta, Madras, and Bombay had in 1876-77 a total municipal income of £668,400, of which £519,322 was derived from taxation, being at the rate of 7s. per head of population. In addition, there were 894 minor municipalities, with a total population of 12,381,059. Their aggregate income was £1,246,974, of which £979,088 was derived from taxation, being at the rate of 1s. 7d. per head. In the presidency towns, rates upon houses, &c., are the chief source of income; but in the district municipalities, excepting Bengal, octroi duties are more relied upon. On the side of expenditure the chief items are conservancy, roads, and police.

Army.—At the present time (1881) the entire constitution of the Indian army is under the consideration of a commission. The existing organization is based upon the historical division into the three presidencies of Bengal, Madras and Bombay There are still three Indian armies, each composed of both European and native troops, with their own commanders-in-chief and separate staff, though the commander-in-chief in Bengal exercises a supreme authority over the other two. There is also a fourth army, known as the Punjab frontier force, which, though on the Bengal establishment, is under the immediate orders of the lieutenant-governor of the province.

Established Strength of the Indian Army in 1877-78.

	Native Troops.						European Troops.						Grand Total.
	Artillery.	Cavalry.	Engineers	Infantry.	Body-Guard.	Total.	Artillery.	Cavalry.	Engineers.	Infantry.	Staff, &c.	Total.	
Bengal army	748	13,016	1,241	48,806	122	63,933	6,879	2,898	232[1]	29,420	854	40,283	104,216
Madras ,, ...	...	1,743	1,461	31,081	8	34,293	2,811	966	57[1]	8,271	628	12,733	47,026
Bombay ,, ...	153	3,587	537	22,296	72	38,355	2,549	483	68[1]	8,271	339	11,710	38,355
Totals.........	901	18,346	3,239	102,183	202	124,871	12,239	4,347	357[1]	45,962	1,821	64.726	189,597

Police. *Police.*—Excluding the village watch, which is still maintained as a subsidiary force in many parts of the country, the total regular police of all kinds in British India in 1877 consisted of a total strength of 157,999 officers and men, being an average of one policeman to every $7\frac{1}{4}$ square miles of total area or to every 1096 of the total population. The total cost of maintenance was £2,511,704, of which £2,165,073 was payable from imperial or provincial revenues. The former figure gives an average cost of £3 per square mile of area and 3d. per head of population. The average pay of each constable was 7 rupees a month, or £8, 8s. a year.

Jails. *Jails.*—In 1877 the total number of places of confinement in British India, including central and district jails and lock-ups, was 636; the total number of prisoners admitted during the year, or remaining over from the previous year, was 587,288; the daily average was 118,456—113,087 males and 5369 females. These figures show 1 male prisoner to every 868 of the male population, 1 female prisoner to every 17,244 of the female population, and 1 prisoner to every 1618 of the total population of both sexes. The places of transportation for all British India are the Andaman and Nicobar Islands, where there are two penal establishments; these contained in 1877 a daily average of 9145 convicts.

EDUCATION.

The existing system of education in India is mainly dependent upon the Government, being directly organized by the state, at least in its higher departments, assisted throughout by grants-in-aid, and under careful inspection. But at no period of its history has India been an altogether unenlightened country. The origin of the Deva-Nágari alphabet is lost in antiquity, though that is generally admitted not to be of indigenous invention. Inscriptions on stone and copper, the palm-leaf records of the temples, and in later days the wide-spread manufacture of paper, all alike indicate, not only the general knowledge, but also the common use, of the art of writing. From the earliest times the caste of Bráhmans has preserved, by oral tradition as well as in MSS., a literature unrivalled alike in its antiquity and in the intellectual subtlety of its contents. The Mahometan invaders introduced the profession of the historian, which reached a high degree of excellence, even as compared with contemporary Europe. Through all changes of government vernacular instruction in its simplest form has always been given, at least to the children of respectable classes, in every large village. On the one hand, the *tols* or seminaries for teaching Sanskrit philosophy at Benares and Nadiyá recall the schools of Athens and Alexandria; on the other, the importance attached to instruction in accounts reminds us of the picture which Horace has left of a Roman education. Even at the present day knowledge of reading and writing is, owing to the teaching of Buddhist monks, as widely diffused throughout Burmah as it is in some countries of Europe. English efforts to stimulate education have ever been most successful when based upon the existing indigenous institutions.

During the early days of the East India Company's rule the promotion of education was not recognized as a duty of Government. The enlightened mind of Warren Hastings did indeed anticipate his age by founding the Calcutta *madrasa* for Mahometan teaching, and by affording steady patronage alike to Hindu *pandits* and European students. But Wellesley's schemes of imperial dominion did not extend beyond the establishment of a college for English officials. Of the Calcutta colleges, that of Sanskrit was founded in 1824, when Lord Amherst was governor-general, the medical college by Lord William Bentinck in 1835, the Hooghly *madrasa* by a wealthy native gentleman in 1836. The Sanskrit college at Benares had been established in 1791, the Agra college in 1823. Meanwhile the missionaries made the field of vernacular education their own. Discouraged by the official authorities, and ever liable to banishment or deportation, they not only devoted themselves with courage to their special work of evangelization, but were also the first to study the vernacular dialects spoken by the common people. Just as two centuries earlier the Jesuits at Madura, in the

[1] All Officers.

extreme south, composed works in Tamil, which are still acknowledged as classical by native authors, so did the Baptist mission at Serampur, near Calcutta, first raise Bengáli to the rank of a literary dialect. The interest of the missionaries in education, which has never ceased to the present day, though now comparatively overshadowed by Government activity, had two distinct aspects. They studied the vernacular, in order to reach the people by their preaching and to translate the Bible; and they taught English, as the channel of non-sectarian learning.

At last the Government awoke to its own responsibility in the matter of education, after the long and acrimonious controversy between the advocates of English and vernacular teaching had worn itself out. The present system dates from 1854, being based upon a comprehensive despatch sent out by Sir C. Wood (afterwards Lord Halifax) in that year. At that time the three universities were founded at Calcutta, Madras, and Bombay; English-teaching schools were established in every district; the benefit of grants-in-aid was extended to the lower vernacular institutions and to girls' schools; and public instruction was erected into a department of the administration in every province, under a director, with a staff of inspectors. In some respects this scheme may have been in advance of the time; but it supplied a definite outline, which has gradually been filled up with each succeeding year of progress. A network of schools has now been spread over the country, graduated from the indigenous village institutions up to the highest colleges. All alike receive some measure of pecuniary support, which is justified by the guarantee of regular inspection; and a series of scholarships at once stimulates efficiency and opens a path to the university for children of the poor. In 1877–78 the total number of educational institutions of all sorts in British India was 66,202, attended by an aggregate of 1,877,942 pupils, showing an average of one school to every 14 square miles, and nine pupils to every thousand of the population. In the same year the total expenditure upon education from all sources was £1,612,775, of which £782,240 was contributed by the provincial governments, £258,514 was derived from local rates, and £32,008 from municipal grants. These items may be said to represent state aid, while endowments yielded £37,218, subscriptions £105,853, and fees and fines £277,039. The degree in which education has been popularized and private effort has been stimulated may be estimated from the fact that in Bengal the total of voluntary payments now exactly balances the total of Government grants.

Universities.—The three universities of Calcutta, Madras, and Bombay were incorporated in 1857, on the model of the university of London. They are merely examining bodies, composed of a chancellor, vice-chancellor, and senate, with the privilege of conferring degrees in arts, law, medicine, and civil engineering. The governing body, or syndicate, consists of the vice-chancellor and certain members of the senate. Quite recently a fourth university, on the same plan, has been founded at Lahore for the Punjab. Though not themselves places of instruction, the universities control the whole course of higher education by means of their examinations. The entrance examination for matriculation is open to all; but when that is passed candidates for higher stages must enrol themselves in one or other of the affiliated colleges. In the ten years ending 1877–78 9686 candidates successfully passed the entrance examination at Calcutta, 6381 at Madras, and 2610 at Bombay. Many fall off at that stage, and very few proceed to the higher degrees. During the same ten years 952 graduated B.A., and only 254 M.A., with honours, at Calcutta; 496 B.A. and 14 M.A. at Madras; 217 B.A. and 28 M.A. at Bombay. Calcutta possesses by far the majority of graduates in law and medicine, while Bombay is similarly distinguished in engineering. In 1877–78 the total expenditure on the four universities was £22,093.

The colleges or institutions for higher instruction may be divided into two classes,—those which teach the arts course of the universities, and those devoted to special branches of knowledge. According to another principle, they are classified into those entirely supported by Government and those which only receive grants-in-aid. The latter class comprises the missionary colleges. In 1877–78 the total number of colleges, including medical and engineering colleges and Mahometan *madrasas*, was 82, attended by 8894 students. Of these, 35 colleges with 3848 students were in Bengal proper, and 21 colleges with 1448 students in Madras. In the same year the total expenditure on the colleges was £186,162, or at the rate of £21 per student.

Boys' Schools.—This large class includes many varieties, which may be subdivided either according to the character of the instruction given, or according to the proportion of Government aid they receive. The higher schools are those in which not only is English taught, but that language is also the medium of instruction. They educate up to the standard of the entrance examination at the universities, and train generally those candidates who seek employment in the upper grades of Government service. As far as possible one of these schools, known as the *zilá* or district school, is established by Government at the head-quarters of every district, and many others receive grants-in-aid. The middle schools, as their name implies, are intermediate between the higher and the primary schools. Generally speaking, they are placed in the smaller towns and larger villages, and they provide that measure of instruction which is recognized to be useful by the middle classes themselves. Some of them teach English, but others only the vernacular. This class includes the *tahsili* schools, established at the headquarters of every *tahsil* or subdivision in the North-Western Provinces. In 1877–78 the total expenditure on both higher and middle schools was £478,250. The lower and primary schools complete the series. They present every degree of efficiency, from the indigenous and unaided village school to the vernacular schools in the presidency capitals. Their extension is the chief test of the success of the educational system. No uniformity prevails in this matter throughout the several provinces. In Bengal up to the last few years primary instruction was sadly neglected; but, since the reforms inaugurated by Sir G. Campbell in 1872, by which the benefit of the grant-in-aid rules was extended to the *páthsálás* or village schools, this reproach has been removed. In 1871–72 the total number of primary schools under inspection was only 2451, attended by 64,779 pupils. By 1877–78 the number of schools had risen to 16,042, and the number of pupils to 360,322, being an increase of about sixfold in six years. In the latter year the total expenditure from all sources was £78,000, towards which Government contributed only £27,000, thus showing how state aid stimulates private outlay. The North-Western Provinces owe their system of primary instruction to their great lieutenant-governor, Mr Thomason, whose constructive talent can be traced in every department of the administration. In addition to the *tahsili* or middle schools already referred to, he drew up a scheme for establishing *halkabandi* or primary schools in every central village (whence their name), to which the children from the surrounding hamlets might resort. His scheme has since been largely developed by means of the educational cess added to the land revenue. In Bombay the primary schools are mainly supported out of local funds raised in a similar manner. In British Burmah, on the other hand, primary education is still left to a great extent in the hands of Buddhist monks, who receive no pecuniary support from Government. The monastic schools are only open to boys, but there are also lay teachers who admit girls to mixed classes. Government has hardly any schools of its own in Burmah, the deficiency being supplied by several missionary bodies, who obtain state aid. In many parts of the Madras presidency, also, the missionaries possess a practical monopoly of education at the present day. In 1877–78 the amount of money expended upon lower and primary schools in British India was £406,135, or just one-fourth of the total educational budget.

Girls' Schools.—Of late years something has been done, though not much, to extend the advantages of education to girls. In this, as in other educational matters, the missionaries have been the pioneers of progress. In a few exceptional places, such as Tinnevelli in Madras, the Khási hills of Assam, and among the Karen tribes of Burmah, female education has a real existence, for in these places the missionaries have influence enough to overcome the prejudices of the people. But elsewhere, even in the large towns and among the English-speaking classes, all attempts to develop the intelligence of women are regarded with scarcely disguised aversion. Throughout the North-Western Provinces, with their numerous and wealthy cities, and a total female population of 15 millions, only 6550 girls attended school in 1877–78. In Bengal, with just double the inhabitants, the corresponding number was less than 12,000. Madras, British Burmah, and to a small degree Bombay and the Punjab, are the only provinces that contribute to the following statistics in any tolerable proportion:—Total girls' schools in 1877–78, 2002; number of pupils, 66,615; mixed schools for boys and girls, 2955; pupils, 90,915; total amount expended on girls' schools, £78,729, of which £27,000 was devoted to the 12,000 girls of Bengal.

Normal and other Special Schools, &c.—In 1877–78 the normal and technical schools numbered 155, with a total of 6864 students;

the total expenditure was £54,260, or an average of nearly £7 per student. School mistresses, as well as masters, are trained in these institutions; and there also the missionaries have shown themselves active in anticipating a work which Government subsequently took up. Of schools of art, the oldest is that founded by Dr A. Hunter at Madras in 1850, and taken in charge by the Education Department in 1856. This school, as also those at Calcutta and Bombay, has been very successful in developing the industrial capacities of the people, and training workmen for public employment. Museums have been established at the provincial capitals and many other large towns. Schools for European and other foreign races have also attracted the attention of Government. In 1877-78 the number of such institutions was 104, with 9121 pupils; the expenditure from all sources was £80,197, or an average of nearly £9 per pupil. Foremost among these are the asylums for the orphans of British soldiers, established at hill stations (*e.g.* Utakamand and Sanáwar) in memory of Sir Henry Lawrence.

News-papers. *Newspapers and Books.*—Closely connected with the subject of education is the steady growth of the vernacular press, which is ever busy issuing both newspapers and books. The missionaries were the first to cast type in the vernacular languages, and to employ native compositors. The earliest newspaper was the Bengáli *Sámáchar Darpan*, which was issued in 1835 by the Baptist Mission at Serampur. For many years the vernacular press preserved the marks of its origin, by being limited almost absolutely to theological controversy. The missionaries continued their work; and they were encountered with their own weapons by the theistic sect of the Bráhma Samáj, and also by orthodox Hindus. So late as 1850 the majority of newspapers were still sectarian rather than political, but during the last twenty years the vernacular press has gradually risen to become a powerful engine of political discussion. The number of newspapers regularly published in the several vernaculars at the present time is said to reach the formidable total of 230. The aggregate number of copies issued is estimated by Mr Roper Lethbridge at about 150,000; but the circulation proper, that is, the actual number of readers, is infinitely larger. In Bengal the vernacular press suffers from the competition of English newspapers, some of which are entirely owned and written by natives. In the north-west, from Lucknow to Lahore, about 100 newspapers are printed in Hindustáni or Urdu, the vernacular of the Mahometans throughout India. Many of these are conducted with considerable ability and enterprise, and may fairly be described as representative of native opinion in the large towns. The Bombay journals are almost equally divided between Marathí and Guzerathi. Those in the former language are characterized by the traditional independence of the race of Sivají; those in the latter language are the organs of the Pársis and of the trading community. The newspapers of Madras printed in Tamil and Telugu are politically unimportant, being still for the most part devoted to religion.

Books. As regards books, or rather registered publications, in the vernacular languages, Bengal takes the lead; while the Punjab, Bombay, the North-Western Provinces, and Madras follow in order. In 1877-78 the total number of registered publications was 4890, of which 544 were in English, 3064 in one of the vernaculars, 719 in a classical language of India, and 563 bilingual. Of the vernacular works, 709 dealt with religion, 663 with poetry and the drama, 330 with language, 195 with science, 181 with fiction, 146 with law, and 95 with medicine.[1]

History.

Non-Aryan or Aboriginal Races.

Aboriginal tribes. Our earliest glimpses of India disclose two races struggling for the soil. The one was a fair-skinned people, who had lately entered by the north-western passes—a people of Aryan (literally "noble") lineage, speaking a stately language, worshipping friendly and powerful gods. The other was a race of a lower type, who had long dwelt in the land, and whom the lordly new-comers drove back before them into the mountains, or reduced to servitude on the plains. The comparatively pure descendants of these two races in India are now nearly equal in number, there being about 18 millions of each; their mixed progeny, sprung chiefly from the ruder stock, make up the mass of the present Indian population.

The lower tribes were an obscure people, who, in the absence of a race-name of their own, are called the non-Aryans or aborigines. They have left no written records; indeed, the use of letters, or of the simplest hieroglyphics, was to them unknown. The sole works of their hands which have come down to us are the rude stone circles and upright slabs or mounds beneath which, like the primitive peoples of Europe, they buried their dead. From these we only discover that, at some far distant but unfixed period, they knew how to make round pots of hard, thin earthenware, that they fought with iron weapons, and that they wore ornaments of copper and gold. The coins of imperial Rome have been found in their later graves. Earlier remains, lying in the upper soils of large areas, prove that these ancient tomb-builders formed only one link in a chain of primæval races. Long before their advent, India was peopled, as far as the depths of the Central Provinces, by tribes unacquainted with the metals, who hunted and warred with polished flint axes and other deftly-wrought implements of stone similar to those dug up in northern Europe. And even these were the successors of yet ruder beings, who have left their agate knives and rough flint weapons in the Narbadá valley. In front of this far-stretching background of the Bronze and Stone Ages, we see the so-called aborigines being beaten down by the newly arrived Aryan race.

The struggle is commemorated by the two names which the victors gave to the early tribes, namely, the Dasyus, or "enemies," and the Dásas, or "slaves." The last remains to this day the family name of multitudes of the lower class in Bengal. The new-comers from the north prided themselves on their fair complexion, and their Sanskrit word for "colour" (*varna*) came to mean "race" or "caste." Their earliest poets, at least three thousand and perhaps four thousand years ago, praised in the *Rig-Veda* their gods, who, "slaying the Dasyus, protected the *Aryan colour*," who "subjected the black-skin to the Aryan man." Moreover, the Aryan, with his finely-formed features, loathed the squat Mongolian faces of the aborigines. One Vedic singer speaks of them as "noseless" or flat-nosed, while another praises his own "beautiful-nosed" gods. The same unsightly feature was commented on with regard to a non-Aryan Asiatic tribe, by the companions of Alexander the Great on his Indian expedition, at least a thousand years later. The Vedic hymns abound in scornful epithets for the primitive tribes, as "disturbers of sacrifices," "gross feeders on flesh," "raw-eaters," "lawless," "not-sacrificing," "without gods," and "without rites." As time went on, and these rude tribes were driven back into the forest, they were painted in still more hideous shapes, till they became the "monsters" and "demons" of the Aryan poet and priest. Their race-name Dasyu, "enemy," thus grew to signify a goblin or devil, as the old Teutonic word for enemy has become the English "fiend."

Nevertheless, all of them could not have been savages. We hear of wealthy Dasyus, and even the Vedic hymns speak much of their "seven castles" and "ninety forts." In later Sanskrit literature the Aryans make alliance with aboriginal princes; and when history at length dawns on the scene, we find some of the most powerful kingdoms of India ruled by dynasties of non-Aryan descent. Nor were they devoid of religious rites, nor of cravings after a future life. "They adorn," says a very ancient Sanskrit treatise,[2] "the bodies of their dead with gifts, with raiment, with ornaments, imagining that thereby they shall attain the world to come." These ornaments are the bits of bronze, copper, and gold, which we now dig up from beneath their rude stone monuments. In the great Sanskrit epic which narrates the advance of the Aryans into southern India, a non-Aryan chief describes his race as "of fearful swiftness, unyielding in battle, in colour like a dark blue cloud."[3]

[1] In the preparation of the administrative sections and statistics, the writer specially acknowledges the assistance of Mr J. S. Cotton.

[2] Chandogya Upanishad, quoted in Muir's *Sanskrit Texts*.

[3] Rámáyana.

Thrust back by the Aryans from the plains, these primitive peoples have lain hidden away in the recesses of the mountains, like the remains of extinct animals which zoologists find in hill-caves. India thus forms a great museum of races, in which we can study man from his lowest to his highest stages of culture.

Among the rudest fragments of mankind are the isolated Andaman islanders in the Bay of Bengal. The old Arab and European voyagers described them as dog-faced man-eaters. The English officers sent to the islands in 1855 to establish a settlement found themselves surrounded by quite naked cannibals of a ferocious type, who daubed themselves when festive with red earth, and mourned in a suit of olive-coloured mud. They used a noise like weeping to express friendship or joy, bore only names of common gender, which they received before birth; and their sole conception of a god was an evil spirit who spread disease. For five years they repulsed every effort at intercourse by showers of arrows; but the officers slowly brought them to a better frame of mind by building sheds near the settlement, where these poor beings might find shelter from the tropical rains, and receive medicines and food.

The Anamalai hills, in southern Madras, form the refuge of a whole series of broken tribes. Five hamlets of long-haired wild-looking Puliars live on jungle products, mice, or any small animals they can catch, and worship demons. Another clan, the Mundavars, shrink from contact with the outside world, and possess no fixed dwellings, but wander over the innermost hills with their cattle, sheltering themselves under little leaf-sheds, and seldom remaining in one spot more than a year. The thick-lipped small-bodied Kaders, "Lords of the Hills," are a remnant of a higher race. They file the front teeth of the upper jaw as a marriage ceremony, live by the chase, and wield some influence over the ruder forest-folk. These hills, now very thinly peopled, abound in the great stone monuments (kistvaens and dolmens) which the primitive tribes used for their dead. The Nairs of south-western India still practice polyandry, according to which a man's property descends not to his own but to his sister's children. That system also appears among the Himálayan tribes at the opposite extremity of India.

In the Central Provinces the aboriginal races form a large proportion of the population. In certain districts, as in the feudatory state of Bastár, they amount to three-fifths of the inhabitants. The most important race, the Gonds, have made some advances in civilization; but the wilder tribes still cling to the forest, and live by the chase, and some of them are reported to have used, within a few years back, flint points for their arrows. The Máriás wield bows of great strength, which they hold with their feet while they draw the string with both hands. A still wilder tribe, the Máris, fly from their grass-built huts on the approach of a stranger. Once a year a messenger comes to them from the local rájá to take their tribute of jungle products. He does not enter their hamlets, but beats a drum outside, and then hides himself. The shy Máris creep forth, place what they have to give in an appointed spot, and run back again into their retreats.

Further to the north-east, in the tributary states of Orissa, there is a poor tribe, 10,000 in number, of Juangs or Patuas, literally the "leaf-wearers," whose women formerly wore no clothes. Their only vestige of covering was a few strings of beads round the waist with a bunch of leaves tied before and behind. Those under the British influence were clothed in 1871 by order of Government, and their native chief was persuaded to do the same work for the others. This leaf-wearing tribe had no knowledge of the metals till quite lately, when foreigners came among them, and no word exists in their native language for iron or any other metal. But their country abounds with flint weapons, so that the Juangs form a remnant to our own day of the Stone Age. "Their huts," writes the officer who knows them best, "are among the smallest that human beings ever deliberately constructed as dwellings. They measure about 6 feet by 8. The head of the family and all the females huddle together in this one shell, not much larger than a dog-kennel." The boys and the young men of the village live in one large building apart by themselves; and this custom of having a common abode for the whole male youth of the hamlet is found among many of the aboriginal tribes in distant parts of India. The Kandhs of Orissa, who kept up their old tribal ritual of human sacrifice until it was put down by the British in 1835–45, and the Santáls in the west of Lower Bengal, who rose in 1855, are examples of powerful and highly developed non-Aryan tribes.

Proceeding to the northern boundary of India, we find the slopes and spurs of the Himálayas peopled by a great variety of rude tribes. As a rule they are fierce, black, undersized, and ill-fed. They formerly eked out a wretched subsistence by plundering the more civilized hamlets of the Assam valley,—a means of livelihood which they are but slowly giving up under British rule. Some of the wildest of them, such as the independent Abars, are now employed as a sort of irregular police, to keep the peace of the border, in return for a yearly gift of cloth, hoes, and grain. Their very names bear witness to their former wild life. One tribe, the Akas of Assam, is divided into two clans, known respectively as "The eaters of a thousand hearths," and "The thieves who lurk in the cotton-field."

Whence came these primitive peoples, whom the Aryan invaders found in the land more than three thousand years ago, and who are still scattered over India, the fragments of a prehistoric world? Written records they do not possess. Their oral traditions tell us little, but such hints as they yield feebly point to the north. They seem to preserve dim memories of a time when the tribes dwelt under the shadow of mightier hill ranges than any to be found on the south of the river plains of Bengal. "The Great Mountain" is the race-god of the Santáls, and an object of worship among other tribes. The Gonds, in the heart of of Central India, have a legend that they were created at the foot of Dewálagiri Peak in the Himálayas. Till lately they buried their dead with the feet turned northwards, so as to be ready to start again for their ancient home in the north.

Non-Aryan languages.

The language of the non-Aryan races, that record of a nation's past more enduring than rock inscriptions or tables of brass, is being slowly made to tell the secret of their origin. It already indicates that the early peoples of India belonged to three great stocks, known as the Tibeto-Burman, the Kolarian, and the Dravidian.

Tibeto-Burmese.

The Tibeto-Burman tribes cling to the skirts of the Himálayas and their north-eastern offshoots. They crossed over into India by the north-eastern passes, and in some prehistoric time had dwelt in Central Asia, side by side with the forefathers of the Mongolians and the Chinese. Several of the hill languages in Eastern Bengal preserve Chinese terms, others contain Mongolian. Thus the Nágás in Assam still use words for *three* and *water* which might almost be understood in the streets of Canton.

The following are the twenty principal dialects of the Tibeto-Burman group:—(1) Cachárí or Bodo, (2) Garo, (3) Tripura or Mrung, (4) Tibetan or Bhutia, (5) Gurung, (6) Murmi, (7) Newar, (8) Lepcha, (9) Miri, (10) Aka, (11) Mishmi dialects, (12) Dhimal, (13) Kanáwari dialects, (14) Míkír, (15) Singpho, (16) Nága dialects, (17) Kuki dialects, (18) Burmese, (19) Khyeng, and (20) Manipuri.

"It is impossible," writes Mr Brandreth, "to give even an approximate number of the speakers included in this group, as many of the languages are either across the frontier or only project a short distance into our own territory. The languages included in this group have not, with perhaps one or two exceptions, both a cerebral and dental row of consonants, like the South-Indian languages; some of them have aspirated forms of the surds, but not of the sonants; others have aspirated forms of both. The languages of this group, even those which most diverge from each other, have several words in common, and especially numerals and pronouns, and also some resemblances of grammar. In comparing the resembling words, the differences between them consist often less in any modification of the root-syllable than in the various additions to the root. Thus in Burmese we have *ná*, 'ear;' Tibetan, *rna-ba*; Magar, *na-kep*; Newar, *nai-pong*; Dhimal, *ná-háthong*; Kiranti dialects, *ná-pro*, *ná-rék*, *ná-phák*; Nága languages, *te-na-ro*, *te-na-rang*; Manipuri, *na-kong*; Kupui, *ka-ná*; Sak, *aka-ná*; Karen, *na-khu*; and so on. It can hardly be doubted that such additions as these to monosyllabic roots are principally determinative syllables for the purpose of distinguishing between what would otherwise have been monosyllabic words having the same sound. These determinatives are generally affixed in the languages of Nepál and in the Dhimal language; prefixed in the Lepcha language, and in the languages of Assam, of Manipur, and of the Chittagong and Arakan hills. Words are also distinguished by difference of tone. The tones are generally of two kinds, described as the abrupt or short, and the pausing or heavy; and it has been remarked that those languages which are most given to adding other syllables to the root make the least use of the tones, and *vice versa*; where the tones most prevail the least recourse is had to determinative syllables."

Kolarian.

The Kolarians, the second of the three non-Aryan stocks, seem also to have entered Bengal by the north-eastern passes. They dwell chiefly in the north, and along the north-eastern edge of the three-sided table-land which covers the southern half of India. Some of the Dravidians, or third stock, appear, on the other hand, to have found their way into the Punjab by the north-western passes. They now inhabit the southern part of the three-sided table-land, as far down as Cape Comorin, the southernmost part of India. It appears as if the two streams of the Kolarian tribes from the north-east and the Dravidians from the north-west had converged and crossed each other in Central India. The Dravidians proved the stronger, broke up the Kolarians, thrust aside their fragments to east and west, and then rushed forward in a mighty body to the south.

It thus happened that, while the Dravidians formed a vast mass in southern India, the Kolarians survived only as isolated tribes, scattered so far apart as soon to forget their common origin. One of the largest of the Kolarian races, the Santáls, dwells on the extreme eastern edge of the three-sided table-land of Central India, where it slopes down into the Gangetic valley of Lower Bengal. The Kurkus, a broken Kolarian tribe, inhabit a patch of country about 400 miles to the west, and have for perhaps thousands of years been cut off from the Santáls by mountains and pathless forests, and by intervening races of the Dravidian and Aryan stocks. The Kurkus and Santáls have no tradition of a common origin; yet at this day the Kurkus speak a language which is little else than a dialect of Santáli. The Savars, once a great Kolarian tribe, mentioned by Pliny and Ptolemy, are now a poor wandering race of woodcutters of northern Madras and Orissa. Yet fragments of them have lately been found deep in Central India, and as far west as Rájputána on the other side.

The nine principal languages of the Kolarian group are—(1) Santáli, (2) Mundári, (3) Ho, (4) Bhumij, (5) Korwa, (6) Kharria, (7) Juang, (8) Kurku, and perhaps (9) Savar. Some of them are separated only by dialectical differences.

"The Kolarian group of languages," writes Mr Brandreth, "has both the cerebral and dental row of letters, and also aspirated forms, which last, according to Caldwell, did not belong to early Dravidian. There is also a set of four sounds, which are perhaps peculiar to Santáli, called by Skrefsrud semi-consonants, and which, when followed by a vowel, are changed respectively into *g*, *j*, *d*, and *b*. Gender of nouns is animate and inanimate, and is distinguished by difference of pronouns, by difference of suffix of a qualifying noun in the genitive relation, and by the gender being denoted by the verb. As instances of the genitive suffix, we have in Santáli *in-ren hopon*, 'my son,' but *in-ak orak*, 'my house.' There is no distinction of sex in the pronouns, but of the animate and inanimate gender. The dialects generally agree in using a short form of the third personal pronoun suffixed to denote the number, dual and plural, of the noun, and short forms of all the personal pronouns are added to the verb in certain positions to express both number and person, both as regards the subject and object, if of the animate gender,—the inanimate gender being indicated by the omission of these suffixes. No other group of languages, apparently, has such a logical classification of its nouns as that shown by the genders of both the South-Indian groups. The genitive in the Kolarian group of the full personal pronouns is used for the possessive pronoun, which again takes all the post-positions, the genitive relation being thus indicated by the genitive suffix twice repeated. The Kolarian languages generally express grammatical relations by suffixes, and add the post-positions directly to the root, without the intervention of an oblique form or genitive or other suffix. They agree with the Dravidian in having inclusive and exclusive forms for the plural of the first personal pronoun, in using a relative participle instead of a relative pronoun, in the position of the governing word, and in the possession of a true causal form of the verb. They have a dual, which the Dravidians have not, but they have no negative voice. Counting is by twenties instead of by tens, as in the Dravidian. The Santáli verb, according to Skrefsrud, has twenty-three tenses, and for every tense two forms of the participle and a gerund."

The compact Dravidians in the south, although in after-days subdued by the higher civilization of the Aryan race which pressed in among them, were never thus broken into fragments. Their pure descendants consist, indeed, of small and scattered tribes; but they have given their languages to 46 millions of people in southern India. That some of the islands in the distant Pacific Ocean were peopled either from the Dravidian settlements in India, or from an earlier common source, remains a conjectural induction of philologers, rather than an established ethnological fact.[1] The aboriginal tribes in southern and western Australia use almost the same words for *I*, *thou*, *he*, *we*, *you*, &c., as the fishermen on the Madras coast, and resemble in many other ways the Madras hill tribes, as in the use of their national weapon the boomerang.

Bishop Caldwell recognizes twelve distinct Dravidian languages:—(1) Tamil, (2) Malayálim, (3) Telugu, (4) Kanarese, (5) Tulu, (6) Kudugu, (7) Toda, (8) Kota, (9) Gond, (10) Khond, (11) Uráon, (12) Rájmahál.

"In the Dravidian group," writes Mr Brandreth, "there is a rational and an irrational gender of the nouns, which is distinguished in the plural of the nouns, and sometimes in the singular also, by affixes which appear to be fragmentary pronouns, by corresponding pronouns, and by the agreement of the verb with the noun, the gender of the verb being expressed by the pronominal suffixes. To give an instance of verbal gender, we have in Tamil, from the root *sey*, 'to do,' *seyd-án*, 'he (rational) did;'—*seyd-ál*, 'she (rational) did;' *seyd-adu*, 'it (irrational) did;' *seyd-ár*, 'they (the rationals) did;' *seyd-a*, 'they (the irrationals) did;'—the full pronouns being *avan*, 'he;' *aval*, 'she;' *adu*, 'it;' *avar*, 'they;' *avei*, 'they.' This distinction of gender, though it exists in most of the Dravidian languages, is not always carried out to the extent that it is in Tamil. In Telugu, Gond, and Khond it is preserved in the plural, but in the singular the feminine rational is merged in the irrational gender. In Gond the gender is further marked by the noun in the genitive relation taking a different suffix, according to the number and gender of the noun on which it depends. In Uráon the feminine rational is entirely merged in the irrational gender, with the exception of the pronoun, which preserves the distinction between rationals and irrationals in the plural; as *as*, 'he,' referring to a god or a man; *ád*, 'she,' or 'it,' referring to a woman or an irrational object; but *ár*, 'they,' applies to both men and women; *abrá*, 'they,' to irrationals only. The rational gender, besides human beings, includes the celestial and infernal deities; and it is further subdivided in some of the languages, but in the singular only, into masculine and feminine. An instance of this subdivision in the Tamil verb was given above.

"The grammatical relations in the Dravidian are generally expressed by suffixes. Many nouns have an oblique form, which is a remarkable characteristic of the Dravidian group; still, with the majority of nouns, the post-positions are added directly to the nominative form. Other features of this group are—the frequent use of formatives to specialize the meaning of the root; the absence of relative pronouns, and the use instead of a relative participle, which is usually formed from the ordinary participle by the same suffix as that which Dr Caldwell considers as the oldest sign of the genitive relation; the adjective succeeding the substantive; of two substantives, the determining preceding the determined; and the verb being the last member of the sentence. There is no true dual in the Dravidian languages. In the Dravidian languages there are two forms of the plural of the pronoun of the first person, one including, the other excluding, the person addressed. As regards the verbs, there is a negative voice, but no passive voice, and there is a causal form."

We discern, therefore, long before the dawn of history, masses of men moving uneasily over India, and violently pushing in among still earlier tribes. They crossed the snows of the Himálayas, and plunged into the tropical forests in search of new homes. Of these ancient races fragments now exist in almost exactly the same stage of human progress as they were when described by Vedic poets over three thousand years ago. Some are dying out, such as the Andaman islanders, among whom only one family in 1869 had so many as three children. Others are increasing, like the Santáls, who have doubled themselves under British rule. Taken as a whole, and including certain half-Hinduized branches, they number 17,716,825, or say 18 millions, equal to three-quarters of the population of England and Wales. But while the bolder or more

[1] See the authorities in Bishop Caldwell's *Comparative Grammar of the Dravidian Languages*, pp. 78–80, &c. (ed. 1857).

isolated of the aboriginal races have thus kept themselves apart, by far the greater portion submitted in ancient times to the Aryan invaders, and now make up the mass of the Hindus.

In Bengal and Assam the aborigines are divided into nearly sixty distinct races. In the North-Western Provinces sixteen tribes of aborigines are enumerated in the census of 1872. In the Central Provinces they number $1\frac{3}{4}$ millions,—the ancient race of Gonds, who ruled the central table-land before the rise of the Marhattás, alone amounting to $1\frac{1}{2}$ millions. In British Burmah the Karens, whose traditions have a singularly Jewish tinge, number 330,000. In Oudh the nationality of the aboriginal tribes has been stamped out beneath successive waves of Rájput and Mahometan invaders. In centres of the ancient Hindu civilization, the aboriginal races have become the low-castes and out-castes on which the social fabric of India rests. A few of them, however, still preserve their ethnical identity as wandering tribes or jugglers, basket-weavers, and fortune-tellers. Thus the Náts, Bediyas, and other gipsy clans are recognized to this day as distinct from the surrounding Hindu population.

The aboriginal races on the plains have supplied the hereditary criminal classes, alike under the Hindus, the Mahometans, and the British. Formerly organized robber communities, they have, under the stricter police administration of our days, sunk into petty pilferers. But their existence is still recognized by the Criminal Tribes Act, passed in 1871, and occasionally enforced within certain localities of northern India.

The non-Aryan hill races, who figured from Vedic times downwards as marauders and invaders, have ceased to be a disturbing element. Many of them appear as predatory clans in Mahometan and early British India. They sallied forth from their mountains at the end of the autumn harvest, pillaged and burned the lowland villages, and retired to their fastnesses laden with the booty of the plains. The measures by which many of these wild races have been reclaimed mark some of the most honourable episodes of Anglo Indian rule. Cleveland's Hill-Rangers in the last century, and the Bhíls and Mhairs in more recent times, are well-known examples of marauding races being turned into peaceful cultivators and loyal soldiers. An equally salutary transformation has taken place in many a remote forest and hill tract of India. The firm order of British rule has rendered their old plundering life no longer possible, and at the same time has opened up to them new outlets for their energies. Their character differs in many respects from that of the tamer population of the plains. Their truthfulness, sturdy loyalty, and a certain joyous bravery, almost amounting to playfulness, appeal in a special manner to the English mind. There is scarcely a single administrator who has ruled over them for any length of time without finding his heart drawn to them, and leaving on record his belief in their capabilities for good.

Primitive Hinduism.

We have seen that India may be divided into three regions. Two of these, the Himálayas in the north and the three-sided table-land in the south, still form the retreats of the non-Aryan tribes. The third, or the great river plains, became in very ancient times the theatre on which a nobler race worked out its civilization.

That race belonged to the splendid Aryan or Indo-Germanic stock, from which the Bráhman, the Rájput, and the Englishman alike descend. Its earliest home seems to have been in Central Asia. From this common camping-ground certain branches of the race started for the east, others for the west. One of the western offshoots founded the Persian kingdom; another built Athens and Lacedæmon, and became the Greek nation; a third went on to Italy, and reared the city on the seven hills which grew into imperial Rome. A distant colony of the same race excavated the silver-ores of prehistoric Spain; and, when we first catch a sight of ancient England, we see an Aryan settlement fishing in willow canoes, and working the tin-mines of Cornwall. Meanwhile other branches of the Aryan stock had gone forth from the primitive home in Central Asia to the east. Powerful bands found their way through the passes of the Himálayas into the Punjab, and spread themselves, chiefly as Bráhmans and Rájputs, over India.

The Aryan offshoots to the east and to the west alike asserted their superiority over the earlier peoples whom they found in possession of the soil. The history of ancient Europe is the story of the Aryan settlements around the shores of the Mediterranean; and that wide term, modern civilization, merely means the civilization of the western branches of the same race. The history and development of India consist of the history and development of the eastern offshoots of the Aryan stock who settled in that land. In the west, the Aryan speech has supplied the modern languages of Europe, America, and England's island empires in the southern Pacific. In the east, Hinduism and Buddhism, the religions of the Indian branch of the Aryans, have become the faiths of more than one-half of the whole human race, and spread Aryan thought and culture throughout Asia to the utmost limits of China and Japan.

Its home in Central Asia.

We know little regarding these noble Aryan tribes in their early camping-ground in Central Asia. From words preserved in the languages of their long-separated descendants in Europe and India, scholars infer that they roamed over the grassy steppes with their cattle, making long halts to rear crops of grain. They had tamed most of the domestic animals, were acquainted with some metals, understood the arts of weaving and sewing, wore clothes, and ate cooked food. They lived the hardy life of the temperate zone, and the feeling of cold seems to be one of the earliest common remembrances of the eastern and the western branches of the race. Ages afterwards, when the Vedic singers in hot India prayed for long life, they asked for "a hundred *winters*." The forefathers of the Greek and the Roman, of the Englishman and the Hindu, dwelt together in Asia, spoke the same tongue, worshipped the same gods. The languages of Europe and India, although at first sight they seem wide apart, are merely different forms of the original Aryan speech. This is especially true of the common words of family life. The names for *father*, *mother*, *brother*, *sister*, and *widow* are the same in most of the Aryan languages, whether spoken on the banks of the Ganges, of the Tiber, or of the Thames. Thus the word *daughter*, which occurs in nearly all of them, has been derived from two Sanskrit roots meaning "to draw milk," and preserves the memory of the time when the daughter was the little milk-maid in the primitive Aryan household.

The ancient religions of Europe and India had a similar origin. They were to some extent made up of the sacred stories or myths which our common ancestors had learned while dwelling together in Central Asia. Some of the Vedic gods were also the gods of Greece and Rome; and to this day the Deity is adored by names derived from the same old Aryan root by Bráhmans in Calcutta, by Protestant clergymen at Westminster, and by Catholic priests in Peru.

The Vedic hymns exhibit the Indian branch of the Aryans on its march to the south-east and in its new homes. The earliest songs disclose the race still to the north of the Khyber Pass, in Cabul; the later ones bring it as far as the Ganges. Their victorious advance eastwards through the intermediate tract can be traced in the Vedic writings almost step by step. One of their famous settlements lay between the two sacred rivers, the Saraswati and the Drishadvati,—supposed to be the modern Sarsuti near Thánesar, in the Punjab, and the Ghaggar, a day's march from it. That fertile strip of land, not more than 60 miles long by 20 broad, was fondly remembered by them as their Holy Land, "fashioned of God, and chosen by the Creator." As their numbers increased, they pushed eastwards along the base of the Himálayas, into what they afterwards called the Land of the Sacred Singers (*Bráhmarshidesha*). Their settlements practically included the five rivers of the Punjab, together with the other great river-system formed by the upper courses of the Jumna and the Ganges. In them the Vedic hymns were composed; and the steady supply of water led the Aryans to settle down from their old state of wandering pastoral tribes into communities of husbandmen. The Vedic poets praised the rivers which enabled them to make this great change—perhaps the most important step in the progress of a race. "May the Indus," they sang, "the far-famed giver of wealth, hear us,—(fertilizing our) broad fields with water." The Himálayas, through whose passes they had reached India, and at whose southern base they long dwelt, made a lasting impression on their memory. The Vedic singer praised "Him whose greatness the snowy ranges, and the sea, and the aerial river declare." In all its long wanderings through India the Aryan race never forgot its northern home. There dwelt its gods and holy singers, and their eloquence descended from heaven among men.

The *Rig-Veda* forms the great literary memorial of the early Aryan settlements in the Punjab. The age of this venerable hymnal is unknown. The Hindus believe, without evidence, that it existed "from before all time," or at least 3001 years B.C.,—nearly 5000 years ago. European scholars have inferred from astronomical dates that its composition was going on about 1400 B.C. But these dates are themselves given in writings of later origin, and might have been calculated backwards. We only know that the Vedic religion had been at work long before the rise of Buddhism in the 6th century B.C. Nevertheless, the antiquity of the *Rig-Veda*, although not to be expressed in figures, is abundantly established. The earlier hymns exhibit the Aryans on the north-western frontiers of India just starting on their long journey. Before the embassy of the Greek Megasthenes, at the end of the 4th century B.C., they had spread their influence as far as the delta of Lower Bengal, 1500 miles distant. At the time of the *Periplus* the southernmost point of India had become a seat of their worship. "What a series of centuries must have elapsed," writes Weber, "before this boundless tract of country, inhabited by wild and vigorous tribes, could have been brought over to Bráhmanism!"

The Bráhmans declare that the Vedic hymns were directly inspired by God. Indeed, in our own times, the great theistic church of Bengal, which rejects Bráhmanical teaching, was rent into two sects on the question of the divine authority of the *Veda*. As a matter of fact, the hymns were composed by certain families of Rishis or psalmists, some of whose names are preserved. The *Rig-Veda* is a very old collection of 1017 of these short lyrical poems, chiefly addressed to the gods, and containing 10,580 verses. They show us the Aryans on the banks of the Indus, divided into various tribes, sometimes at war with each other, sometimes united against the "black-skinned" aborigines. Caste, in its later sense, is unknown. Each father of a family is the priest of his own household. The chieftain acts as father and priest to the tribe; but at the greater festivals he chooses some one specially learned in holy offerings to conduct the sacrifice in the name of the people. The chief himself seems to have been elected; and his title of Vís-pati, literally "Lord of the Settlers," survives in the old Persian Vis-paiti, and as the Lithuanian Wiéz-patis in central Europe at this day. Women enjoyed a high position, and some of the most beautiful hymns were composed by ladies and queens. Marriage was held sacred. Husband and wife were both "rulers of the house" (*dampatí*), and drew near to the gods together in prayer. The burning of widows on their husbands' funeral-pile was unknown, and the verses in the *Veda* which the Bráhmans afterwards distorted into a sanction for the practice have the very opposite meaning. "Rise, woman," says the sacred text to the mourner; "come to the world of life. Come to us. Thou hast fulfilled thy duties as a wife to thy husband."

The Aryan tribes in the *Veda* are acquainted with most of the metals. They have blacksmiths, coppersmiths, and goldsmiths among them, besides carpenters, barbers, and other artisans. They fight from chariots, and freely use the horse, although not yet the elephant, in war. They have settled down as husbandmen, till their fields with the plough, and live in villages or towns. But they also cling to their old wandering life, with their herds and "cattle-pens." Cattle, indeed, still form their chief wealth, the coin (Latin, *pecunia*) in which payments of fines are made; and one of their words for war literally means "a desire for cows." They have learned to build "ships," perhaps large river-boats, and seem to have heard something of the sea. Unlike the modern Hindus, the Aryans of the *Veda* ate beef, used a fermented liquor or beer made from the *soma* plant, and offered the same strong meat and drink to their gods. Thus the stout Aryans spread eastwards through northern India, pushed on from behind by later arrivals of their own stock, and driving before them, or reducing to bondage, the earlier "black-skinned" races. They marched in whole communities from one river-valley to another, each house-father a warrior, husbandman, and priest, with his wife, and his little ones, and cattle. Ear Ary life.

These free-hearted tribes had a great trust in themselves and their gods. Like other conquering races, they believed that both themselves and their deities were altogether superior to the people of the land and their poor rude objects of worship. Indeed, this noble self-confidence is a great aid to the success of a nation. Their divinities—in Sanskrit, *Devata*, literally "the Shining Ones"—were the great powers of nature. They adored the Father-heaven, (*Dyaush-pitar*, the *Dies-piter* or *Jupiter* of Rome, the *Zeus* of Greece, the Low German *Duus*, and, through the old French god-demon *Dus-ius*, the *Deuce* of English slang), together with Mother-earth, and the Encompassing Sky (*Varuna* in Sanskrit, *Uranus* in Latin, *Ouranos* in Greek). Indra, or the aqueous vapour that brings each autumn the precious rain on which plenty or famine still depends, received the largest number of hymns. By degrees, as the settlers realized more and more keenly the importance of the periodical rains in their new life as husbandmen, he became the chief of the Vedic gods. "The gods do not reach unto thee, O Indra, nor men; thou overcomest all creatures in strength." Agni, the God of fire (Latin *igni-s*), ranks perhaps next to Indra in the number of hymns addressed to him as "the youngest of the gods," "the lord and giver of wealth." The Maruts are the Storm Gods, "who make the rocks to tremble, who tear in pieces the forest." Ushas, "the High-born Dawn" (Greek, *Eos*), "shines upon us like a young wife, rousing every living being to go forth to his work." The Asvins, or "Fleet Outriders" of the Dawn, are the first rays of sunrise, "Lords of Lustre." The Sun himself (Súrjya), the Wind (Váyu), the Friendly Day (Mitra), the animating fermented juice of the Sacrificial Plant (Soma) and many others, are invoked in the *Veda*,—in all about thirty-three gods, "who are eleven in heaven, eleven on earth, and eleven dwelling in glory in mid-air." Earl ligio

The terrible blood-drinking deities of modern Hinduism are scarcely known in the *Veda*. Buffaloes are indeed offered; and one hymn points to a symbolism based on human sacrifices, an early practice apparently extinct before the time of the Vedic singers. The great horse sacrifice was substituted for the flesh and blood of a man. But, as a whole, the hymns are addressed to bright, friendly gods. Rudra, who was destined to become the Siva of the Hindus, and the third person, or Destroyer, in their Triad, is only the god of Roaring Tempests in the *Veda*; Vishnu, the second person, or Preserver, in the Hindu Triad, is but slightly known as the deity of the Shining Firmament; while Brahma, the first person, or Creator, has no separate existence in these simple hymns. The names of the dreadful Mahádeva, Dúrga, Kálí, and of the gentler Krishna and Ráma, are equally unknown in the *Rig-Veda*.

While the aboriginal races buried their dead under rude stone monuments, the Aryan—alike in India, in Greece, and in Italy—made use of the funeral-pile as the most solemn method of severing the mortal from the immortal part of man. As he derived his natural birth from his parents, and a partial regeneration, or second birth, from the performance of his religious duties, so the fire, by setting free the soul from the body, completed the third or heavenly birth. His friends stood round the pyre as round a natal bed, and commanded his eye to go to the sun, his breath to the wind, his limbs to the earth,—the water and plants whence they had been derived. But "as for his unborn part, do thou, Lord (Agni), quicken it with thy heat; let thy flame and thy brightness quicken it; convey it to the world of the righteous." The doctrine of transmigration was unknown. The circle round the funeral-pile sang with an assurance that their friend went direct to a state of blessedness and reunion with the loved ones who had gone before.

The hymns of the *Rig-Veda* were composed, as we have seen, by the Aryans in their colonies along the Indus, and on their march eastwards towards the Jumna and upper Ganges. The growing numbers of the settlers, and the arrival of fresh Aryan tribes from behind, still compelled them to advance. From the Land of the Sacred Singers Manu describes them as spreading through "The Middle Land" (*Madhyadesha*), comprising the whole river systems of Upper India as far east as Oudh and Allahábád, with the Himálayas as its northern and the Vindhyá ranges as its southern boundary. The conquest of the vast new tracts thus included seems not to have commenced till the close of the Rig-Vedic era, and it must have been the work of many generations. During this advance the simple faith of the Rig-Vedic singers was first adorned with stately rites, and then extinguished beneath them. The race progressed from a loose confederacy of tribes into several well-knit nations, each bound together by the strong central force of kingly power, directed by a powerful priesthood and organized on a firm basis of caste.

te. Whence arose this new constitution of the Aryan tribes into nations, with castes, priests, and kings? We have seen that, although in their earlier colonies on the Indus each father was priest in his family, yet the chieftain, or lord of the settlers, called in some man specially learned in holy offerings to conduct the great tribal sacrifices. Such men were highly honoured, and the famous quarrel which runs throughout the whole *Veda* sprang from the claims of two rival sages, Vashishtha and Visvámitra, to perform one of these ceremonies. The art of writing was unknown, and the hymns and sacrificial words had to be handed down by word of mouth from father to son. It thus happened that the families who learned them by heart became, as it were, the hereditary owners of the liturgies required at the most solemn offerings to the gods. Members of these households were chosen again and again to conduct the tribal sacrifices, to chant the battle-hymn, to implore the divine aid, or to pray away the divine wrath. Even the *Rig-Veda* recognizes the importance of these sacrifices. "That king," says a verse, "before whom marches the priest, he alone dwells well-established in his own house, to him the people bow down. The king who gives wealth to the priest, he will conquer, him the gods will protect." The tribesmen first hoped, then believed, that a hymn or prayer which had once acted successfully, and been followed by victory, would again produce the same results. The hymns became a valuable family property for those who had composed or learned them. The *Rig-Veda* tells how the prayer of Vashishtha prevailed "in the battle of the ten kings," and how that of Visvámitra "preserves the tribe of the Bhárats." The potent prayer was termed *bráhma*, and he who offered it *bráhman*. Woe to all who despised either! "Whosoever," says the *Rig-Veda*, "scoffs at the prayer (*bráhma*) which we have made, may hot plagues come upon him, may the sky burn up that hater of Bráhmans" (*bráhma-dvísh*). Certain families thus came to have, not only an hereditary claim to conduct the great sacrifices, but also the exclusive knowledge of the ancient hymns, or at any rate of the traditions which explained their symbolical meaning. They naturally tried to render the ceremonies solemn and imposing. By degrees a vast array of ministrants grew up around each of the greater sacrifices. There were first the officiating priests and their assistants, who prepared the sacrificial ground, dressed the altar, slew the victims, and poured out the libations; second, the chanters of the Vedic hymns; third, the reciters of other parts of the service; fourth, the superior priests, who watched over the whole, and corrected any mistakes.

Meanwhile other castes had been gradually formed. As the Aryans moved eastwards from the Indus, some of the warriors were more fortunate than others, or received larger shares of the conquered lands. Such families had not to till their fields with their own hands, but could leave that work to be done by the aboriginal races whom they subdued. In this way there grew up a class of warriors, freed from the labour of husbandry, who surrounded the chief or king, and were always ready for battle. It seems likely that these kinsmen and "companions of the king" formed an important class among the early Aryan tribes in India, as they certainly did among the ancient branches of the race in Europe, and still do at the petty courts of India. Their old Sanskrit names, *Kshattriya*, *Rájanya*, and *Rájbansi*, mean "connected with the royal power," or "of the royal line"; their usual modern name *Rájput* means "of royal descent." In process of time, when the Aryans settled down, not as mere fighting clans, but as powerful nations, in the middle land along the Jumna and Ganges, this warrior class grew in numbers and in power. The black races had been reduced to serfdom, or driven back into the Himálayas and the Vindhyás, on the north and the south of that fertile tract. The incessant fighting, which had formed the common lot of the tribes on their actual migration eastwards from the Indus, ceased. A section of the people laid aside their arms, and devoted themselves to agriculture or other peaceful pursuits. The sultry heats of the Middle Land must also have abated their old northern energy, and led them to love repose. Those who, from family ties or from personal inclination, preferred a soldier's life had to go beyond the frontier to find an enemy. Distant expeditions of this sort could be undertaken much less conveniently by the husbandman than in the ancient time, when his fields lay on the very border of the enemy's country, and had just been wrested from it. Such expeditions required and developed a class of regular soldiers whose presence was not constantly needed at home for tilling the land. The old warrior companions and kinsmen of the king formed a nucleus round which gathered all the more daring spirits, and laid the foundation of a military caste. The Aryans on the Ganges, in the "Middle Land," thus found themselves divided into three classes—first, the priests, or Bráhmans; second, the warriors and king's companions, called in ancient times Kshattriyas, at the present day Rájputs; third, the husbandmen, or agricultural settlers, who retained the old name of Vaisyas, from the root *vis*, which in the Vedic period had included the whole "people." These three classes gradually became distinct castes; intermarriage between them ceased, and each kept more and more strictly to its hereditary employment. But they were all recognized as belonging to the "twice-born" or Aryan race, were all present at the great national sacrifices, and all worshipped the same bright gods. Beneath them was a fourth or servile class, called Súdras, the remnants of the vanquished aboriginal tribes whose lives had been spared. These were "the slave-bands of black descent," the Dásas of the *Veda*. They were distinguished from their "twice-born" Aryan conquerors as being only "once-born," and by many contemptuous epithets. They were not allowed to be present at the great national sacrifices, nor at the feasts which followed them. They could never rise from their servile condition, and to them was assigned the severest toil in the fields, and all the hard and dirty work of the village community. Of the four Indian castes, three had a tendency to increase. As the Aryan conquests spread, more aboriginal tribes were reduced to serfdom as Súdras. The warriors, or Kshattriyas, would constantly receive additions from the more wealthy or enterprising members of the cultivating class. When an expedition or migration went forth to subdue new territory, all the colonists would for a time lead a military life, and their sons would probably all regard themselves as Kshattriyas. In ancient times entire tribes, and at the present day the mass of the population throughout large tracts, thus claim to be of the warrior or Rájput caste. Moreover, the kings and chief fighting-men of aboriginal races who, without being conquered by the Aryans, entered into alliance with them, would likely assume names of the warrior or Kshattriya rank. We see this process going on before our eyes among many of the aboriginal peoples. The Bráhmans, in their turn, seem at first to have received into their body distinguished families of Kshattriyan descent. In later times, too, we find that sections of aboriginal races were "manufactured" into Bráhmans. The Vaisya or cultivating caste did not tend in this manner to increase. No one felt ambitious to win his way into it, except perhaps the poor Súdras, to whom any change of condition was forbidden. The Vaisyas themselves tended in early times to rise into the more honourable warrior class, and at a later period to be mingled with the labouring multitude of Súdras and mixed descent. In many provinces they have almost disappeared as a distinct caste from the modern population. In ancient India, as at the present day, the three conspicuous castes were (1) the priests and (2) warriors, of Aryan birth, and (3) the serfs or Súdras, the remnants of earlier races. The Kshattriyas or Rájputs, at any rate in some parts of India, seem to represent a quite separate ethnical movement from that of the Bráhmans—that is to say, either a different Aryan migration into India, or an altogether distinct race of perhaps Scythic origin. The Súdras had no rights, and, once conquered, ceased to struggle against their fate. But a long contest raged between the priests and warriors for the chief place in the Aryan commonwealth.

Bráhmans.

In order to understand that contest, we must go back to the time when the priests and warriors were simply fellow-tribesmen. The priestly or Bráhman caste grew slowly out of the families of Rishis who composed the Vedic hymns, or were chosen to conduct the great tribal sacrifices. In after times the whole Bráhman population of India pretended to trace their descent from seven Rishis. But the composers of the Vedic hymns were sometimes kings or distinguished warriors rather than priests; the *Veda* itself speaks of these royal Rishis (*Rájarshis*). When the Bráhmans put forward their claim to the highest rank, the warriors or Kshattriyas were slow to admit it; and, when the Bráhmans went a step farther, and declared that only members of their families could be priests, or gain admission into the priestly caste, the warriors disputed their pretensions. In later ages the Bráhmans, having the exclusive keeping of the sacred writings, effaced from them, as far as possible, all traces of the struggle. They taught that their caste had come forth from the mouth of God, divinely appointed to the priesthood from the beginning of time. Nevertheless, a large body of Vedic verses and Sanskrit texts has now been brought to bear upon the struggle between the Bráhmans and Kshattriyas for the highest rank.[1]

In many of the Aryan tribes, however, the priests failed to establish themselves as an exclusive order. Indeed, the four castes, and especially the Bráhman caste, seem only to have obtained their full development amid the plenty of the Middle Land (*Madhyadesha*), watered by the Jumna and the Ganges. The earlier Aryan settlements to the west of the Indus remained outside the caste system; the later Aryan offshoots to the south and east of the middle land only partially carried that system with them. But in the Middle Land itself, with Delhi as its western capital and the great cities of Ajodhya and Benares on its eastern frontier, the Bráhmans grew by degrees into a compact, learned, and supremely influential body, the makers of Sanskrit literature. Their language, their religion, and their laws became in after times the standards aimed at throughout all India. They naturally denounced all who did not submit to their pretensions, and stigmatized the other Aryan settlements who had not accepted their caste system as lapsed tribes or outcastes (*Vrishalas*). Among the lists of such fallen races we read the name afterwards applied to the Ionians or Greeks (*Yavanas*). The Bráhmans of the middle land had not only to enforce their supremacy over the powerful warriors of their own kingdoms, but to extend it among the Aryan tribes who had never fully accepted the caste system. That must have been the slow work of ages, and it seems to have led to bitter feuds. See BRAHMANISM, vol. iv. p. 201.

Br... m... al la... co...

While the Bráhmans claimed religion, theology, and philosophy as their special domain, and the chief sciences and arts as supplementary sections of their divinely-inspired knowledge, they secured their social supremacy by codes of law. Their earliest *Dharma-sástras*, or legal writings, belong to the Sútra period, or scholastic development, of the *Veda*. But their two great digests, upon which the fabric of Hindu jurisprudence has been built up, are of later date. The first of these, the code of Manu, is separated from the Vedic era by a series of Bráhmanical developments, of which we possess only a few of the intermediate links. It is a compilation of the customary law current probably about the 5th century B.C., and exhibits the social organization which the Bráhmans, after their

[1] The quarrel between the two sages Visvámitra and Vashishtha, which runs through the whole *Veda*, is typical of this struggle. Visvámitra stands as a representative of the royal-warrior rank, who claims to perform a great public sacrifice. The white-robed Vashishtha represents the Bráhmans or hereditary priesthood, and opposes the warrior's claim. In the end Visvámitra established his title to conduct the sacrifice; but the Bráhmans explain this by saying that his virtues and austerities won admission for him into the priestly family of Bhrigus. He thus became a Bráhman, and could lawfully fill the priestly office. Visvámitra serves as a typical link, not only between the priestly and the worldly castes, but also between the sacred and the profane sciences. He was the legendary founder of the art of war, and his son Susru-fa is quoted as the earliest authority on Indian medicine. These two sciences of war and medicine form *upa-Vedas*, or supplementary sections of the divinely inspired knowledge of the Bráhmans. Another royal Rishi, Vítahavya, "attained the condition of Bráhmanhood, venerated by mankind," by a word of the saintly Bhrigu. Parasu-Ráma, the divine champion of the Bráhmans, was of warrior descent by his mother's side. Manu, their legislator, sprang from the warrior caste; and his father is expressly called "the seed of all the Kshattriyas." But when the Bráhmans had firmly established their supremacy they became reluctant to allow the possibility of even princes finding an entrance into their sacred order. King Ganaka was more learned than all the Bráhmans at his court, and performed terrible penances to attain to Bráhmanhood. Yet the legends leave it doubtful whether he gained his desire. The still more holy but probably later Matanga wore his body to skin and bone by a thousand years of austerities, and was held from falling by the hand of Indra himself. Nevertheless, he could not attain to Bráhmanhood. The reformer, Gautama Buddha, who in the 6th century before Christ overthrew the Bráhman supremacy, and founded a new religion, was a prince of warrior descent, perhaps born in too late an age to be adopted into and utilized by the Bráhman caste.

successful struggle for the supremacy, had established in the Middle Land of Bengal. The Bráhmans, indeed, claimed for their laws a divine origin, and ascribed them to the first Manu, or Aryan man, 30 millions of years ago. But, as a matter of fact, the laws of Manu are the result of a series of attempts to codify the usages of some not very extensive centre of Bráhmanism in northern India,—a metrical digest of local customs condensed by degrees from a legendary mass of 100,000 couplets (*slokas*) into 2684. They may possibly have been reduced to their final form of a written code with a view to securing the system of caste against the popular movement of Buddhism, and thus giving a rigid fixity to the privileges of the Bráhmans.

The second great code of the Hindus, that of Yájnavalkya, belongs to a period when Buddhism had established itself, and probably to a territory where it was beginning to succumb to the Bráhmanical reaction. It represents the Bráhmanical side of the great controversy (although a section of it deals with the organization of monasteries), refers to the execution of deeds on metal plates, and altogether marks an advance in legal precision. Its compilation belongs to a period apparently not earlier than the 2d century A.D., and certainly not later than the 6th or 7th.

These codes deal with Hindu law in three branches, namely—(1) domestic and civil rights and duties, (2) the administration of justice, (3) purification and penance. They stereotyped the unwritten usages which regulated the family life and social organization of the old Aryan communities in the middle land. They did not pretend to supply a body of law for all the numerous races of India, but only for Hindu communities of the Bráhmanical type. It is doubtful whether they quite accurately represent the actual customary law even in such communities, for they were apparently drawn up with a view to asserting and maintaining the special privileges of the Bráhmans. This they effect by a rigid demarcation of the employments of the people, each caste or division of a caste having its own hereditary occupation assigned to it; by stringent rules against intermingling the castes by marriage; by forbidding the higher castes, under severe penalties, to eat or drink or hold social intercourse with the lower; and by punishing the lower castes with still more cruel penances for defiling by their touch the higher castes, or in any way infringing on their privileges. They exhibit the Hindu community in the four ancient divisions of priests, warriors, cultivators, and serfs (*súdras*). But they disclose that this old Aryan classification failed to represent the actual facts even of the Aryan communities in northern India. They admit that the mass of the people did not belong to any one of the four castes, and ascribe its origin to mixed concubinage or illicit connexions. The ancient Bráhmanical communities in northern India, as revealed by the codes themselves, consisted—first, of an Aryan element divided into priests, warriors, and cultivators, all of whom bore the proud title of the twice-born, and wore the sacred thread; second, of the subjugated races, "the once-born" Súdras; and third, of the vast residue of the Varna-sankara, literally the "mingled colours," a great but uncertain number of castes to whom was assigned a mixed descent from the four recognized classes. The same division exists to this day. According to the census of 1871, the separate tribes and castes in Lower Bengal do not fall short of a thousand; in the North-Western Provinces the Hindu population was arranged under two hundred and ninety-one specified castes besides numerous subdivisions. The distinctly recognized "mixed castes" throughout British India cannot be estimated at less than three hundred, and probably amount to many more.

As the Bráhmans spread their influence eastwards and southwards from the Middle Land, they carried their codes with them. The number of their sacred law books (*Dharma-sástras*) amounted to at least fifty-six, and separate schools of Hindu law sprang up. Thus the Dáyabhága version of the law of inheritance prevails in Bengal while the Mitákshará commentary on Yájnavalkya is current in Madras and throughout southern and western India. But all modern recensions of Hindu law rest upon the ancient codes; and these codes, as we have seen, only recorded the usages of certain Bráhmanical centres in the north, and perhaps did not fairly record even them. As the Bráhmans gradually moulded the population of India into Hinduism, such codes proved too narrow a basis for dealing with the rights, duties, and social organization of the people. The later Hindu legislators, accordingly, inculcated the recognition of the local usages or land-law of each part of the country, and of each class or tribe. While binding together and preserving the historical unity of the Aryan twice-born castes by systems of law founded on their ancient codes, they made provision for the customs and diverse stages of civilization of the ruder peoples of India, over whom they established their ascendency. By such provisions, alike in religion and law, the Bráhmans incorporated the Indian races into that loosely coherent mass known as the Hindu population.

It is to this plastic element that Hinduism owes its success; and it is an element which English administrators have sometimes overlooked. The races of British India exhibit many stages of domestic institutions from the polyandry of the Nairs to the polygamy of the Kulin Bráhmans. The structure of their industrial organization varies, from the nomadic husbandry of the Burmese to the long chain of tenures which in Bengal stretches from the proprietor through a series of middle-men to the actual tiller of the soil. Every stage in human progress is represented, from the hunting tribes of the central plateau to the rigid trade-guilds of Guzerat. The Hindu legislators recognized that each of these diverse stages of social development had its own usages and common law. Vrihaspati says: "The laws (*dharma*) practised by the various countries, castes, and tribes, they are to be preserved; otherwise the people are agitated." Devala says: "What gods there are in any country, . . . and whatsoever be the custom and law anywhere, they are not to be despised there; the law there is such." Varáhamihira says: "The custom of the country is first to be considered; what is the rule in each country, that is to be done." The most learned English scholar in southern India has thus summed up the matter: "By custom only can the Dharma-sástra [Hindu law] be the rule of others than Bráhmans [only one-thirtieth of the population of Madras], and even in the case of Bráhmans it is very often superseded by custom."[1]

The English, on assuming the government of India, wisely declared that they would administer justice according to the customs of the people. But the high courts enforce the Bráhmanical codes with a comprehensiveness and precision unknown in ancient India. Thus in Bengal the custom of *sagai*, by which deserted or divorced wives among the lower castes marry again, was lately tried according to "the spirit of Hindu law"; while in Madras learned judges have pointed out a divergence between the Hindu law as now administered and the actual usages of the people. Those usages are unwritten and uncertain. The Hindu law is printed in many accessible forms, and Hindu barristers are ever pressing its principles upon the courts. Efforts at comprehensive codification in British India are thus surrounded by special difficulties, for it would be improper to give the fixity of a code to all the unwritten half-fluid usages current among the three-hundred unhomogeneous castes of Hindus, while it might be fraught with future injustice to exclude any of them. Each age has the gift of adjusting its institutions to its actual wants, especially among tribes whose customs have not been reduced to written law. Many of those customs will, if left to themselves, die out; others of them, that prove suited to the new social developments under British rule, will live. But the process of natural selection must be, to some extent, the work of time, and not a single act of conscious legislation. This has been recognized by the ablest of Anglo-Indian codifiers. They apply the word code to the systematic arrangement of the rules relating to some well-marked section of juristic rights, or to some executive department of the administration of justice. "In its larger sense," write the Indian Law Commissioners, 1879, "of a general assemblage of all the laws of a community, no attempt has yet been made in this country to satisfy the conception of a code. The time for its realization has manifestly not arrived."

The Bráhmans were not merely the depositaries of the sacred books, the philosophy, the science, and the laws of the ancient Hindu commonwealth; they were also the creators and custodians of its secular literature. They had a practical monopoly of Vedic learning, and their policy was to trace back every branch of knowledge and intellectual effort to the *Veda*.

Bráhman civilization.

In order to understand the long domination of the Bráhmans and the influence which they still wield, it is necessary to keep in mind their position as the great literary caste. Their priestly supremacy has been repeatedly assailed, and was during a space of several hundred years overthrown. But throughout twenty-two centuries they have been the counsellors of Hindu princes and the teachers of the Hindu people. They represent the early Aryan civilization of India; and the essential history of the Hindus is a narrative of the attacks upon the continuity of that civilization,—that is to say, of attacks upon the Bráhmanical system of the Middle Land, and of the modifications and compromises to which that system has had to submit. Those attacks range themselves under six epochs:—first, the religious uprising of the half-Bráhmanized Aryan tribes on the east of the Middle Land, initiated by the preaching of Buddha in the 6th century B.C., culminating in the Buddhist kingdoms

[1] Dr Burnell's *Dáya-Vibhága*, Introd. p. xv.; see also *The Hindu Law as administered by the High Court of Judicature at Madras*, by J. Nelson, M.A., District Judge of Cuddapah, chaps. iii. and iv. (Madras, 1877).

about the commencement of our era, and melting into modern Hinduism about the 8th century A.D.; second, warlike inroads of non-Bráhmanical Aryans or other races from the west, commencing with the Greek invasions in the 4th century B.C., and continuing under the Græco-Bactrian empire and its successors to probably the 3d or 5th century A.D.; third, the influence of the non-Aryan tribes of India and of the non-Aryan low-castes incorporated from them, —an influence ever at work, indeed by far the most powerful agent in dissolving Bráhmanism into Hinduism, but represented in a special manner by the non-Aryan kingdoms about the 7th and 8th centuries A.D.; fourth, the reaction against the low beliefs, priestly oppression, and bloody rites which resulted from this compromise between Bráhmanism and aboriginal worship, a reaction which received an impetus from the preaching of Sankar-Achárjya, who founded a philosophical Sivaite sect in the 8th or 9th century, and received its full development under a line of great Vishnuvite reformers from the 12th to the 16th centuries A.D.; fifth, Mahometan invasions and the rule of Islám, 1000 to 1765 A.D.; sixth, the English supremacy, and the great popular upheaval which it has produced in the 18th and 19th centuries.

Buddhist Period.

(6th century B.C. to 8th century A.D.)

Buddhism. The first great solvent of Bráhmanism was the teaching of Buddha. The life of this celebrated man has three sides,—its personal aspects, its legendary developments, and its religious consequences upon mankind. In his own person Buddha appears as a prince and preacher of ancient India. In the legendary developments of history Buddha ranks as a divine teacher among his followers, as an incarnation of Vishnu among the Hindus, and apparently as a saint of the Christian church, with a day assigned to him in both the Greek and Roman calendars. As a religious founder he left behind him a system of beliefs which has gained more disciples than any other creed in the world, and which, after a lapse of twenty-four centuries, is now professed by 500 millions of people, or more than one-third of the human race.

The life of Buddha is related at length under BUDDHISM, vol. iv. p. 424. In this place it is unnecessary to give more than a brief sketch of the history of Buddhism in India.

On the death of Buddha, five hundred of his disciples met in a cave near Rájágriha, to gather together his sayings. This was the first council. They chanted the lessons of their master in three great divisions—the words of Buddha to his disciples, his code of discipline, and his system of doctrine. These became the three collections of Buddha's teaching, and the word for a Buddhist council means literally "a singing together." A century afterwards, a second council of seven hundred was held at Vaisali, to settle disputes between the more and the less strict followers of Buddhism. It condemned a system of ten "indulgences" which had grown up, but it led to the separation of the Buddhists into two hostile parties, who afterwards split into eighteen or more sects.

Spread of Buddhism. During the next two hundred years Buddhism spread over northern India, perhaps receiving a new impulse from the Greek kingdoms in the Punjab. About 244 B.C. Asoka, the king of Magadha or Behar, became a zealous convert to Buddhism. He is said to have supported 64,000 Buddhist priests; he founded many religious houses, and his kingdom is called the Land of the Monasteries (Vihára or Behar) to this day. He did for Buddhism what Constantine afterwards effected for Christianity; he organized it on the basis of a state religion. This he accomplished by five means—by a council to settle the faith, by edicts promulgating its principles, by a state department to watch over its purity, by missionaries to spread its doctrines, and by an authoritative collection of its sacred books. In 244 B.C. Asoka convened at Patná the third Buddhist council of one thousand elders. Evil men, taking on them the yellow robe of the order, had given forth their own opinions as the teaching of Buddha. Such heresies were now corrected; and the Buddhism of southern Asia practically dates from Asoka's council. In a number of edicts, both before and after the synod, he published throughout India the grand principles of the faith. Such edicts are still found graven deep upon pillars, in caves, and on rocks, from the Yusafzai valley beyond Pesháwar on the north-western frontier, through the heart of Hindustán, to Káthiáwár and the Central Provinces on the south and Orissa in the east. Tradition states that Asoka set up 64,000 memorial columns or topes; and the thirty inscriptions extant in our own day show how widely these royal sermons were spread over India. In the year of the council, the king also founded a state department to watch over the purity and to direct the spread of the faith. A minister of justice and religion (Dharma Mahámátra) directed its operations; and, one of its first duties being to proselytize, he was specially charged with the welfare of the aborigines among whom its missionaries were sent. Asoka did not think it enough to convert the inferior races without looking after their material interests. Wells were to be dug and trees planted along the roads; a system of medical aid was established throughout his kingdom and the conquered provinces, as far as Ceylon, for both man and beast. Officers were appointed to watch over domestic life and public morality, and to promote instruction among the women as well as the youth.

Asoka's edicts.

Asoka recognized proselytism by peaceful means as a state duty. The rock inscriptions record how he sent forth missionaries "to the utmost limits of the barbarian countries," to "intermingle among all unbelievers" for the spread of religion. They shall mix equally with Bráhmans and beggars, with the dreaded and the despised, both within the kingdom "and in foreign countries, teaching better things." Conversion is to be effected by persuasion, not by the sword. Buddhism was at once the most intensely missionary religion in the world and the most tolerant. This character of a proselytizing faith which wins its victories by peaceful means, so strongly impressed upon it by Asoka, has remained a prominent feature of Buddhism to the present day. Asoka, however, not only took measures to spread the religion; he also endeavoured to secure its orthodoxy. He collected the body of doctrine into an authoritative version, in the Magadhi language or dialect of his central kingdom in Behar,—a version which for two thousand years has formed the canon (*pitakas*) of the southern Buddhists.

The fourth and last of the great councils was held under King Kanishka, according to one tradition, four hundred years after Buddha's death. The date of Kanishka is still uncertain; but, from the evidence of coins and inscriptions, his reign has been fixed in the 1st century after Christ, or, say, 40 A.D. Kanishka, the most famous of the Saka conquerors, ruled over north-western India and the adjoining countries. His authority had its nucleus in Kashmír, but it extended to both sides of the Himálayas, from Yarkand and Khokan to Agra and Sind. His council of five hundred compiled three commentaries on the Buddhist faith. These commentaries supplied in part materials for the Tibetan or northern canon, drawn up at a subsequent period. The northern canon, or, as the Chinese proudly call it, the "greater vehicle of the law," includes many later corruptions or developments of the Indian faith as originally embodied by Asoka (244 B.C.) in the "lesser vehicle," or canon of the southern Buddhists.

The Kanishka commentaries were written in the Sanskrit language, perhaps because the Kashmír and northern priests who formed his council belonged to isolated Aryan colonies, which had been little influenced by the growth of the Indian vernacular dialects. In this way Kanishka and his Kashmír council (? 40 A.D.) became in some degree to the northern or Tibetan Buddhists what Asoka and his Patná council (244 B.C.) had been to the Buddhists of Ceylon and the south.

The missionary impulse given by Asoka quickly bore fruit. In the year after his great council at Patná his son Mahindo carried Asoka's version of the Buddhist scriptures in the Magadhi language to Ceylon. He took with him a band of fellow missionaries; and soon afterwards his sister, the princess Sanghamitta, who had entered the order, followed with a company of nuns. It was not, however, till six hundred years later (410–432 A.D.) that the holy books were rendered into Páli, the sacred language of the southern Buddhists. About the same time missionaries from Ceylon finally established the faith in Burmah (450 A.D.). The Burmese themselves assert that two Buddhist preachers landed in Pegu as early as 207 B.C. Some indeed place their arrival just after the Patná council (244 B.C.), and point out the ruined city of Tha-ton, between the Tsi-tang and Salwín estuaries, as the scene of their pious labours. Siam was converted to Buddhism in 638 A.D.; Java received its missionaries direct from India between the 5th and the 7th centuries, and spread the faith to Bali and Sumatra. While southern Buddhism was thus wafted across the ocean, another stream of missionaries had found its way by Central Asia into China. Their first arrival in that empire is said to date from the 2d century B.C., although it was not till 65 A.D. that Buddhism there became an established religion. The Græco-Bactrian kingdoms in the Punjab and beyond it afforded a favourable soil for the faith. The Scythian dynasties that succeeded them accepted it, and the earliest remains which recent discovery has unearthed in Afghánistán are Buddhist. Kanishka's council, soon after the commencement of the Christian era, gave a fresh impetus to the faith. Tibet, south Central Asia, and China lay along the great missionary routes of northern Buddhism; the Kirghis are said to have carried Buddhist settlements as far west as the Caspian; on the east, the religion was introduced into the Korea in 372 A.D., and thence into Japan in 552.

Buddhism never ousted Bráhmanism from any large part of India. The two systems co-existed as popular religions during more than a thousand years (244 B.C. to about 800 A.D.), and modern Hinduism is the joint product of both. Certain kings and certain eras were intensely Buddhistic; but the continuous existence of Bráhmanism is abundantly proved from the time of Alexander (327 B.C.) downwards. The historians who chronicled his march, and the Greek ambassador Megasthenes, who succeeded them (300 B.C.) in their literary labours, bear witness to the predominance of the old faith in the period immediately preceding Asoka. Inscriptions, local legends, Sanskrit literature, and the drama disclose the survival of Bráhman influence during the next six centuries (244 B.C. to 400 A.D.). From 400 A.D. we have the evidence of the Chinese pilgrims, who toiled through Central Asia into India as the birthplace of their faith. Fa-Hian entered India from Afghánistán, and journeyed down the whole Gangetic valley to the Bay of Bengal in 399–413 A.D. He found Bráhman priests equally honoured with Buddhist monks, and temples to the Indian gods side by side with the religious houses of his own faith. Hwen Tsang also travelled to India from China by the Central Asia route, and has left a fuller record of the state of the two religions in the 7th century. His journey extended from 629 to 645 A.D., and everywhere throughout India he found the two faiths eagerly competing for the suffrages of the people. By that time, indeed, Bráhmanism was beginning to assert itself at the expense of the other religion. The monuments of the great Buddhist monarchs, Asoka and Kanishka, confronted him from the time he neared the Punjab frontier; but so also did the temples of Siva and his "dread" queen Bhímá. Throughout north-western India he found Buddhist convents and monks surrounded by "swarms of heretics." The political power was also divided, although the Buddhist sovereigns predominated. A Buddhist monarch ruled over ten kingdoms in Afghánistán. At Peshávar the great monastery built by Kanishka was deserted, but the populace remained faithful. In Kashmír king and people were devout Buddhists, under the teaching of five hundred monasteries and five thousand monks. In the country identified with Jáipur, on the other hand, the inhabitants were devoted to heresy and war.

Buddhist influence in northern India seems, during the 7th century A.D., to have centred in the fertile doáb or plain between the Jumna and the Ganges. At Kanauj (Kanyákubja), on the latter river, Hwen Tsang found a powerful Buddhist monarch, Síláditya, whose influence reached from the Punjab to north-eastern Bengal, and from the Himálayas to the Narbadá river. There flourished one hundred Buddhist convents and ten thousand monks. But the king's eldest brother had been lately slain by a sovereign of eastern India, a hater of Buddhism; and two hundred temples to the Bráhman gods reared their heads under the protection of the devout Síláditya himself. This monarch seems to have been an Asoka of the 7th century A.D., and he practised with primitive vigour the two great Buddhist virtues of spreading of the faith and charity. The former he attempted by means of a general council in 634 A.D. Twenty-one tributary sovereigns attended, together with the most learned Bráhman and Buddhist monks of their kingdoms. But the sole object of the convocation was no longer the undisputed assertion of the Buddhist religion. It dealt with the two distinct phases of the religious life of India. First there was a discussion between the Buddhists and Bráhmans, especially of the Sánkhya and Vaiseshika schools, and then followed a dispute between the two Buddhist sects who followed respectively the northern and the southern canons, known as "the greater and the lesser vehicle of the law." The rites of the populace were of as composite a character as the doctrines of their teachers. On the first day of the council a statue of Buddha was installed with great pomp; on the second, an image of the sun-god; on the third, a figure of Siva.

Síláditya held a solemn distribution of his royal treasures every five years. Hwen Tsang describes how on the plain near Allahábád, where the Ganges and the Jumna unite their waters, all the kings of the empire, and a vast multitude of people, were feasted for seventy-five days. Síláditya brought forth the stores of his palace, and gave them away to Bráhmans and Buddhists, monks and heretics, without distinction. At the end of the festival he stripped off his jewels and royal raiment, gave them to the bystanders, and, like Buddha of old, put on the rags of a beggar. By this ceremony the monarch commemorated the Great Renunciation of the founder of the Buddhist faith, and at the same time practised the highest duty inculcated alike by the Buddhist and Bráhmanical religions, namely, almsgiving. Hwen Tsang describes a distribution on a smaller scale in the western kingdom of Valabhí (*circa* 636 A.D.). "For seven days every year the king holds a great assembly at which he distributes to the multitude of recluses choice dishes, the three garments, medicine, the seven precious things, and rare objects of great value. After giving all these in alms he buys them back at double price." The intellect of this king, we are told, was weak and narrow.[1] Similar "fields of charity" seem to have been held by many Buddhist princes in memory of the Great Renunciation. The vast monastery of Nalanda in Behar formed a seat of learning which recalls the universities of mediæval Europe. Ten thousand monks and novices of the eighteen schools there studied theology, philosophy, law, science, especially medicine, and practised their devotions. They were supported from the royal funds.

Hwen Tsang travelled from the Punjab to the mouth of the Ganges, and made journeys into southern India. But everywhere he found the two religions mingled. Gayá, which holds so high a sanctity in the legends of Buddha, had already become a great Bráhman centre. On the east of Bengal, Assam had never been converted to Buddhism. In the south-west, Orissa was a stronghold of the faith; at the seaport of Tamluk at the mouth of the Húglí (Hooghly), the temples to the Bráhman gods were five times more numerous than the convents of the faithful. On the Madras coast Buddhism flourished; and indeed throughout southern India the faith seems still to have been in the ascendant, although struggling against Bráhman heretics and their gods.

Decline of Buddhism.

During the next two centuries Bráhmanism gradually became the ruling religion. There are legends of persecutions instigated by Bráhman reformers, such as Kumarila Bhatta and Sankar-Achárjya. But the downfall of Buddhism seems to have resulted from natural decay, and from new movements of religious thought, rather than from any general suppression by the sword. Its extinction is contemporaneous with the rise of Hinduism, and belongs to a subsequent part of this sketch. In the 11th century, only outlying states, such as Kashmír and Orissa, remained faithful; and before the Mahometans fairly came upon the scene Buddhism as a popular faith had disappeared from India. During the last ten centuries Buddhism has been a banished religion from its native home. But it has won greater triumphs in its exile than it could ever have achieved in the land of its birth. It has created a literature and a religion for more than a third of the human race, and has profoundly affected the beliefs of the rest. Five hundred millions of men, or 35 per cent. of the inhabitants of the world, still follow the teaching of Buddha. Afghánistán, Nepál, Eastern Turkistán, Tibet, Mongolia, Manchuria, China, Japan, the Eastern Archipelago, Siam, Burmah, Ceylon, and India at one time marked the magnificent circumference of its conquests. Its shrines and monasteries stretched in a continuous line from the Caspian to the Pacific, and still extend from the confines of the Russian empire to the equatorial archipelago. During twenty-four centuries Buddhism has encountered and outlived a series of powerful rivals. At this day it forms one of the three great religions of the world, and is more numerously followed than either Christianity or Islám. In India its influence has survived its separate existence. It not only left behind it a distinct sect, but it supplied a basis upon which Bráhmanism finally developed from the creed of a caste into the religion of the people. This Buddhistic influence on Hinduism will be afterwards noticed. The distinct sect is known as the JAINS (*q.v.*), who number about half a million[2] in India. The noblest survivals of Buddhism in India are to be found, not among any peculiar body, but in the religion of the people; in that principle of the brotherhood of man, with the reassertion of which each new revival of Hinduism starts; in the asylum which the great Hindu sects afford to women who have fallen victims to caste rules, to the widow and the out-caste; in that gentleness and charity to all men, which take the place of a poor-law in India, and give a high significance to the half-satirical epithet of the "mild" Hindu.

Greek-Roman Period.

Gr... inv...

The external history of India commences with the Greek invasion in 327 B.C. Some indirect trade between India and the Levant seems to have existed from very ancient times. Homer was acquainted with tin[3] and other articles of Indian merchandise by their Sanskrit names; and a long list has been made of Indian products mentioned in the Bible.[4] But the first Greek historian who speaks clearly of India was Hecatæus of Miletus (549-486 B.C.); the knowledge of Herodotus (450 B.C.) ended at the Indus; and Ctesias, the physician (401 B.C.), brought back from his residence in Persia only a few facts about the products of India, its dyes and fabrics, monkeys and parrots. India to the east of the Indus was first made known in Europe by the historians and men of science who accompanied Alexander the Great in 327 B.C. Their narratives, although now lost, are condensed in Strabo, Pliny, and Arrian. Soon afterwards Megasthenes, as Greek ambassador resident at a court in the centre of Bengal (306-298 B.C.), had opportunities for the closest observation. The knowledge of the Greeks and Romans concerning India practically dates from his researches, 300 B.C.[5]

Ale... and...

Alexander the Great entered India early in 327 B.C., crossed the Indus above Attock, and advanced, without a struggle, over the intervening territory of the Taxiles[6] to the Jhelum (Hydaspes). He found the Punjab divided into petty kingdoms, jealous of each other, and most of them inclined to join an invader rather than to oppose him. One of these local monarchs, Porus, disputed the passage of the Jhelum, with a force which, substituting guns for chariots, exactly equalled the army of Ranjit Sinh, the ruler of the Punjab in the present century.[7] Plutarch gives a vivid description of the battle from Alexander's own letters. Having drawn up his troops at a bend of the Jhelum, about 14 miles west of the modern field of

[1] *Report of Arch. Survey, Western India, for* 1874-75, p. 83.

[2] Returned by the census of 1872 as 485,020 "Buddhists" in India, besides the 2,447,831 Buddhists in Burmah. Except in a few spots, chiefly among the spurs of the Himálayas and in south-eastern Bengal, the Indian Buddhists may be generally reckoned as Jains.

[3] Greek, *Kassiteros*; Sanskrit, *Kastira*; hence, subsequently, the name of Cassiterides given to the Scilly Islands. *Elephas*, ivory, through the Arabian *eleph* (from Arabic *el*, the, and Sanskrit *ibha*, domestic elephant), is also cited.

[4] Dr Birdwood's *Handbook to the British Indian Section of the Paris Exhibition of* 1878, pp. 20-35.

[5] The fragments of the *Indica* of Megasthenes, collected by Dr Schwanbeck, with the first part of the *Indica* of Arrian, the *Periplus Maris Erythræi*, and Arrian's *Account of the Voyage of Nearchus*, have been translated in two most useful volumes by Mr J. W. M'Crindle, M.A. (Trübner, 1877 and 1879). The *Indica* of Ctesias, with the 15th Book of Strabo, is also promised; and the difficult sections referring to India in Ptolemy's *Geographia*, properly annotated, would complete a work of the highest value to Indian history.

[6] The Takkas, said to be a Turanian race, were the earliest inhabitants of Ráwal Pindí district. They gave their name to the town of Takshásila or Taxila, which Alexander found "a rich and large city, the most populous between the Indus and Hydaspes" (Arrian); it is identified with the ruins of Deri Shahan. Taki or Asarur, on the road between Lahore and Pindí Bhatiyán, was the capital of the Punjab in 633 A.D.

[7] Professor Cowell, who thinks that the Greeks probably exaggerated the numbers of the enemy, judiciously remarks:—"Porus, one of several who occupied the Punjab, is said to have had 200 elephants, 300 chariots, 400 horse, and 30,000 efficient infantry; which, as observed by Sir A. Burnes, is (substituting guns for chariots) exactly the establishment of Ranjit Sinh, who was master of the whole Punjab and several other territories" (Cowell, App. iii. to Elphinstone's *Hist. Ind.*, p. 262, ed. 1866). General Cunningham, who has given a lucid account of the battle, with an excellent map, *Anc. Geog. of India*, pp. 159-177 (ed. 1871), states the army of Alexander at "about 50,000 men, including 5000 auxiliaries under Mophis of Taxila."

Chilianwála,[1] the Macedonian general crossed under shelter of a tempestuous night. The chariots hurried out by Porus stuck in the muddy bank of the river, and in the general engagement which followed his elephants refused to face the Greeks, and, wheeling round, trampled his own army under foot. His son fell early in the onset; Porus himself fled wounded, but, on tendering his submission, was confirmed in his kingdom, and became the conqueror's trusted friend.

Alexander built two memorial cities on the scene of his victory,—Bucephalia on the west bank, near the modern Jalálpur, named after his beloved charger slain in the battle, and Nicæa, the present Mong, on the east side of the river.

Alexander advanced south-east through the kingdom of the younger Porus to Amritsar, and, after a sharp bend backward to the west, to fight the Cathæi at Sangala, he reached the Beas (Hyphasis). There, at a spot not far from the modern battlefield of Sobráon, he halted his victorious standards.[2] He had resolved to march to the Ganges; but his troops were worn out by the heats of the Punjab summer, and their spirits broken by the hurricanes of the south-west monsoon. The native tribes had already risen in his rear, and the conqueror of the world was forced to turn back before he had crossed even the frontier province of India. The Sutlej, the eastern districts of the Punjab, and the mighty Jumna still lay between him and the Ganges. A single defeat might be fatal to his army; if the battle on the Jhelum had not gone in his favour, not a Greek would have reached the Afghán side of the passes. Yielding at length to the clamour of his troops, he led them back to the Jhelum. He there embarked 8000 of them in boats previously prepared, and floated down the river; the remainder of his army marched in two divisions along the banks.

The country was hostile, and the Greeks held only the land on which they encamped. At Múltán (Mooltan), then as now the capital of the southern Punjab, he had to fight a pitched battle with the Malli, and was severely wounded in taking the city. His enraged troops put every soul within it to the sword. Farther down, near the confluence of the five rivers of the Punjab, he made a long halt, built a town,—Alexandria, the modern Uchch,—and received the submission of the neighbouring states. A Greek garrison and satrap, left there by Alexander, laid the foundation of a lasting influence. Having constructed a new fleet suitable for the greater rivers on which he was now to embark, he proceeded southwards through Sind, and followed the course of the Indus until he reached the ocean. In the apex of the delta he founded a city—Patala—which remains to this day under the name of Hyderabad, the capital of Sind.[3] At the mouth of the Indus Alexander beheld for the first time the majestic phenomenon of the tides. One part of his army he shipped off under the command of Nearchus to coast along the Persian Gulf; the other he himself led through southern Baluchistán and Persia to Susa, where, after terrible losses from want of water and famine on the march, he arrived in 325 B.C.

During his two years' campaign in the Punjab and Sind, Alexander captured no province, but he made alliances, founded cities, and planted garrisons. He had transferred much territory to chiefs and confederacies devoted to his cause; every petty court had its Greek faction; and the detachments which he left behind at various positions, from the Afghán frontier to the Beas, and from near the base of the Himálayas to the Sind delta, were visible pledges of his return. At Taxila (Deri-Shahan) and Nicæa (Mong) in the northern Punjab, at Alexandria (Uchch) in the southern Punjab, at Patala (Hyderabad) in Sind, and at other points along his route, he established military settlements of Greeks or allies. A large body of his troops remained in Bactria; and, in the partition of the empire which followed Alexander's death in 323 B.C., Bactria and India eventually fell to Seleucus Nicator, the founder of the Syrian monarchy.

Meanwhile a new power had arisen in India. Among the Indian adventurers who thronged Alexander's camp in the Punjab, each with his plot for winning a kingdom or crushing a rival, Chandra Gupta, an exile from the Gangetic valley, seems to have played a somewhat ignominious part. He tried to tempt the wearied Greeks on the banks of the Beas with schemes of conquest in the rich south-eastern provinces; but, having personally offended their leader, he had to fly the camp (326 B.C.). In the confused years which followed, he managed, with the aid of plundering hordes, to form a kingdom on the ruins of the Nanda dynasty in Magadha, or Behar (316 B.C.).[4] He seized the capital, Pataliputra, the modern Patná, established himself firmly in the Gangetic valley, and compelled the north-western principalities, Greeks and natives alike, to acknowledge his suzerainty.[5] While, therefore, Seleucus was winning his way to the Syrian monarchy during the eleven years which followed Alexander's death, Chandra Gupta was building up an empire in northern India. Seleucus reigned in Syria from 312 to 280 B.C., Chandra Gupta in the Gangetic valley from 316 to 292 B.C. In 312 B.C. the power of both had been consolidated, and the two new sovereignties were soon brought face to face.

Magadha kingdom.

In that year Seleucus, having recovered Babylon, proceeded to re-establish his authority in Bactria and the Punjab. In the latter province he found the Greek influence decayed. Alexander had left behind a mixed force of Greeks and Indians at Taxila. No sooner was he gone than the Indians rose and slew the Greek governor; the Macedonians massacred the Indians; a new governor, sent by Alexander, murdered the friendly Punjab prince, Porus, and was himself driven out of the country by the advance of Chandra Gupta from the Gangetic valley. Seleucus, after a war with Chandra Gupta, determined to ally himself with the new power in India rather than to oppose it. In return for five hundred elephants, he ceded the Greek settlements in the Punjab and the Cabul valley, gave his daughter to Chandra Gupta in marriage, and stationed an ambassador, Megasthenes, at the Gangetic court (*circa* 306–298 B.C.). Chandra Gupta became familiar to the Greeks as Sandrocottus, king of the Prasii; his capital, Pataliputra,[6] or Patná, was rendered into Palibothra. On the other hand, the names of Greeks and kings of Grecian dynasties appear in the rock inscriptions, under Indian forms.[7]

Megasthenes.

Megasthenes has left a life-like picture of the Indian people. Notwithstanding some striking errors, the observations which he jotted down at Patná, three hundred years before Christ, give as

[1] And about thirty miles south-west of Jhelum town.

[2] The change in the course of the Sutlej has altered the old position of that river to the Beas at this point. The best small map of Alexander's route is No. V. in General Cunningham's *Anc. Geog. of India*, p. 104 (ed. 1871)—64 miles to the inch.

[3] For its successive appearances in history, see General Cunningham's *Anc. Geog. of India*, pp. 279-287, under Patala or Nirankot. He gives an excellent map of Alexander's campaign in Sind at p. 248. Patala (Pattala, Pitasila, or Pattale) was formerly identified with Thatha, a town near to where the western arm of the Indus bifurcates (M'Crindle, *Commerce and Navigation of the Erythræan Sea*, p. 156, ed. 1879).

[4] *Corpus Inscriptionum Indicarum*, i. Pref. vii.

[5] For the dynasty of Chandra Gupta see *Numismata Orientalia* (Ceylon fasciculus), pp. 41–50.

[6] The modern Patná, or Pattana, means simply "the city." For its identification with Pataliputrapura and Mr Ravenshaw's crucial discoveries see General Cunningham's *Anc. Geog. India*, p. 452 *seq.*

[7] The Greeks as Yonas (Yavanas) are the Ἰάονες or Ionians. In the 13th edict of Asoka five Greek princes appear: Antiochus (of Syria), Ptolemy (Philadelphus of Egypt), Antigonus (Gonatus of Macedon), Magas (of Cyrene), Alexander (II. of Epirus).

accurate an account of the social organization in the Gangetic valley as any which existed when the Bengal Asiatic Society commenced its labours at the end of the last century (1785). Up to the time of Megasthenes the Greek idea of India was a very vague one. Their historians spoke of two classes of Indians,—certain mountainous tribes who dwelt in northern Afghánistán under the Caucasus or Hindu Kush, and a maritime race living on the coast of Baluchistán. Of the India of modern geography lying beyond the Indus they practically knew nothing. It was this India to the east of the Indus that Megasthenes opened up to the Western world. He describes the classification of the people, dividing them, however, into seven castes instead of four,[1]—namely, philosophers, husbandmen, shepherds, artisans, soldiers, inspectors, and the counsellors of the king. The philosophers were the Bráhmans, and the prescribed stages of their life are indicated. Megasthenes draws a distinction between the Bráhmans (Βραχμᾶνες) and the Sarmanæ (Σαρμάναι), from which some scholars have inferred that the Buddhist Sarmanas were a recognized class fifty years before the council of Asoka. But the Sarmanæ also include Bráhmans in the first and third stages of their life as students and forest recluses.[2] The inspectors[3] or sixth class of Megasthenes have been identified with Asoka's *Mahámátra* and his Buddhist inspectors of morals.

The Greek ambassador observed with admiration the absence of slavery in India, the chastity of the women, and the courage of the men. In valour they excelled all other Asiatics; they required no locks to their doors; above all, no Indian was ever known to tell a lie. Sober and industrious, good farmers, and skilful artisans, they scarcely ever had recourse to a lawsuit, and lived peaceably under their native chiefs. The kingly government is portrayed almost as described in Manu, with its hereditary castes of councillors and soldiers. Megasthenes mentions that India was divided into one hundred and eighteen kingdoms; some of which, such as that of the Prasii under Chandra Gupta, exercised suzerain powers. The village system is well described, each little rural unit seeming to be an independent republic. Megasthenes remarked the exemption of the husbandmen (Vaisyas) from war and public services, and enumerates the dyes, fibres, fabrics, and products (animal, vegetable, and mineral) of India. Husbandry depended on the periodical rains; and forecasts of the weather, with a view to "make adequate provision against a coming deficiency," formed a special duty of the Bráhmans. "The philosopher who errs in his predictions observes silence for the rest of his life."

Before the year 300 B.C. two powerful monarchies had thus begun to act upon the Bráhmanism of northern India, from the east and from the west. On the east, in the Gangetic valley, Chandra Gupta (316–292 B.C.) firmly consolidated the dynasty which during the next century produced Asoka (264–223 B.C.), established Buddhism throughout India, and spread its doctrines from Afghánistán to China, and from Central Asia to Ceylon. On the west, the heritage of Seleucus (312–280 B.C.) diffused Greek influences, and sent forth Græco-Bactrian expeditions to the Punjab. Antiochus Theos (grandson of Seleucus Nicator) and Asoka (grandson of Chandra Gupta), who ruled these two monarchies in the 3d century B.C., made a treaty with each other (256). In the next century Eucratides, king of Bactria, conquered as far as Alexander's royal city of Patala, and possibly sent expeditions into Cutch and Guzerat, 181–161 B.C. Of the Græco-Bactrian monarchs, Menander advanced farthest into North-Western India, and his coins are found from Cabul, near which he probably had his capital, as far as Muttra on the Jumna. The Buddhist dynasty of Chandra Gupta profoundly modified the religion of northern India from the east; the empire of Seleucus, with its Bactrian and later offshoots deeply influenced the science and art of Hindustán from the west.

Græco-Bactrian conquests.

Bráhman astronomy owed much to the Greeks, and what the Buddhists were to the architecture of northern India, that the Greeks were to its sculpture. Greek faces and profiles constantly occur in ancient Buddhist statuary, and enrich almost all the larger museums in India. The purest specimens have been found in the Punjab, where the Ionians settled in greatest force. As we proceed eastward from the Punjab, the Greek type begins to fade. Purity of outline gives place to lusciousness of form. In the female figures, the artists trust more and more to swelling breasts and towering chignons, and load the neck with constantly accumulating jewels. Nevertheless, the Grecian type of countenance long survived in Indian art. It is perfectly unlike the present coarse conventional ideal of sculptured beauty, and may even be traced in the delicate profiles on the so called sun temple at Kanárak, built in the 12th century A.D. on the remote Orissa shore.

Greek influence in art.

It must suffice to indicate the ethnical and dynastic influences thus brought to bear upon India, without attempting to assign dates to the individual monarchs. The chronology of the twelve centuries intervening between the Græco-Bactrian period and the Mahometan conquest still depends on a mass of conflicting evidence derived from inscriptions, legendary literature, unwritten traditions, and coins.[4] Four systems of computation exist, based upon the Vikramáditya, Saka, Seleucidan, and Parthian eras. In the midst of this confusion we see dim masses moving southwards from Central Asia into India. The Græco-Bactrian kings are traced by coins as far as Muttra on the Jumna; and Sanskrit texts have recently revealed their advance through the Middle Land of the Bráhmans (Madhyadesha) to Sáketa (or Ajodhya), the capital of Oudh, and to Patná in Behar.[5] The credentials of the Indian embassy to Augustus in 22–20 B.C. were written on skins,—a circumstance which indicates the extent to which Greek usage had overcome Bráhmanical prejudices. During the century preceding the Christian era Scythian or Tartar hordes began to supplant the Græco-Bactrian influence in the Punjab.

Ethnic influences

Scythic and Non-Aryan Influences.

About 126 B.C. the Tartar tribe of Su is said to have driven out the Greek dynasty from Bactria, and the Græco-Bactrian settlements in the Punjab were overthrown by the Tue-Chi.[6] The Scythian migrations towards India culminated in the empire of Kanishka, who held the fourth Buddhist council, *circa* 40 A.D., and practically became the royal founder of northern Buddhism. The Scythic element played an important part in the history of northern India. Under Kanishka and his successors a connexion was established with the Buddhist nations of central and eastern Asia, traces of which survived to the time of Hwen Tsang (629–645 A.D.) in the name of China-pati, about 10 miles to the west of the Beas river.[7] China-pati is said to have been the town which Kanishka appointed for the residence of his Chinese hostages. It has been suggested that the *Aswamedha*, or great horse sacrifice, in some of its Indian developments at any rate, was based upon Scythic ideas. "It was in effect," writes Mr Edward Thomas, "a martial challenge, which consisted in letting the victim who was to crown the imperial triumph at the year's end go free to wander at will over the face of the earth, its sponsor being bound to follow its hoofs, and to conquer or conciliate" the chiefs through whose territories it passed. Such a prototype seems to him to shadow forth the life of the Central Asia communities of the horseman class, "among

Expulsion of Græco-Bactrian dynasty

Scythians.

[1] *Ancient India as described by Megasthenes and Arrian, being fragments of the Indika*, by J. W. M'Crindle, M.A., p. 40 (ed. 1877).

[2] Brahmachárins and Vánaprasthas (ὑλόβιοι). Weber very properly declines to identify the Σαρμάναι exclusively with the Buddhist Sarmana. *Hist. Ind. Lit.*, p. 28 (ed. 1878).

[3] The ἔφοροι (Diodorus, Strabo), ἐπίσκοποι (Arrian).

[4] The evidence is well indicated in the Report of the *Archæological Survey of Western India for* 1874–75, p. 49 (Mr E. Thomas's monograph).

[5] Weber, *Hist. Ind. Lit.*, p. 251-52, with his valuable notes, quoting Goldstücker (ed. 1878).

[6] De Guignes, supported by Professor Cowell on the evidence of coins. Appendix to Elphinstone's *History of India*, p. 269 (ed. 1866).

[7] General Cunningham's *Anc. Geog. Ind.*, p. 200.

whom a steed captured in hostile forays had so frequently to be traced from camp to camp, and surrendered or fought for at last."[1]

An effort has been made to trace Buddha himself to a Scythic origin. He belonged to a royal stock of Sákyas; and the Chinese records supply an intermediate link between his birthplace in Bengal and the supposed home of his race in Central Asia. It is inferred from them that a branch of the Scythian hordes who overran western Asia about 625 B.C. made its way to Patala on the Indus, the site selected by Alexander in 325 B.C. for his head-quarters in that delta, and still the capital of Sind under the name of Hyderabad. One portion of these Patala Scythians went westwards by the Persian Gulf to Assyria; another section eventually moved north-east into the Gangetic valley, and became the Sákyas of Kapilavastu, among whom Buddha was born.[2] His dying command, that he should be buried according to the old custom of his race, and a mound erected over his remains, is opposed to the Indo-Aryan form of obsequies by cremation; but it is essentially in accord with the Scythian mode of disposing of the dead. In the topes or funeral mounds of Buddhism is seen a reproduction of the royal Scythian tombs of which Herodotus speaks.[3] It is therefore argued that the Christian fathers trace back, by no accident, the Manichean doctrine to one "Scythianus," whose disciple Terebinthus took the name of Buddha.[4]

cy-nian ynas-es.

Whatever may be the value of this conjecture, the influence of the Scythian dynasties in northern India is an historical fact. The northern or Tibetan form of Buddhism, represented by Kanishka and his council in 40 A.D., made its way down to the plains of Hindustán, and during the next six centuries competed with the earlier Buddhism of Asoka. The Chinese pilgrim in 629–645 A.D. found both the northern or Scythic and the southern forms of Buddhism in full vigour in India. He spent fourteen months at China-pati, the town where Kanishka had kept his Chinese hostages in the Punjab; and he records the debates between the northern and southern sects of Buddhists in Oudh, Behar, Káthiáwár, and at other places. The Scythic influence in India was a dynastic as well as a religious one. The evidence of coins and the names of Indian tribes of reigning families, such as the Sákas, Huns, and Nágas, point to Scythian settlements as far south as the Central Provinces.[5]

Many scholars believe that the Scythians poured down upon India in such masses as to supplant the previous population. The Jits or Játs,[6] who form nearly one-half of the inhabitants of the Punjab, are identified with the Getæ; their great subdivision the Dhe, with the Dahæ, whom Strabo places on the shores of the Caspian. This view has received the support of most eminent investigators, from Professor H. H. Wilson to General Cunningham, the director-general of the archæological survey.[7] The existing division between the Eastern Játs and the Dhe has, indeed, been traced back to the contiguity of the Massa-getæ or Great Getæ[8] and the Dahæ, who dwelt by the side of each other in Central Asia, and who may have advanced together during the great Scythian movement towards India on the decline of the Bactrian empire. Without pressing such identifications too closely in the service of particular theories, the weight of authority is in favour of a Scythian origin for this most numerous and most industrious section of the population of the Punjab.[9] A similar descent has been assigned to certain of the Rájput tribes. Colonel Tod, still the standard historian of Rájásthán, strongly insisted on this point. Some relationship between the Játs and the Rájputs, although obscure, is acknowledged; and, although the *jus connubii* no longer exists between them, an inscription shows that they intermarried in the 5th century A.D.[10] Professor Cowell, indeed, regarded the arguments for the Scythic descent of the Rájputs as inconclusive.[11] But the whole evidence now collected was not before him; and authorities of great weight have deduced alike from local investigation[12] and from Sanskrit literature[13] a Scythic origin for the Játs, and for some at least of the Rájput tribes. We shall see that the Scythian hordes also supplied certain of the Non-Aryan or so-called aboriginal races of India.

ythian ttle-ments.

The Scythic settlement was not effected without a struggle. As Chandra Gupta advanced from the Gangetic valley, and rolled back the tide of Græco-Bactrian conquest (*circa* 312–306 B.C.), so the Indian heroes of the first century before and after Christ are native princes who stemmed the torrent of Scythian invasion. Vikramáditya, king of Ujjain won his paramount place in Indian story by driving out the invaders. An era, the *Samvat*, beginning in 57 B.C. was founded in honour of his achievements. Its date[14] seems at variance with his legendary victories over the Scythian Kanishka in the first century after Christ;[15] but his very name suffices to commemorate his struggle against the northern hordes as Vikramáditya Sakári, or the enemy of the Scythians. His reign forms the Augustan era of Sanskrit literature; and tradition has ascribed the highest efforts of the Indian intellect during many centuries to the poets and philosophers, or nine gems, of his court. As Chandra Gupta, who freed India from the Greeks, is celebrated in the drama *Mudrá-rákshasa*, so Vikramáditya, the vanquisher of the Scythians, forms the central royal personage of the Hindu stage.

Expulsion o Scy-thians

Vikramáditya's achievements, however, formed no final deliverance, but merely an episode in a long struggle between the Indian dynasties and new races from the north. Another popular era, the *Saka* (literally the

[1] *Report of Archæological Survey of Western India*, pp. 37, 38, 1876. But see, in opposition to Mr Thomas's view, M. Senart in the French *Journ. Asiatique*, 1875, p. 126.

[2] *Catena of the Buddhist Scriptures from the Chinese*, by S. Beal, pp. 126–130 (Trübner, 1871).

[3] Herod. iv. 71, 72, 217.

[4] "I believe," says the greatest living authority on Indo-Chinese Buddhism, "the legend of Sákya was perverted into this history of Scythianus."—S. Beal, *Catena, ut supra*, p. 129, footnote.

[5] Muir's *Sanskrit Texts*, chap. v. vol. i, 1868; C. Grant's *Gazetteer of the Central Provinces*, lxx. &c., Nágpur, 1870; *Reports of the Archæological Survey of India and of Western India*; Professor H. H. Wilson (and Dr F. Hall), *Vishnu Purána*, ii. 134.

[6] The word occurs as Játs and Jats, but the identity of the two forms has been established by reference to the *Ain-i-Akbari*. Some are Hindus, others Mahometans.

[7] See, among other places, part iv. of his *Archæological Report*, p. 19.

[8] *Massa* means "great" in Pehlevi.

[9] It should be mentioned, however, that Dr Trumpp believes them to be of Aryan origin (*Zeitsch. d. Deutsch. Morg. Gesellsch.*, xv. p. 690). See Mr J. Beames's admirable edition of Sir Henry Elliot's *Glossary of the Races of the North-Western Provinces*, vol. i. pp. 103–137 (ed. 1869).

[10] Inscription discovered in Kotah state; No. 1 of Inscription Appendix to Colonel Tod's *Annals and Antiquities of Rájásthán*, vol. i. p. 701, note 3 (Madras reprint, 1873).

[11] Appendix to Elphinstone's *Hist. Ind.*, pp. 250 *seq.* (ed. 1866).

[12] Tod's *Rájásthán*, pp. 52, 483, 500, &c., vol. i. (Madras reprint, 1873).

[13] Dr Fitz-Edward Hall's edition of Professor H. H. Wilson's *Vishnu Purána*, vol. ii. p. 134. The Húnas, according to Wilson, were "the White Huns, who were established in the Punjab and along the Indus, as we know from Arrian, Strabo, and Ptolemy, confirmed by recent discoveries of their coins and by inscriptions." "I am not prepared," says Dr Fitz-Edward Hall, "to deny that the ancient Hindus when they spoke of the Húnas included the Huns. In the Middle Ages, however, it is certain that a race called Húna was understood by the learned of India to form a division of the Kshattriyas."—Professor Dowson's *Dict. Hind. Mythology*, &c., p. 122.

[14] *Samvatsara*, "the year." The uncertainty which surrounds even this long accepted finger-post in Indian chronology may be seen from Dr J. Fergusson's paper "On the Sáka and Samvat and Gupta Eras," *Journal Roy. As. Soc.*, new series, vol. xii., especially p. 172.

[15] The Hushka, Jushka, and Kanishka family of the Rájá Tarangini, or chronicles of Kashmír, are proved by inscriptions to belong to the 4th century of the Seleucidan era, or the 1st century A.D.

Scythian), takes its commencement in 78 A.D.,[1] and is supposed to commemorate the defeat of the Scythians by a king of southern India, Saliváhana.[2] During the seven centuries which followed, three powerful monarchies, the Sáhs, Guptas, and Valabhís, established themselves in northern and western India. The Sáhs of Suráshtra are traced by coins and inscriptions from 60 or 70 B.C. to after 235 A.D.[3] After the Sáhs come the Guptas of Kanauj,[4] in the North-Western Provinces, the Middle Land (Madhyadesha) of ancient Bráhmanism. The Guptas introduced an era of their own, commencing in 319 B.C., and ruled in person or by viceroys over northern India during one hundred and fifty years, as far to the south-west as Káthiáwár. The Gupta dynasty was overthrown by foreign invaders, apparently a new influx of Huns or Tartars from the north-west (450–470 A.D.). The Valabhís succeeded the Guptas, and ruled over Cutch, the north-western districts of Bombay[5] and Málwá, from 480 to after 722 A.D.[6] The Chinese pilgrim gives a full account of the court and people of Valabhí (630–640 A.D.). Buddhism was the state religion, but heretics (Bráhmans) abounded; and the Buddhists themselves were divided between the northern school of the Scythian dynasties and the southern or Indian school of Asoka. The Valabhís seem to have been overthrown by the early Arab invaders of Sind in the 8th century.

Early Indian dynasties.

The relations of these three Indian dynasties, the Sáhs, Guptas, and Valabhís, to the successive hordes of Scythians who poured down on northern India are obscure. There is abundant evidence of a long-continued struggle, but the attempt to assign dates to its chief episodes has not yet produced results which can be accepted as final. Two Vikramáditya Sakáris, or vanquishers of the Scythians, are required for the purposes of chronology; and the great battle of Korúr, near Múltán, at which the Scythian hosts perished, has been shifted backwards and forwards from 78 to 544 A.D.[7] The truth seems to be that, during the first six centuries of the Christian era, the fortunes of the Scythian or Tartar races rose and fell from time to time in northern India. They more than once sustained great defeats; and they more than once overthrew the native dynasties. Their presence is abundantly attested during the century before Christ, represented by Vikramáditya (57 B.C.); during the first century after Christ, represented by the Kanishka family (2 B.C. to 87 A.D.); and thence to the time of Cosmas Indicopleustes, about 535 A.D. The latest writer on the subject[8] believes that it was the White Huns who overthrew the Guptas between 465 and 470 A.D. He places the great battles of Korúr and Maushari, which "freed India from the Sákas and Húnas," between 524 and 544 A.D. Cosmas Indicopleustes, who traded in the Red Sea about 535 A.D., speaks of the Huns as a powerful nation in northern India in his days.[9]

[1] Monday, 14th March, 78 A.D., Julian style.

[2] General Cunningham. See also Mr E. Thomas's letter, dated 16th September 1874, to the *Academy*, which brings this date within the period of the Kanishka family (2 B.C. to 87 A.D.).

[3] By Mr Newton. See Mr E. Thomas, "On the Coins of the Sáh Kings," *Archæol. Rep. Western India*, p. 44, 1876; and Dr J. Fergusson, *Journ. Roy. As. Soc.*, 1880.

[4] Now a town of only 17,000 inhabitants in Farrakhábád district, but with ruins extending over a semicircle of 4 miles in diameter.

[5] Lat-desa, including the collectorates of Surat, Broach, Kaira, and parts of Baroda territory.

[6] The genealogy is worked out in detail by Mr E. Thomas, *ut supra*, pp. 80–82.

[7] 78 A.D. was the popularly received date, commemorated by the *Sáka* era; "between 524 and 544 A.D." is suggested by Dr Fergusson (p. 284 of *Journ. Roy. As. Soc.*, vol. xii.) in the latest discussion of the subject during 1880.

[8] Dr J. Fergusson, *ut supra*, pp. 282–284, &c.

[9] *Topographia Christiania*, lib. xi. p. 338, Paris, 1707; *apud* Fergusson, *ut supra*.

Non-Aryan dynasties.

While Greek and Scythic influences had thus been at work in northern India during nine centuries (327 B.C. to 544 A.D.), another element was profoundly affecting the future of the Indian people. In a previous section we have traced the fortunes, and sketched the present condition, of the non-Aryan "aborigines." The Bráhmanical Aryans never effected anything like a complete subjugation of these earlier races. The tribes and castes of non-Aryan origin still number about 18 millions in British territory; the castes who claim a pure Aryan descent are under 17 millions. The non-Aryans have influenced the popular dialects of almost every province, and in southern India have given their speech to 46 millions of people. The Vedic settlements along the five rivers of the Punjab were merely colonies or confederacies of Aryan tribes, who had pushed in among a non-Aryan population. When an Aryan family advanced to a new territory, it had often, as in the case of the Pándava brethren, to clear the forest and drive out the aboriginal people. This double process constantly repeated itself, and so late as 1657 A.D., when the Hindu rájá founded the present city of Bareilly, his first work was to cut down the jungle and expel the Katheriyas. The ancient Bráhmanical kingdoms of the Middle Land, or Madhyadesha, in the North-Western Provinces and Oudh, were surrounded by non-Aryan peoples. All the legendary advances beyond the centre of Aryan civilization, narrated in the epic poets, were made into the territory of non-Aryan races. When we begin to catch historic glimpses of India, we find the most powerful kingdoms ruled by non-Aryan princes. Thus the Nandas, whom Chandra Gupta succeeded in Behar, were a Súdra or non-Aryan dynasty; and, according to one account, Chandra Gupta and his grandson Asoka came of the same stock.[10]

The Buddhist religion did much to incorporate the non-Aryan tribes into the Indian polity. During the long struggle against Græco-Bactrian and Scythian inroads (327 B.C. to 544 A.D.), the Indian aboriginal races must have had an ever-increasing importance, whether as enemies or allies. At the end of that struggle we discover them in some of the fairest tracts of northern India. In almost every district throughout Oudh and the North-Western Provinces ruined towns and forts are ascribed to aboriginal races who ruled at different periods, according to the local legends, between the 5th and 11th centuries A.D. When the Mahometan conquest supplies an historical footing after 1000 A.D., non-Aryan races were in possession of some of these districts, and had been lately ousted from others.

The statistical survey has brought to light many traces of these obscure peoples. It would be impossible to follow that survey through each locality; but we propose, with the utmost brevity, to indicate a few of the results. Starting from the west, Alexander the Great found Ráwal Pindí district in the hands of the Takkas or Takshaks, from whom its Greek name of Taxila was derived. This people has been traced to a Scythian migration about the 6th century B.C.[11] Their settlements in the 4th century B.C. seem to have extended from the Paropamisan range[12] in Afghánistán deep into northern India. Their Punjab capital, Takshásila or Taxila, was the largest city that Alexander found between the Indus and the Jhelum (327

[10] The *Mudrá-rákshasa* represents Chandra Gupta as related to the last of the Nandas; the commentator on the *Vishnu Purána* says he was the son of a Nanda by a low-caste woman. Professor Dowson's *Dict. Hindu Mythology*, &c., p. 68 (Trübner, 1879).

[11] Such dates have no pretension to be anything more than intelligent conjectures based on very inadequate evidence. With regard to the Takshaks, see Colonel Tod and the authorities which he quotes, *Rájásthán*, vol. i. 53 *passim*; 93 *seq.* (Madras reprint, 1873).

[12] Where Alexander found them as the Paræ-tacæ—*pahári*, or Hill Tacæ (?).

B.C.).[1] Saliháváua, from whom the Sáka or Scythian era took its commencement (78 A.D.), is held by some authorities to have been a Takshak.[2] In the 7th century A.D. Taki,[3] perhaps derived from the same race, was the capital of the Punjab. The Scythic Takshaks are supposed to have been the source of the great serpent race, the Takshaks or Nágás, who figure so prominently in Sanskrit literature and art, and whose name is still retained by the Nágá tribes of our own day. The words Nágá and Takshak in Sanskrit both mean "a snake," or mythological tailed monster. The Takshaks are identified with the Scythian Takkas, and the Nágás have been connected with the Tartar patriarch Nagas, the second son of El-khán.[4] The two names, however, seem to have been applied by the Sanskrit writers to a variety of non-Aryan peoples in India, whose religion was of an anti-Aryan type. We learn, for example, how the four Pándu brethren of the Mahábhárata turned out the snake-king Takshaka from his primæval Khándava forest. The Takshaks and Nágás were the tree and serpent worshippers, whose rites and objects of adoration have impressed themselves so deeply on the architecture and sculpture of India. The names were applied in a confused manner to different races of Scythic origin; and the greatest authority on tree and serpent worship in India has deliberately selected the term "Scythian" for the anti-Aryan elements which entered so largely into the Indian religions both in ancient and modern times.[5] The Chinese records give a full account of the Nágá geography of ancient India. They enumerate numerous and powerful Nágá kingdoms, from which Buddhism derived many of its converts. The Chinese chroniclers, indeed, classify the Nágá princes of India into two great divisions, as Buddhists and non-Buddhists. The serpent worship which formed so typical a characteristic of the Indo-Scythic races led the Chinese to confound them with the objects of their adoration; and the Indian Nágás and their rites seem to have supplied the Dragon races of Chinese Buddhism and of religious and secular art in China.

As the Greek invaders found Ráwal Pindí district in possession of a Scythic race of Takkas in 327 B.C., so the Musalmán conqueror found it inhabited by a fierce non-Aryan race of Ghakkars thirteen hundred years later. The Ghakkars for a time imperilled the safety of Mahmúd of Ghazní in 1008 A.D. Ferishta describes them as savages addicted to polyandry and infanticide. The tide of Mahometan conquest rolled on, but the Ghakkars remained in possession of their submontane tract. In 1205 they slew the second Mahometan conquerer of India, Muhammad Ghori, in his tent, and ravaged the Punjab to the gates of Lahore; and, in spite of conversion to Islám by the sword, it was not till 1525 that they made their submission to Bábar in return for a grant of country. During the next two centuries they rendered great services to the Mughal dynasty against the Afghán usurpers, and rose to high influence in the Punjab. Driven from the plains by the Síkhs in 1765, the Ghakkar chiefs maintained their independence in the Murree (Marri) Hills till 1830, when they were crushed after a bloody struggle. In 1849 Ráwal Pindí passed, with the rest of the Síkh territories, under British rule. But the Ghakkars revolted four years afterwards, and threatened Murree, the summer capital of the Punjab, so late as 1857. They now number only 10,153 persons, described by the British officers as "a fine spirited race, gentlemen in ancestry and bearing, and clinging under all reverses to the traditions of noble blood."

We have selected the inhabitants of Ráwal Pindí district to illustrate the long-continued presence and vitality of the non-Aryan races in India. We shall deal more briefly with other parts of the country. Proceeding inwards to the North-Western Provinces, we find traces of an early Buddhist civilization having been overturned by rude non-Aryan races. In Bareilly district, for example, the wild Ahírs from the north, the Bhíls from the south, and the Bhars from the west seem to have expelled highly developed Aryan communities not long before 1000 A.D. Still farther to the east, all remains of prehistoric masonry in Oudh and the North-Western Provinces are assigned either to the ancient Buddhists or to a mediæval race of Bhars. The Bhars appear to have possessed the north Gangetic plains in the centuries coeval with the fall of Buddhism. Their kingdoms extended over most of Oudh, and lofty mounds covered with ancient groves still mark the sites of their forgotten cities. They are the mysterious "fort-builders" to whom the peasantry ascribe any ruin of unusual size. In the western districts their power is said to have been crushed by the Sharki dynasty of Jaunpur in the end of the 14th century. In the eastern districts of the north Gangetic plain, the Bhars figure still more prominently in local traditions, and an attempt has been made to trace their continuous history. In Gorakhpur district a movement of aboriginal Tharus and Bhars seems to have overwhelmed the early outposts of Aryan civilization several centuries before Christ. They afterwards became vassals of the Buddhist kingdom of Behar on the south-east, and on the fall of that power, about 550, the Bhars regained their independence. The Chinese pilgrim in the 7th century comments on the large number of monasteries and towers in this region—the latter probably monuments of the struggle with the aboriginal Bhars, who were there finally crushed between the 7th and 10th centuries.

As we advance still farther eastwards into Bengal, we find that the non-Aryan races have within historical time supplied a large part of the Hindu population. In the north the Koch established their dominion upon the ruins of the Aryan kingdom of Kámrúp, which the Afghán king of Bengal had overthrown in 1489. The Koch gave their name to the native state of Kuch (Cooch) Behar, and their descendants, together with those of other non-Aryan tribes, form the mass of the people in the neighbouring British districts. Some eluded the effects of their low origin by becoming Musalmáns, and thus obtained that social equality which Islám grants to all mankind. The rest have merged more or less into the Hindu population; but masses of them claim, in virtue of their position as an old dominant race, to belong to the Kshattriya caste. They call themselves Rájbansís, a term exactly corresponding to the Rájputs of western India. The rájás of Kuch Behar lay claim to a divine origin, in order to conceal their aboriginal descent; and all remembrance of the Koch tribe is carefully avoided at court.

Proceeding still eastwards, we enter the adjacent valley of Assam, until last century the seat of another non-Aryan ruling race. The Ahams entered Assam from the south-east about 1350 (?), had firmly established their power by 1663, gradually yielded to Hinduism, and were overpowered by fresh invasions from Burmah between 1750 and 1820, when the valley was annexed to British India.

Bhils. Bhars. Koch. Ahams.

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[1] Arrian. The Bráhman mythologists, of course, found an Aryan pedigree for so important a person as King Taksha, and make him the son of Bharata, and nephew of Ráma-chandra!

[2] Tod, *Rájásthán*, i. 95 (ed. 1873).

[3] Taki, or Asarur, 45 miles west of Lahore. General Cunningham, *Anc. Geog. Ind.*, p. 191, and map vi. (ed. 1871). This Taki lies considerably to the south-east of the Takshásila of Alexander's expedition.

[4] Tod, *Rájásthán*, i. 53 (ed. 1873).

[5] Dr J. Fergusson's *Tree and Serpent Worship*, p. 71-72. (India Museum, 4to, 1868). For the results of more recent local research, see Mr Rivett-Carnac's papers in the *Journ. of the As. Soc., Bengal*, "The Snake Symbol in India," "Ancient Sculpturings on Rocks," "Stone Carvings at Mainpuri," &c.; and the Hon. Ráo Sáhib Vishvanáks Náráyan Mandlik's "Serpent Worship in Western India," and other essays, in the *Bombay As. Soc. Journal*.

By the Burmese the Ahams have been completely crushed as a dominant race, and their national priests, to the number of 179,000, have been forced to till the soil to gain their living. But the people of Assam are still so essentially made up of aboriginal races and their Hinduized descendants that not 65,000 persons of even alleged pure Aryan descent can be found in a population exceeding 4 millions.

Non-Aryans south of the Ganges.

We have hitherto confined our survey to the country on the north of the Ganges. If we pass to the southern Gangetic plain, we find that almost every tract has traditions of a non-Aryan tribe, either as a once dominant race or as lying at the root of the local population. The great division of Bundelkhand contains several crushed peoples of this class, and takes its name from the Bundelas, a tribe of at least semi-aboriginal descent. As we rise from the Gangetic plain into the highlands of the Central Provinces, we reach the abiding home of the non-Aryan tribes. One such race after another—Gaulís, Nágás, Gonds, Ahírs—ruled from the Sátpura plateau. If we turn to the lower provinces of Bengal we find the delta peopled by masses of non-Aryan origin. One section of them has merged into low-caste Hindus; another section has sought a more equal social organization by accepting the creed of Mahomet. But such changes of faith do not alter their ethnical type; and the Musalmán of the delta differs as widely in race from the Afghán as the low-caste Hindu of the delta differs from the Bráhman. Throughout southern India the non-Aryan elements make up almost the entire population, and have supplied the great Dravidian family of languages, spoken by 46 millions of people.

Mahometan Period.

At the very time that Buddhism was being crushed out of India by the Bráhmanic reaction, a new faith was being born in Arabia, destined to supply a youthful fanaticism which should sweep the country from the Himálayas to Cape Comorin, and from the western to the eastern sea. Muhammad, commonly known as Mahomet, the founder of Islám, died at Medina in 632 A.D., while the Chinese pilgrim Hwen Tsang was still on his travels. The first Mahometan invasion of India is placed in 664, only thirty-two years after the death of the prophet. The Punjab is said to have been ravaged on this occasion with no permanent results. The first Mahometan conquest was the outlying province of Sind, which from the point of view of geology may be regarded as a continuation of the desert of Baluchistán. In 711, or seventy-nine years after the death of Mahomet, an Arab army under Muhammad Kásim invaded and conquered the Hindus of Sind in the name of Walid I., caliph of Damascus, of the Bene-Umyyeh line. In the same year Roderic, the last of the Goths, fell before the victorious Saracens in Spain. But in India the bravery of the Rájputs and the devotion of the Bráhmans seem to have afforded a stronger national bulwark than existed in western Europe. In 750 the Hindus rose in rebellion and drove out the Musalmán tyrant, and the land had rest for one hundred and fifty years.

Mahometan invasions.

Mahmúd of Ghazní.

The next Mahometan invasion of India is associated with the name of Sultán Mahmúd of Ghazní. Mahmúd was the eldest son of Sabuktagín, surnamed Nasr-ud-dín, in origin a Turkish slave, who had established his rule over the greater part of modern Afghánistán and Khorasán with Ghazní as his capital. In 977 Sabuktagín is said to have defeated Jáipal, the Hindu rájá of Lahore, and to have rendered the Punjab tributary. But his son Mahmúd was the first of the great Musalmán conquerors whose names still ring through Asia. Mahmúd succeeded to the throne in 997. During his reign of thirty-three years he extended the limits of his father's kingdom from Persia on the east to the Ganges on the west; and it is related that he led his armies into the plains of India no less than seventeen times. In 1001 he defeated Rájá Jáipal a second time, and took him prisoner. But Anandpal, the son of Jáipal, raised again the standard of national independence, and gathered an army of Rájput allies from the furthest corners of Hindustán. The decisive battle was fought in the valley of Peshâwar. Mahmúd won the day by the aid of his Turkish horsemen, and thenceforth the Punjab has been a Mahometan province, except during the brief period of Síkh supremacy. The most famous of Mahmúd's invasions of India was that undertaken in 1024 against Guzerat. The goal of this expedition was the temple dedicated to Siva at Somnáth, around which so many legends have gathered. It is reported that Mahmúd marched through Ajmír, to avoid the desert of Sind; that he found the Hindus gathered on the neck of the peninsula of Somnáth in defence of their holy city; that the battle lasted for two days; that in the end the Rájput warriors fled to their boats, while the Bráhman priests retired into the inmost shrine; that Mahmúd, introduced into this shrine, rejected all entreaties by the Bráhmans to spare their idol, and all offers of ransom; that he smote the image with his club, and forthwith a fountain of precious stones gushed out. Until the British invasion of Afghánistán in 1839, the club of Mahmúd and the sandal-wood gates of Somnáth were preserved at the tomb of the great conqueror near Ghazní. The club has now disappeared, and the gates carried back to India by General Nott are recognized to be a clumsy forgery. To Mahometans Mahmúd is known, not only as a champion of the faith, but as a munificent patron of literature. The dynasty that he founded was not long-lived. Fourteen of his descendants occupied his throne within little more than a century, but none of them achieved greatness. A blood-feud arose between them and a line of Afghán princes who had established themselves among the mountains of Ghor. In 1152 Bahrám, the last of the Ghaznivide Turks, was overthrown by Allah-ud-dín of Ghor, and the wealthy and populous city of Ghazní was razed to the ground. But even the Ghoride conqueror spared the tomb of Mahmúd.

Khusru, the son of Bahrám, fled to Lahore, and there established the first Mahometan dynasty within India. It speedily ended with his son, also called Khusru, whom Muhammad Ghori, the relentless enemy of the Ghaznivide house, carried away into captivity in 1186.

The Afgháns of Ghor or Ghur thus rose to power on the downfall of the Turks of Ghazní. The founder of the family is said to have been Izzud-dín al Husáin, whose son Allah-ud-dín destroyed Ghazní, as already mentioned. Allah-ud-dín had two nephews, Ghíyás-ud-dín and Muiz-ud-dín, the latter of whom, also called Shahab-ud-dín by Musalmán chroniclers, and generally known in history as Muhammad Ghori, is the second of the great Mahometan conquerors of India. In 1176 he took Múltán and Uchch; in 1187 Lahore fell into his hands; in 1191 he was repulsed before Delhi, but soon afterwards he redeemed this disaster. Hindustán Proper was at that period divided between the two Rájput kingdoms of Kanauj and Delhi. Muhammad Ghori achieved his object by playing off the rival kings against each other. By 1193 he had extended his conquests as far east as Benares, and the defeated Rájputs migrated in a body to the hills and deserts now known as Rájputána. In 1199 one of his lieutenants, named Bakhtiyar, advanced into Bengal, and expelled by an audacious stratagem the last Hindu rájá of Nadiyá. The entire northern plain, from the Indus to the Brahmaputra, thus lay under the Mahometan yoke. But Muhammad Ghori never settled himself permanently in India. His favourite residence is said to have been the old capital of Ghazní, while he governed his Indian conquests through the agency of a favourite slave, Kutab-ud-dín. Muhammad Ghori died in 1206, being assassinated by some Ghakkar tribesmen while sleeping in his tent by the bank of the Indus; on his death both Ghor and Ghazní drop out of history, and Delhi first appears as the Mahometan capital of India.

On the death of Muhammad Ghori, Kutab-ud-dín at once laid aside the title of viceroy, and proclaimed himself sultán of Delhi. He was the founder of what is known as the slave dynasty, which lasted for nearly a century (1206–1288). The name of Kutab is preserved in the *minar*, or pillar of victory, which still stands amid the ruins of ancient Delhi, towering high above all later structures. Kutab himself is said to have been successful as a general and an administrator, but none of his successors has left a mark in history.

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...lh- ...lín.

In 1294 Allah-ud-dín Khiljí, the third of the great Mahometan conquerors of India, raised himself to the throne of Delhi by the treacherous assassination of his uncle Firoz II., who had himself supplanted the last of the slave dynasty. Allah-ud-dín had already won military renown by his expeditions into the yet unsubdued south. He had plundered the temples at Bhílsa in central India, which are admired to the present day as the most interesting examples of Buddhist architecture in the country. At the head of a small band of horsemen, he had ridden as far south as Deogiri in the Deccan, and plundered the Marhattá capital. When once established as sultán, he planned more extensive schemes of conquest. One army was sent to Guzerat under Alaf Khán, who conquered and expelled the last Rájput king of Anhalwár or Pátan. Another army, led by the sultán in person, marched into the heart of Rájputána, and stormed the rock-fortress of Chitor, where the Rájputs had taken refuge with their women and children. A third army, commanded by Malik Kafúr, a Hindu renegade and favourite of Allah-ud-dín, penetrated to the extreme south of the peninsula, scattering the unwarlike Dravidian races, and stripping every Hindu temple of its accumulations of gold and jewels. To this day the name of Malik Kafúr is remembered in the remote district of Madura, in association with irresistible fate and every form of sacrilege.

Allah-ud-dín died in 1316, having subjected to Islám the Deccan and Guzerat. Three of his descendants followed him upon the throne, but their united reigns extended over only five years. In 1321 a successful revolt was headed by Ghiyas-ud-dín Tughlak, governor of the Punjab, who is said to have been of Turkish origin. The Tughlak dynasty lasted for about seventy years, until it was swept away by the invasion of Timúr, the fourth Mahometan conqueror of India, in 1398. Ghiyas-ud-dín, the founder of the line, is only known for having removed the capital from Delhi to a spot about 4 miles further to the east, which he called Tughlakábád. His son and successor, Muhammad Tughlak, who reigned from 1325 to 1351, is described by Elphinstone as "one of the most accomplished princes and one of the most furious tyrants that ever adorned or disgraced human nature." He wasted the treasure accumulated by Allah-ud-dín in purchasing the retirement of the Mughal hordes, who had already made their appearance in the Punjab. When the internal circulation failed, he issued a forced currency of copper, which is said to have deranged the whole commerce of the country At one time he raised an army for the invasion of Persia. At another he actually despatched an expedition against China, which perished miserably in the Himálayan passes. When Hindustán was thus suffering from his misgovernment, he conceived the project of transferring the seat of empire to the Deccan, and compelled the inhabitants of Delhi to remove a distance of 700 miles to Deogiri or Daulatábád. And yet during the reign of this sultán both the Tughlak dynasty and the city of Delhi are said to have attained their utmost growth. Muhammad was succeeded by his cousin Firoz, who likewise was not content without a new capital, which he placed a few miles north of Delhi, and called after his own name. Meanwhile the remote provinces of the empire began to throw off their allegiance to the sultáns of Delhi. The independence of the Afghán kings of Bengal is generally dated from 1336, when Muhammad Tughlak was yet on the throne. The commencement of the reign of Allah-ud-dín, the founder of the Báhmani dynasty in the Deccan, is variously assigned to 1347 and 1357. Zafar Khán, the first of the Ahmadábád kings, acted as an independent ruler from the time of his first appointment as governor of Guzerat in 1391. These and other revolts prepared the way for the fourth great invasion of India under Timúr (Tamerlane).

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Timúr's invasion

Accordingly, when Timúr invaded India in 1398, he encountered but little organized resistance. Mahmúd, the last of the Tughlak dynasty, being defeated in a battle outside the walls of Delhi, fled into Guzerat. The city was sacked and the inhabitants massacred by the victorious Mughals. But the invasion of Timúr left no permanent impress upon the history of India, except in so far as its memory fired the imagination of Bábar (Baber), the founder of the Mughal dynasty. The details of the fighting and of the atrocities may be found related in cold blood by Timúr himself in the *Malfuzat-i-Timúri*, which has been translated in Elliot's *History of India as told by its own Historians*, vol. iii. Timúr marched back to Samarkand as he had come, by way of Cabul, and Mahmúd Tughlak ventured to return to his desolate capital. He was succeeded by what is known as the Sayyid dynasty, which held Delhi and a few miles of surrounding country for about forty years. The Sayyids were in their turn expelled by Beloli, an Afghán of the Lodi tribe, whose successors removed the seat of government to Agra, which thus for the first time became the imperial city. In 1525 Bábar (Baber), the fifth in descent from Timúr, and also the fifth Mahometan conqueror, invaded India at the instigation of the governor of the Punjab, won the victory of Pánipat over Ibráhim, the last of the Lodi dynasty, and founded the Mughal empire, which lasted, at least in name, until 1857.

Dynast... of south... ern Ind...

Before entering upon the story of the Mughal empire, it is desirable to give a short sketch of the condition of southern India at this period, which marks a turning point in Indian history. The earliest local traditions agree in dividing the extreme south into four provinces, Kerala, Pandya, Chola, and Chera, which together made up the country of Dravida, occupied by Tamil-speaking races. Of these kingdoms the greatest was that of Pandya, with its capital of Madura, the foundation of which is assigned on high authority to the 4th century B.C. Other early southern cities whose sites can be identified are Combaconum and Tanjore, the successive capitals of the Chola kingdom, and Talkad in Mysore, now buried by the sands of the Káveri (Cauvery), the capital of the Chera kingdom. The local *Purana*, or chronicle of Madura, gives a list of two Pandyan dynasties, the first of which has seventy-three kings, the second forty-three. Parakrama, the last king of the second dynasty, was overthrown by the Mahometan invader, Málik Kafúr, in 1324; but the Musalmáns never established their power in the extreme south, and a series of Hindu lines ruled at Madura into the 18th century. No other Dravidian kingdom can boast such a continuous succession as that of Madura. The chronicles enumerate fifty Chera kings, and no less than sixty-six Chola kings, as well as many minor dynasties which ruled at various periods over fractions of the south. Little confidence, however, can be placed in Hindu genealogies, and the early history of the Dravidian races yet remains to be deciphered from mouldering palm leaves and the more trustworthy inscriptions on copper and stone. Authentic history begins with the Hindu empire of Vijayanagar or Narsingha, which exercised an ill-defined sovereignty over the entire south from the 12th to the 16th century. The foundation of the city of Vijayanagar is assigned to the year 1118, and to an eponymous hero, Rájá Vijaya, the fifth of his line. Its extensive ruins are still to be traced on the right bank of the Tungabhadra river within the Madras district of Bellary. The city itself has not been inhabited since it was sacked by the Mahometans in 1565, but vast remains still exist of temples, fortifications, tanks, and bridges, haunted by beasts of prey and venomous reptiles. The empire of Vijayanagar represents the last stand made by the national faith in India against conquering Islam. For at least three centuries its sway over the south was undisputed, and its rájás waged wars and concluded treaties of peace with the sultáns of the Deccan on equal terms.

Mahometan dynasties in Deccan.

The earliest of the Mahometan dynasties in the Deccan was that founded by Allah-ud-dín in 1347 or 1357, which has received the name of the Báhmani dynasty from the supposed Bráhman descent of its founder. The capital was first at Gulbargah, and was afterwards removed to Bidar, both which places still possess magnificent palaces and mosques in ruins. Towards the close of the 14th century the Báhmani empire fell to pieces, and five independent kingdoms divided the Deccan among them. These were—(1) the Adíl Sháhi dynasty, with its capital at Bijapur, founded in 1489 by a son of Amurath II., sultán of the Ottomans; (2) the Kutab Sháhi dynasty, with its capital at Golconda, founded in 1512 by a Turkoman adventurer; (3) the Nizám Sháhi dynasty, with its capital at Ahmadnagar, founded in 1490 by a Bráhman renegade, from the Vijayanagar court; (4) the Ímad Sháhi dynasty of Berar, with its capital at Ellichpur, founded in 1484 also by a Hindu from Vijayanagar; (5) the Barid Sháhi dynasty, with its capital at Bidar, founded about 1492 by one who is variously described as a Turk and a Georgian slave. It is, of course, impossible here to trace in detail the history of these several dynasties. In 1565 they combined against the Hindu rájá of Vijayanagar, who was defeated and slain in the decisive battle of Talikota. But, though the city was sacked and the supremacy of Vijayanagar for ever destroyed, the Mahometan victors did not themselves advance into the south. The Naiks or feudatories of Vijayanagar everywhere asserted their independence. From them are descended the well-known Pálegárs of the south, and also the present rájá of Mysore. One of the blood-royal of Vijayanagar fled to Chandragiri, and founded a line which exercised a prerogative of its former sovereignty by granting the site of Madras to the English in 1639. Another scion claiming the same high descent lingers to the present day near the ruins of Vijayanagar, and is known as the rájá of Anagundi, a feudatory of the nizám of Hyderabad. Despite frequent internal strife, the sultáns of the Deccan retained their independence until conquered by the Mughal emperor Aurangzeb in the latter half of the 17th century. To complete this sketch of India at the time of Bábar's invasion it remains to say that an independent Mahometan dynasty reigned at Ahmadábád in Guzerat for nearly two centuries (from 1391 to 1573), until conquered by Akbar; and that Bengal was similarly independent, under a line of Afghán kings, with Gaur for their capital, from 1336 to 1573. When, therefore, Bábar invaded India in 1525, the greater part of the country was Mahometan, but it did not recognize the authority of the Afghán sultan of the Lodi dynasty, who resided at Agra, and also ruled the historical capital of Delhi. After having won the battle of Pánipat, Bábar was no more acknowledged as emperor of India than his ancestor Timúr had been. Bábar, however, unlike Timúr, had resolved to settle in the plains of Hindustán, and carve out for himself a new empire with the help of his Mughal followers. His first task was to repel an attack by the Rájputs of Chitor, who seem to have attempted to re-establish at this time a Hindu empire. The battle was fought at Sikri near Agra, and is memorable for the vow made by the easy living Bábar that he would never again touch wine. Bábar was again victorious, but died shortly afterwards in 1530. He was succeeded by his son Humáyún, who is chiefly known as being the father of Akbar. In Humáyún's reign the subject Afgháns rose in revolt under Sher Sháh, a native of Bengal, who for a short time established his authority over all Hindustán. Humáyún was driven as an exile into Persia; and, while he was flying through the desert of Sind, his son Akbar was born to him in the petty fortress of Umarkot. But Sher Sháh was killed at the storming of the rock-fortress of Kálinjar, and Humáyún, after many vicissitudes, succeeded in re-establishing his authority at Lahore and Delhi.

Mughal dynasty.

Af... rev...

Humáyún died by an accident in 1556, leaving but a circumscribed kingdom, surrounded on every side by active foes, to his son Akbar, then a boy of only fourteen years. Akbar the Great, the real founder of the Mughal empire as it existed for two centuries, was the contemporary of our own Queen Elizabeth (1558-1603). He was born in 1542, and his reign lasted from 1556 to 1605. When his father died he was absent in the Punjab, fighting the revolted Afgháns, under the guardianship of Bairám Khán, a native of Badakshán, whose military skill largely contributed to recover the throne for the Mughal line. For the first seven years of his reign Akbar was perpetually engaged in warfare. His first task was to establish his authority in the Punjab, and in the country around Delhi and Agra. In 1568 he stormed the Rájput stronghold of Chitor, and conquered Ajmír. In 1570 he obtained possession of Oudh and Gwalior. In 1572 he marched in person into Guzerat, defeated the last of the independent sultáns of Ahmadábád, and formed the province into a Mughal viceroyalty or subah. In the same year his generals drove out the Afgháns from Bengal, and reunited the lower valley of the Ganges to Hindustán. Akbar was then the undisputed ruler of a larger portion of India than had ever before acknowledged the sway of one man. But he continued to extend his conquests throughout his lifetime. In 1578 Orissa was annexed to Bengal by his Hindu general Todar Mall, who forthwith organized a revenue survey of the whole province. Cabul submitted in 1581, Kashmír in 1586, Sind in 1592, and Kandahár in 1594. At last he turned his arms against the Mahometan kings of the Deccan, and wrested from them Berar; but the permanent conquest of the south was reserved for Aurangzeb.

Al...

If the history of Akbar were confined to this long list of conquests, his name would on their account alone find a high place among those which mankind delights to remember. But it is as a civil administrator that his reputation is cherished in India to the present day. With regard to the land revenue, the essence of his procedure was to fix the amount which the cultivators should pay at one-third of the gross produce, leaving it to their option to pay in money or in kind. The total land revenue received by Akbar amounted to about $16\frac{1}{2}$ millions sterling. Comparing the area of his empire with the corresponding area now under the British, it has been calculated that Akbar, three hundred years ago, obtained $15\frac{1}{2}$ millions where they obtain only $13\frac{1}{2}$ millions,—an amount representing not more than one-half the purchasing power of Akbar's $15\frac{1}{2}$ millions. The distinction between *khálsa* land, or the imperial demesne, and *jagír* lands, granted revenue free or at quit rent in reward for services, also dates from the time of Akbar. As regards his military system, Akbar invented a sort of feudal organization, by which every tributary rájá took his place by the side of his own Mughal nobles. In theory it was an aristocracy based only upon military command; but practically it accomplished the object at which it aimed by incorporating the hereditary chiefships of Rájputána among the mushroom creations of a Mahometan despotism. Musalmáns and Hindus were alike known only as *mansabdárs* or commanders of so many horse, the highest title being that of *amír* (ameer), corrupted by European travellers into *umrah* or *omrah*. The third and last of Akbar's characteristic measures were those connected with religious innovation, about which it is difficult to speak with precision. The necessity of conciliating the proud warriors of Rájputana had taught him toleration from his earliest days. His favourite wife was a Rájput princess, and another wife is said to have been a Christian. Out of four hundred and fifteen of his *mansabdárs* whose names are recorded, as many as fifty-one were Hindus. Starting from the broad ground of general toleration, Akbar was gradually led on by the stimulus of cosmopolitan discussion to question the truth of his inherited faith. The counsels of his friend Abul Fazl, coinciding with that sense of superhuman omnipotence which is bred of despotic power, led him at last to promulgate a new state religion, based upon natural theology, and comprising the best practices of all known creeds. In this strange faith Akbar himself was the prophet, or rather the head of the church. Every morning he worshipped the sun in public, as being the representative of the divine soul that animates the universe, while he was himself worshipped by the ignorant multitude.

Akbar died in 1605, in his sixty-third year. He lies buried beneath a plain slab in the magnificent mausoleum which he had reared at Sikandra, near his capital of Agra. As his name is still cherished in India, so his tomb is still honoured, being covered by a cloth presented by Lord Northbrook when viceroy in 1873.

Jahángír.

The reign of Jahángír, his son, extended from 1605 to 1627. It is chiefly remarkable for the influence exercised over the emperor by his favourite wife, surnamed Núr Mahál, or the Light of the Harem. The currency was struck in her name, and in her hands centred all the intrigues that made up the work of administration. She lies buried by the side of her husband at Lahore, whither the seat of government had been moved by Jahángír, just as Akbar had previously transferred it from Delhi to Ágra. It was in the reign of Jahángír that the English first established themselves at Surat, and also sent their first embassy to the Mughal court.

Jahángír was succeeded by his son Sháh Jahán, who had rebelled against his father, as Jáhangír had rebelled against Akbar. Sháh Jahán's reign is generally regarded as the period when the Mughal empire attained its greatest magnificence, though not its greatest extent of territory. He founded the existing city of Delhi, which is still known to its Mahometan inhabitants as Jahánábád. At Delhi also he erected the celebrated peacock throne; but his favourite place of residence was Agra, where his name will ever be associated with the marvel of Indian architecture, the Táj Mahál. That most chaste and most ornamental of buildings was erected by Sháh Jahán as the mausoleum of his favourite wife Mumtaz Mahál, and he himself lies by her side. It is said that twenty thousand workmen laboured on the work for twenty years. Besides the Táj, Sháh Jahán also built at Agra within the old fort the palace and the pearl mosque, both of which, like the Táj, have been preserved to be objects of admiration to the present day. Sháh Jahán had four sons, whose fratricidal wars for the succession during their father's lifetime it would be tedious to dwell upon. Suffice it to say that Aurangzeb, by mingled treachery and violence, supplanted or overthrew his brothers and proclaimed himself emperor in 1658, while Sháh Jahán was yet alive.

Aurangzeb.

Aurangzeb's long reign, from 1658 to 1707, may be regarded as representing both the culminating point of Mughal power and the beginning of its decay. Unattractive as his character was, it contained at least some elements of greatness. None of his successors on the throne was anything higher than a debauchee or a puppet. He was the first to conquer the independent sultáns of the Deccan, and to extend his authority to the extreme south. But even during his lifetime two new Hindu nationalities were being formed in the Marhattás and the Síkhs; while immediately after his death the nawabs of the Deccan, of Oudh, and of Bengal raised themselves to practical independence. Aurangzeb had indeed enlarged the empire, but he had not strengthened its foundations. During the reign of his father Sháh Jahán he had been viceroy of the Deccan or rather of the northern portion only, which had been annexed to the Mughal empire since the reign of Akbar. His early ambition was to conquer the Mahometan kings of Bíjapur and Golconda, who, since the downfall of Vijayanagar, had been practically supreme over the south.

Rise of Marhattá power.

This object was not accomplished without many tedious campaigns, in which Sivají, the founder of the Marhattá confederacy, first comes upon the scene. In name Sivají was a feudatory of the house of Bíjapur, on whose behalf he held the rock-forts of his native Gháts; but in fact he found his opportunity in playing off the Mahometan powers against one another, and in rivalling Aurangzeb himself in the art of treachery. In 1680 Sivají died, and his son and successor, Sambhají, was betrayed to Aurangzeb and put to death. The rising Marhattá power was thus for a time checked, and the Mughal armies were set free to operate in the eastern Deccan. In 1686 the city of Bíjapur was taken by Aurangzeb in person, and in the following year Golconda also fell. No independent power then remained in the south, though the numerous local chieftains, known as *pálegárs* and *naiks*, never formally submitted to the Mughal empire. During the early years of his reign Aurangzeb had fixed his capital at Delhi, while he kept his dethroned father, Sháh Jahán, in close confinement at Agra. In 1682 he set out with his army on his victorious march into the Deccan, and from that time until his death in 1707 he never again returned to Delhi. In this camp life Aurangzeb may be taken as representative of one aspect of the Mughal rule, which has been picturesquely described by European travellers of that day. They agree in depicting the emperor as a peripatetic sovereign, and the empire as held together by its military highways no less than by the strength of its armies. The great road running across the north of the peninsula, from Dacca in the east to Lahore in the west, is generally attributed to the Afghán usurper, Sher Sháh. The other roads branching out southward from Agra, to Surat and Burhanpur and Golconda, were undoubtedly the work of Mughal times. Each of these roads was laid out with avenues of trees, with wells of water, and with frequent *saráis* or rest-houses. Constant communication between the capital and remote cities was maintained by a system of foot-runners, whose aggregate speed is said to have surpassed that of a horse. Commerce was conducted by means of a caste of bullock-drivers, whose occupation in India is hardly yet extinct.

Decline of Mughal empire.

On the death of Aurangzeb in 1707, the decline of the Mughal empire set in with extraordinary rapidity. Ten emperors after Aurangzeb are enumerated in the chronicles, but none of them has left any mark on history. His son and successor was Bahádur Sháh, who reigned only five years. Then followed in order three sons of Bahádur Sháh, whose united reigns occupy only five years more. In 1739 Nádir Sháh of Persia, the sixth and last of the great Mahometan conquerors of India, swept like a whirlwind over Hindustán, and sacked the imperial city of Delhi. Thenceforth the Great Mughal (Mogul) became a mere name, though the hereditary succession continued unbroken down to our own day Real power had passed into the hands of Mahometan courtiers and Marhattá generals, both of whom were then carving for themselves kingdoms out of the dismembered empire, until at last British authority placed itself supreme over all. From the time of Aurangzeb no Musalmán, however powerful, dared to assume the title of sultán or emperor, with the single exception of Tipú's brief paroxysm of madness. The name of *nawáb*, corrupted by Europeans into "nabob," appears to be an invention of the Mughals to express delegated authority, and as such it is the highest title conferred upon Mahometans at the present day, as *mahárájá* is the highest title conferred upon Hindus. At first nawábs were only found in important cities, such as Surat and Dacca, with the special function of administering civil justice; criminal justice was in the hands of the *kotwál*. The corresponding officials at that time in a large tract of country were the *subahdár* and the *faujdár*. But the title of subahdár, or viceroy, gradually dropped into desuetude, as the paramount power was shaken off, and nawáb became a territorial title with some distinguishing adjunct. During the troubled period of intrigue and assassination that followed on the death of Aurangzeb, two Mahometan foreigners rose to high position as courtiers and generals, and succeeded in transmitting their power to their sons. The one was Chin Kulich Khán, also called Asof Jah, and still more commonly Nizám-ul-Mulk, who was of Turkomán origin, and belonged to the Sunni sect. His independence at Hyderabad in the Deccan dates from 1712. The other was Saádat Alí Khán, a Persian, and therefore a Shiá, who was appointed subahdár or nawáb of Oudh in 1720. Thenceforth these two important provinces paid no more tribute to Delhi, though their hereditary rulers continued to seek formal recognition from the emperor on their succession. The Marhattás were in possession of the entire west and great part of the centre of the peninsula; while the rich and unwarlike province of Bengal, though governed by an hereditary line of nawábs founded by Murshid Kuli Khán in 1704, still continued to pour its wealth into the imperial treasury. The central authority never recovered from the invasion of Nádir Sháh in 1739, who carried off plunder variously estimated at from 8 to 30 millions sterling The Marhattás closed round Delhi from the south, and the Afgháns from the west. The victory of Pánipat, won by Ahmad Sháh Duráni over the united Marhattá confederacy in 1761, gave the Mahometans one more chance of rule. But Ahmad Sháh had no ambition to found a dynasty of his own, nor were the British in Bengal yet ready for territorial conquest. Sháh Alam, the lineal heir of the Mughal line, was thus permitted to ascend the throne of Delhi, where he lived during the great part of a long life as a puppet in the hands of Mahádají Sindhia He was succeeded by Akbar II., who lived similarly under the shadow of British protection. Last of all came Bahádur Sháh, who atoned for his association with the mutineers in 1857 by banishment to Burmah. Thus ended the Mughal line, after a history which covers three hundred and thirty years. Mahometan rule remodelled the revenue system, and has left behind forty millions of Musalmáns in British India.

End of Mughal line.

Early European Settlements.

Mahometan invaders have always entered India from the north-west. Her new conquerors approached from the sea and from the south. From the time of Alexander to that of Vasco da Gama, Europe had enjoyed little direct intercourse with the East. An occasional traveller brought back stories of powerful kingdoms and of untold wealth; but the passage by sea was unthought of, and by land many wide deserts and warlike tribes lay between. Commerce, indeed, never ceased entirely, being carried on chiefly by the Italian cities on the Mediterranean, which traded to the ports of the Levant. But to the Europeans of the 15th century India was practically an unknown land, which powerfully attracted the imagination of spirits stimulated by the Renaissance, and ardent for discovery. All the learning on this subject has been collected by Dr Birdwood in his admirable *Report on the Old Records of the India Office* (1879), from which the present section is largely borrowed. In 1492 Christopher Columbus set sail under the Spanish flag to seek India beyond the Atlantic, bearing with him a letter to the great khan of Tartary. The expedition under Vasco da Gama started from Lisbon five years later, and, doubling the Cape of Good Hope, cast anchor off the city of Calicut on the 20th May 1498, after a prolonged voyage of nearly eleven months. From the first Da Gama encountered hostility from the "Moors," or rather Arabs, who monopolized the sea-borne trade; but he seems to have found favour with the *zamorin*, or Hindu rájá of Malabar. It may be worth while to recall the contemporary condition of India at that epoch. An Afghán of the Lodi dynasty was on the throne of Delhi, and another Afghán king was ruling over Bengal. Ahmadábád in Guzerat, Gulbargah, Bíjapur, Ahmadnagar, and Ellichpur in the Deccan were each the capital of an independent Mahometan kingdom; while the Hindu rájá of Vijayanagar was recognized as paramount over the entire south, and was perhaps the most powerful monarch to be found at that time in all India. Neither Mughal nor Marhattá had yet appeared above the political horizon.

After staying nearly six months on the Malabar coast, Da Gama returned to Europe by the same route as he had come, bearing with him the following letter from the zamorin to the king of Portugal: "Vasco da Gama, a nobleman of your household, has visited my kingdom and has given me great pleasure. In my kingdom there is abundance of cinnamon, cloves, ginger, pepper, and precious stones. What I seek from thy country is gold, silver, coral, and scarlet." The arrival of Da Gama at Lisbon was celebrated with national rejoicings scarcely less enthusiastic than had greeted the return of Columbus. If the West Indies belonged to Spain by priority of discovery, Portugal might claim the East Indies by the same right. Territorial ambition conspired with the spirit of proselytism and with the greed of commerce to fill all Portuguese minds with the dream of a mighty Oriental empire. The early Portuguese discoverers were not traders or private adventurers, but admirals with a royal commission to conquer territory and promote the spread of Christianity A second expedition, consisting of thirteen ships and twelve hundred soldiers, under the command of Cabral, was despatched in 1500. "The sum of his instructions was to begin with preaching, and, if that failed, to proceed to the sharp determination of the sword." On his outward voyage Cabral was driven by stress of weather to the coast of Brazil. Ultimately he reached Calicut, and established factories both there and at Cochin, in the face of active hostility from the natives. In 1502 the king of Portugal obtained from Pope Alexander VI. a bull constituting him "lord of the navigation, conquests, and trade of Ethiopia, Arabia, Persia, and India." In that year Vasco da Gama sailed again to the East, with a fleet numbering twenty vessels. He formed an alliance with the rájás of Cochin and Cananore against the zamorin of Calicut, and bombarded the latter in his palace. In 1503 the great Alfonso d'Albuquerque is first heard of, as in command of one of three expeditions from Portugal. In 1505 a large fleet of twenty-two sail and fifteen thousand men was sent under Francisco de Almeida, the first Portuguese governor and viceroy of India. In 1509 Albuquerque succeeded as governor, and widely extended the area of Portuguese influence. Having failed in an attack upon Calicut, he seized Goa, which has ever since remained the capital of Portuguese India. Then, sailing round Ceylon, he captured Malacca, the key of the navigation of the Indian archipelago, and opened a trade with Siam and the Spice Islands. Lastly, he sailed back westwards, and, after penetrating into the Persian Gulf and the Red Sea, returned to Goa only to die in 1515. In 1524 Vasco da Gama came out to the East for the third time, and he too died at Cochin. For exactly a century, from 1500 to 1600, the Portuguese enjoyed a monopoly of Oriental trade.

"From Japan and the Spice Islands to the Red Sea and the Cape of Good Hope, they were the sole masters and dispensers of the treasures of the east; while their possessions along the Atlantic coast of Africa and in Brazil complete their maritime empire. But they never commanded the necessary resources either of military strength or personal character for its maintenance and defence. They were also in another way unprepared for the commerce of which they thus obtained the control. Their national character had been formed in their secular contest with the Moors, and above all things they were knights errant and crusaders, who looked on every pagan as an enemy at once of Portugal and of Christ. It is impossible for any one who has not read the contemporary narratives of their discoveries and conquests to conceive the grossness of the superstition and the cruelty with which the whole history of their exploration and subjugation of the Indies is stained. Albuquerque alone endeavoured to conciliate the good will of the natives, and to live in friendship with the Hindu princes, who were naturally better pleased to have the Portuguese, as governed by him, for their neighbours and allies than the Mahometans whom he had expelled or subdued. The justice and magnanimity of his rule did as much to extend and confirm the power of the Portuguese in the East as the courage and success of his military achievements; and in such veneration was his memory held by the Hindus, and even by the Mahometans, in Goa that they were accustomed to repair to his tomb, and there utter their complaints, as if in the presence of his shade, and call upon God to deliver them from the tyranny of his successors. The cruelties of Soarez, Sequeyra, Menezes, Da Gama, and succeeding viceroys drove the natives to desperation, and encouraged the princes of western India in 1567 to form a league against the Portuguese, in which they were at once joined by the king of Achin. Their undisciplined armies were not able to stand against the veteran soldiers of Portugal, 200 of whom, at Malacca, utterly routed and put to flight a force of 15,000 of the enemy. When, in 1578, Malacca was again besieged by the king of Achin, the small garrison of Portuguese succeeded in inflicting a loss on him of 10,000 men and all his cannon and junks. Twice again, in 1615 and for the last time in 1628, it was besieged, and on each occasion the Achinese were repulsed with equal bravery and good fortune. But these incessant attacks on the Portuguese evinced the decline of their empire, while the increased military forces sent out to the East proved an insupportable drain on the revenues and population of Portugal.

"In 1580 the crown of Portugal, consequent on the death of King Sebastian, became united with that of Spain, under Philip II.,—an event which proved the last fatal blow to the maritime and commercial supremacy of Portugal. It proved fatal in many ways, but chiefly because the interests of Portugal in Asia were subordinated to the European interests of Spain. In 1640 Portugal again became a separate kingdom, but in the meanwhile the Dutch and English had appeared in the Eastern Seas, and before their indomitable competition the Portuguese trade and dominion of the Indies withered away as rapidly as it had sprung up. The period of the highest development of Portuguese commerce was probably from 1590 to 1610, on the eve of the subversion of their political power by the Dutch, and when their political administration in India was at its lowest depth of degradation. At this period a single fleet of Portuguese merchantmen sailing from Goa to Cambay or Surat would number as many as 150 or 250 'carracks.' Now only one Portuguese ship sails from Lisbon to Goa in the year."

The only remaining Portuguese possessions in India are Goa, Daman, and Diu, all on the west coast, with an area of 1086 square miles and a population of 407,712 souls. The general census of 1871 also returned 426 Portuguese dwelling in British India, not including those of mixed descent, of whom about 30,000 are found in Bombay and 20,000 in Bengal, chiefly in the neighbourhood of Dacca and Chittagong. The latter are known as Firinghis; and, excepting that they retain the Roman Catholic faith and European surnames, are scarcely to be distinguished either by colour or by habits of life from the natives among whom they live.

Dutch settlements. The Dutch were the first European nation to break through the Portuguese monopoly. During the 16th century Bruges, Antwerp, and Amsterdam became successively the great emporia whence Indian produce, imported by the Portuguese, was distributed to Germany and even to England. At first the Dutch, following in the track of the English, attempted to find their way to India by sailing round the north coasts of Europe and Asia. William Barents is honourably known as the leader of three of these arctic expeditions, in the last of which he perished. The first Dutchman to double the Cape of Good Hope was Cornelius Houtman, who reached Sumatra and Bantam in 1596. Forthwith private companies for trade with the East were formed in many parts of the United Provinces, but in 1602 they were all amalgamated by the states-general into "The Dutch East India Company." Within a few years the Dutch had established factories on the continent of India, in Ceylon, in Sumatra, on the Persian Gulf, and on the Red Sea, besides having obtained exclusive possession of the Moluccas. In 1618 they laid the foundation of the city of Batavia in Java, to be the seat of the supreme government of the Dutch possessions in the East Indies, which had previously been at Amboyna. At about the same time they discovered the coast of Australia, and in North America founded the city of New Amsterdam or Manhattan, now New York. During the 17th century the Dutch maritime power was the first in the world. The massacre of Amboyna in 1623 led the English East India Company to retire from the Eastern seas to the continent of India, and thus, though indirectly, contributed to the foundation of the British Indian empire. The long naval wars and bloody battles between the English and the Dutch within the narrow seas were not terminated until William of Orange united the two crowns in 1689. In the far East the Dutch ruled without a rival, and gradually expelled the Portuguese from almost all their territorial possessions. In 1635 they occupied Formosa; in 1640 they took Malacca, a blow from which the Portuguese never recovered; in 1651 they founded a colony at the Cape of Good Hope, as a half-way station to the East; in 1658 they captured Jaffnapatam, the last stronghold of the Portuguese in Ceylon; in 1664 they wrested from the Portuguese all their earlier settlements on the pepper-bearing coast of Malabar. The rapid and signal downfall of the Dutch colonial empire is to be explained by its short-sighted commercial policy. It was deliberately based upon a monopoly of the trade in spices, and remained from first to last destitute of the true imperial spirit. Like the Phœnicians of old, the Dutch stopped short of no acts of cruelty towards their rivals in commerce; and, like the Phœnicians, they failed to introduce a respect for their own higher civilization among the natives with whom they came in contact. The knell of Dutch supremacy was sounded by Clive, when in 1758 he attacked the Dutch at Chinsurah both by land and water, and forced them to an ignominious capitulation. In the great French war from 1781 to 1811 England wrested from Holland every one of her colonies, though Java was restored in 1816 and Sumatra in exchange for Malacca in 1824. At the present time the Dutch flag flies nowhere on the mainland of India, though the quaint houses and regular canals at Chinsurah, at Negapatam, at Jaffnapatam, and at many petty ports on the Coromandel and Malabar coasts, remind the traveller of familiar scenes in the Netherlands. In the census of 1872 only seventy Dutchmen were enumerated throughout the whole of India.

English maritime expeditions. The earliest English attempts to reach India were made by the North-West Passage. In 1496 Henry VII. granted letters patent to John Cabot and his three sons (of whom one was the better known Sebastian) to fit out two ships for the exploration of that route. They failed, but discovered the island of Newfoundland, and sailed along the coast of America from Labrador to Virginia. In 1553 the ill-fated Sir Hugh Willoughby attempted to force a passage along the north of Europe and Asia, the successful accomplishment of which has been reserved for a Swedish savant of our own generation. Sir Hugh perished miserably, but his second in command, Chancellor, reached a harbour on the White Sea, now Archangel. Thence he penetrated by land to the court of the grand-duke of Moscow, and laid the foundation of "the Russia Company for carrying on the overland trade between India, Persia, Bokhara, and Moscow." Many subsequent attempts were made at the North-West Passage from 1576 to 1616, which have left on our modern maps the imperishable names of Frobisher, Davis, Hudson, and Baffin. Meanwhile, in 1577, Sir Francis Drake had circumnavigated the globe, and on his way home had touched at Ternate, one of the Moluccas, the king of which island agreed to supply the English nation with all the cloves it produced. "The first Englishman who actually visited India was Thomas Stephens, in 1579, unless there be any foundation in fact for the statement of William of Malmesbury, that in the year 883 Sighelmus of Sherborne, being sent by King Alfred to Rome with presents to the pope, proceeded from thence to the East Indies to visit the tomb of St Thomas at Mylapore (Mailapur, also called Saint Thomé, a suburb of Madras), and brought back with him a quantity of jewels and spices. Stephens was educated at New College, Oxford, and was rector of the Jesuits' College in Salsette. His letters to his father are said to have roused great enthusiasm in England to trade directly with India.

Overland expeditions. In 1583 three English merchants, Ralph Fitch, James Newberry, and Leedes, went out to India overland as mercantile adventurers. The jealous Portuguese threw them into prison at Ormuz, and again at Goa. At length Newberry settled down as a shopkeeper at Goa, Leedes entered the service of the Great Mughal, and Fitch, after a lengthened peregrination in Ceylon, Bengal, Pegu, Siam, Malacca, and other parts of the East Indies, returned to England."

The defeat of the "Invincible Armada" in 1588, at which time the crowns of Spain and Portugal were united, gave a fresh stimulus to maritime enterprise in England; and the successful voyage of Cornelius Houtman in 1596 showed the way round the Cape of Good Hope into waters hitherto monopolized by the Portuguese

East India Company. The foundation of the English East India Company was on this wise:—"In 1599 the Dutch, who had now firmly established their trade in the East, having raised the price of pepper against us from 3s. per lb to 6s. and 8s., the merchants of London held a meeting on the 22d September at Founders' Hall, with the lord mayor in the chair, and agreed to form an association for the purpose of trading directly with India. Queen Elizabeth also sent Sir John Mildenhall by Constantinople to the Great Mughal to apply for privileges for the English company, for which she was then preparing a charter, and on the 31st December 1600 the English East India Company was incorporated by royal charter under the title of 'The Governor and Company of Merchants of London trading to the East Indies.'" The original company had only one hundred and twenty-five shareholders, and a capital of £70,000, which was raised to £400,000 in 1612, when voyages were first undertaken on the joint-stock account. Courten's association, known also as "The Assada Merchants," from a factory founded by them in Madagascar, was established in 1635, but, after a period of internecine rivalry, united with the London Company in 1650. In 1655 the "Company of Merchant Adventurers" obtained a charter from Cromwell to trade with India, but united with the original company two years later. A more formidable rival subsequently appeared in the English company, or "General Society trading to the East Indies," which was incorporated under powerful patronage in 1698, with a capital of 2 millions sterling. According to Evelyn, in his *Diary* for March 5, 1698, "the old East India Company lost their business against the new company by ten votes in parliament, so many of their friends being absent, going to see a tiger baited by dogs." However, a compromise was speedily effected through the arbitration of Lord Godolphin in 1702, and the London and the English companies were finally amalgamated in 1709, under the style of "The United Company of Merchants of England trading to the East Indies." At the same time the Company advanced a loan to the state of £3,190,000 at 3 per cent. interest, in consideration of the exclusive privilege to trade to all places between the Cape of Good Hope and the Straits of Magellan.

The early voyages of the Company, from 1600 to 1612, are distinguished as the "separate voyages," twelve in number. The subscribers individually bore the expenses of each voyage, and reaped the whole profits. With the exception of the fourth, all these separate voyages were highly prosperous, the profits hardly ever falling below 100 per cent. After 1612 the voyages were conducted on the joint-stock account.

The following chronological sketch of the progress of the Company in the East is quoted almost verbatim from Dr Birdwood's valuable report:—

"The English were everywhere opposed from the first, as the Dutch had been, by the Portuguese; but James Lancaster succeeded in the first voyage (1602) in establishing commercial relations with the king of Achin, and at Priaman in the island of Sumatra, and with the Moluccas, and at Bantam, where he settled a factory or 'House of Trade' in 1603. In 1604 the Company undertook their second voyage, commanded by Sir Henry Middleton, who extended their trade to Banda and Amboyna. The success of these voyages was so great that it induced a number of private merchants to endeavour to obtain a participation in the trade; and in 1606 James I. granted a licence to Sir Edward Michelborne and others to trade 'to Cathay, China, Japan, Corea, and Cambaya.' Michelborne, however, on arriving in the East, instead of exploring new sources of commerce as the East India Company were doing, followed the pernicious example of the Portuguese in plundering the native traders among the islands of the Indian Archipelago. He in this way secured a considerable booty, but brought great disgrace on the British name, and much hindered the Company's business at Bantam. In 1608 Captain D. Middleton, in command of the fifth voyage, was prevented by the Dutch from trading at Banda, but succeeded in obtaining a cargo at Pulo Way. In that year also Captain Hawkins in the third voyage, commanded by Captain Keeling, proceeded from Surat as envoy from James I. and the East India Company to the court of the Great Mughal. He was graciously received by the emperor (Jahángír), and remained three years at Agra. In 1609 Captain Sharpey, who had conducted the fourth voyage, obtained the grant of free trade at Aden, and a cargo of pepper at Priaman. In that year also the Company constructed the dockyard at Deptford,—which was the beginning, observes Sir William Monson, 'of the increase of great ships in England.' In 1611 Sir Henry Middleton, in command of the sixth voyage, arrived before Cambay, and resolutely fought the Portuguese, who tried to beat him off, and obtained some important concessions from the native powers. In 1610-11 also Captain Hippon, commanding the seventh voyage, succeeded in establishing agencies at Masulipatam and in Siam, and at Patania or Patany on the Malay peninsula, and a factory at Pettipollee.

"In 1614 the Company's fleet, of the tenth voyage, under Captain Best, was attacked off Swalley, the port of Surat, at the mouth of the river Tápti, by an overwhelming force of Portuguese, who were utterly defeated in four successive engagements, to the great astonishment of the natives, who had hitherto considered them to be invincible. The first fruit of that decisive victory was the settlement of a factory at Surat, with subordinate agencies at Gogra, Ahmadábád, and Cambay. Trade was also opened with the Persian Gulf. In 1614 an agency was established by Mr Edwards of the Surat factory at Ajmír. In 1615 Sir Thomas Roe was sent out by James I. as ambassador to the court of Jahángír, and succeeded in placing the Company's trade in the Mughal dominions on a more favourable footing. The factory at Surat was the chief seat of the Company's government in western India until the presidency was transferred to Bombay in 1685. In 1618 the English established a factory at Mocha, while the Dutch compelled them to resign all pretensions to the Spice Islands. In that year also the Company failed in its attempt to open a trade with Dabul, Baticola, and Calicut, through a want of sincerity on the part of the zamorin. In 1619 it was permitted to settle a factory and build a fort at Jask, in the Persian Gulf.

"In 1619 also the 'Treaty of Defence' with the Dutch, to prevent disputes between the English and Dutch companies, was ratified. When it was proclaimed in the East, hostilities solemnly ceased for the space of an hour, while the Dutch and English fleets, dressed out in all their flags and with yards manned, saluted each other; but the treaty ended in the smoke of that stately salutation, and perpetual and fruitless contentions between the Dutch and English companies went on the same as ever. Up to that time the English company did not possess any portion of territory in sovereign right in the Indies, excepting in the island of Lantore or Great Banda. That island was governed by a commercial agent of the Company, who had under him thirty Europeans as clerks, overseers, and warehousemen; and these, with two hundred and fifty armed Malays, constituted the only force by which it was protected. In the islands of Banda and Pulo Roon and Rosengyn the Company possessed factories, in each of which were ten agents. At Macassar and Achin also they possessed factories or agencies, the whole being subordinate to Bantam. Such was the precarious situation of the English Company in the East at the commencement of their long struggle for commercial equality with the Dutch, whose ascendency in the Indian Archipelago was already firmly established on the basis of territorial dominion and authority. In 1620 the Dutch, notwithstanding the Treaty of Defence concluded the previous year, expelled the English from Pulo Roon and Lantore, and in 1621 from Bantam. The fugitive factors attempted to establish themselves first at Pulicat and afterwards at Masulipatam on the Coromandel coast, but were effectually opposed by the Dutch. In 1620 also the Portuguese made an attack upon the English fleet under Captain Shillinge, but were again defeated with great loss, and from that time the estimation in which the Portuguese were held by the natives of India steadily declined, while that of the English was proportionately raised. In that year the Company established agencies at Agra and Patná. In 1622 the English, joining with the Persians, attacked and took Ormuz from the Portuguese, and obtained from Sháh Abbas a grant in perpetuity of the customs of Gombroon. This was the first time that the English took the offensive against the Portuguese. In the same year the Company succeeded in re-establishing their factory at Masulipatam.

"On the 17th February 1623 occurred the 'Massacre of Amboyna;' and from that time the Dutch remained masters of Lantore and the neighbouring islands, and of the whole trade of the Indian Archipelago, until these islands were recaptured by the English in the great naval wars which commenced in 1793. In 1624 the English, unable to oppose the Dutch, withdrew nearly all their factories from the Archipelago, the Malay peninsula, Siam, and Japan. Some of the factors and agents retired to the island of Lagundy in the Strait of Sunda, but were forced, by its unhealthiness, to abandon it.

"In 1625-26 a factory was established at Armagáon on the Coromandel coast, subordinate to Masulipatam; but in 1628 Masulipatam was, in consequence of the oppressions of the native governor, for a time abandoned in favour of Armagáon, which then mounted twelve guns and had twenty-three factors and agents. In 1629 the factory at Bantam was re-established as an agency subordinate to Surat; and in 1630 Armagáon, reinforced by twenty soldiers, was placed under the presidency of Surat. In 1632 the factory was re-established at Masulipatam, by a firman, known as the 'Golden Firman,' from the king of Golconda. In 1634, by a firman dated February 2, the Company obtained from the Great Mughal liberty to trade in Bengal, without any other restriction than that their ships were to resort only to Pippli in Orissa. The Portuguese were in the same year expelled from Bengal. In 1634-35 Bantam was again raised to an independent presidency, and an agency was established at Tatta, or 'Scindy.' In 1637 Courten's Association (chartered 1635) settled agencies at Goa, Baticola, Kárwár (Carwar), Achin, and Rájápur. Its ships had in 1636 plundered some native vessels at Surat and Diu, which disgraced the Company with the Mughal authorities (who could not comprehend the distinction between the Company and the Association), and depressed the English trade with Surat, while that of the Dutch proportionately increased. In 1638 Armagáon was abandoned as unsuited for commerce; and in 1639-40 Fort St George, Maderaspatam ('Chinnepatam'), was founded by Francis Day, and the factors at Armagáon were at once removed to it. It was made subordinate to Bantam, until raised in 1683 to the rank of a presidency. In 1640 the Company established an agency at Bussorah, and a factory at Kárwár. Trade having much extended, the Company's yard at Deptford was found too small for their ships, and they purchased some copyhold ground at Blackwall, which at that time was a waste marsh, without an inhabitant; and there they opened another dockyard, in which was built the 'Royal George,' of 1200 tons, the largest ship yet seen in England. In 1642 the factories at Balasore and Húglí (Hooghly) were established. In 1645, in consequence of services rendered by Dr Gabriel Broughton, surgeon of the 'Hopewell,' to the emperor Sháh Jahán, additional privileges were granted to the Company; and in 1646 the governor of Bengal, who had also been professionally benefited by Broughton, made concessions which placed the factories at Balasore and Hooghly on a more favourable footing. In 1647 Courten's Association established its colony at Assada, in Madagascar. In 1652 Cromwell declared war against the Dutch on account of their accumulated injuries against the Company. In 1653 the Company's factory at Lucknow was withdrawn. No record has been found of its establishment. In 1658 the Company established a factory at Kásimbázár (Cossimbazar, 'Castle Bazaar'), and their establishments in Bengal were made subordinate to Fort St George instead of Bantam.

"In 1661 Bombay was ceded to the British crown as part of the dower of Catharine of Braganza. It was not delivered up by the Portuguese until 1665, and was transferred to the East India Company in 1668. The seat of the western presidency was removed to it from Surat in 1685. At that time the Company's establishments in the East Indies consisted of the presidency of Bantam, with its dependencies of Jambee, Macassar, and other places in the Indian Archipelago; Fort St George and its dependent factories on the Coromandel coast and Bengal; and Surat, with its affiliated dependency of Bombay, and factories at Broach, Ahmadábád, and other places in western India, and at Gombroon and Bussorah in the Persian Gulf and Euphrates valley. In that year also (1661) the factory at Biliapatam was founded. In 1663 the factories which had been established at Patná, Balasore, and Kásimbázár were ordered to be discontinued, and purchases made only at Hooghly. In 1664 Surat was pillaged by Sivají, but Sir George Oxenden bravely defended the English factory; and the Mughal emperor, in admiration of his conduct, granted the Company an exemption from customs for one year.

"In 1681 Bengal was separated from Madras, and Mr Hodges appointed 'agent and governor' of the Company's affairs 'in the Bay of Bengal, and of the factories subordinate to it at Kásimbázár, Patná, Balasore, Maldah, and Dacca. A corporal of approved fidelity, with twenty soldiers, was to be a guard to the agent's person at the factory of Hooghly, and to act against interlopers.' In 1683 Fort St George (Madras) was constituted a presidency. In 1684 Sir John Child was made 'captain-general and admiral of India,' and Sir John Wyborne 'vice-admiral and deputy governor of Bombay;' and in 1685 the seat of the presidency was transferred from Surat to Bombay. In 1686 the factory at Hooghly was much oppressed by the governor of Bengal, and the Company's business in India generally suffered from the wars of the Mughals and Marhattás. Sir John Child was therefore appointed 'governor-general,' with full power in India to make war or peace, and ordered to proceed to inspect the Company's possessions in Madras and Bengal, and arrange for their safety. On the 20th of December the Company's agent and council quitted the open factory at Hooghly, and retired to Sutanati (Calcutta). Tegnapatam (Fort St David) was first settled in this year (1686), and definitively established in 1691-92. In 1687 the Company retired from all its factories and agencies in Bengal to Madras, but established the settlement of Fort York at Bencoolen. In 1689 the Company's factories at Vizagapatam and Masulipatam were seized by the Mahometans, and the factors massacred. It was in 1689 also that at last the Company determined to consolidate their position in India on the basis of territorial sovereignty, in order to acquire the political status of an independent power in their relations with the Mughals and Marhattás. To this end they passed the following resolution for the guidance of the local governments in India:—'The increase of our revenue is the subject of our care, as much as our trade; 'tis that must maintain our force when twenty accidents may interrupt our trade; 'tis that must make us a nation in India; without that we are but a great number of interlopers, united by His Majesty's royal charter, fit only to trade where nobody of power thinks it their interest to prevent us; and upon this account it is that the wise Dutch, in all their general advices that we have seen, write ten paragraphs concerning their government, their civil and military policy, warfare, and the increase of their revenue, for one paragraph they write concerning trade.'"

It will be convenient to refer in this place to the other European nations who attempted at various times to open trade with the East. The Portuguese at no time attempted to found a company, but always maintained their Eastern trade as a royal monopoly. The first incorporated company was the English, established in 1600, which was quickly followed by the Dutch in 1602. The Dutch conquests, however, were made in the name of the state, and rank as national colonies, not as private possessions. Next came the French, whose first East India Company was formed in 1604, the second in 1611, the third in 1615, the fourth (Richelieu's) in 1642, the fifth (Colbert's) in 1644. The sixth was formed by the union of the French East and West India, Senegal, and China companies under the name of "The Company of the Indies," in 1719. The exclusive privileges of the company were, by the king's decree, suspended in 1769, and the company was finally abolished by the National Assembly in 1796. The first Danish East India Company was founded in 1612, and the second in 1670. The settlements of Tranquebar and Serampur were both founded in 1616, and acquired by the English by purchase from Denmark in 1845. Other Danish settlements on the mainland of India were Porto Novo, and Eddova and Holcheri on the Malabar coast. The company founded by the Scotch in 1695 may be regarded as having been still-born; and the "Royal Company of the Philippine Islands," incorporated by the king of Spain in 1733, had little to do with India proper; of more importance, though but short-lived, was "The Ostend Company," incorporated by the emperor of Austria in 1723, its factors being chiefly persons who had served the Dutch and English companies. But the opposition of the maritime powers forced the court of Vienna in 1727 to suspend the company's charter for seven years. The Ostend company, after passing through a very trying existence, prolonged through the desire of the Austrian Government to participate in the growing East India trade, became bankrupt in 1784, and was finally extinguished by the regulations which were prescribed on the renewal of the English East India Company's charter in 1793. The last nation of Europe to engage in maritime trade with India was Sweden. When the Ostend company was suspended, a number of its servants were thrown out of employment, of whose special knowledge of the East Mr Henry Koning, of Stockholm, took advantage, obtaining a charter for the "Swedish Company," dated June 13, 1731. This company was reorganized in 1806. The extent to which foreign nations now carry on direct dealings with India may be inferred approximately from the following figures, taken from the census report of 1871. There were then in British India about 8000 inhabitants of continental Europe; but of these the nationality of only 2628 was more particularly specified, chiefly in Bengal. Germans numbered 755, French, 631; Portuguese, 426; Italians, 282; Greeks, 127; Swedes, 73; Russians, 72; Dutch, 70; Norwegians, 58; Danes, 45; Spaniards, 32; Belgians, 20; Swiss, 19; Turks, 18.

British Empire (1765 *to* 1881).

The political history of the British in India begins in the 18th century with the French wars in the Carnatic. Fort St George, the nucleus of Madras, was their earliest territorial possession, properly so called, in India, having been founded by Thomas Day in 1639. The land on which it stood, with an area round of about 5 miles in length by 1 mile in breadth, was purchased from the rájá of Chandragiri, who claimed to be the lineal descendant of the Hindu emperors of Vijayanagar. The French settlement of Pondicherri, about 100 miles lower down the Coromandel coast, was established in 1672, and for many years the English and French traded side by side, without either active rivalry or territorial ambition. The English, especially, appear to have been submissive to the native powers at Madras no less than in Bengal. They paid their annual rent of 1200 pagodas (say £500) to the deputies of the Mughal empire when Aurangzeb annexed the south, and on two several occasions bought off a besieging army with a heavy bribe.

On the death of Aurangzeb in 1707, the whole of southern India became practically independent of Delhi. In the Deccan Proper, the Nizám-ul-Mulk founded an independent dynasty, with Hyderabad for its capital, which exercised a nominal sovereignty over the entire south. The Carnatic, or the lowland tract between the central plateau and the eastern sea, was ruled by a deputy of the nizám, known as the nawáb of Arcot, who in his turn asserted claims to hereditary sovereignty. Further south, Trichinopoli was the capital of a Hindu rájá, and Tanjore formed another Hindu kingdom under a degenerate descendant of the line of Sivají. Inland, Mysore was gradually growing into a third Hindu state, while everywhere local chieftains, called *pálegárs* or *naiks*, were in semi-independent possession of citadels or hill-forts.

French and English wars.

In that condition of affairs the flame of war was kindled between the English and the French in Europe in 1745. Dupleix was at that time governor of Pondicherri, and Clive was a young writer at Madras. An English fleet first appeared on the Coromandel coast, but Dupleix by a judicious present induced the nawáb of Arcot to interpose and prevent hostilities. In 1746 a French squadron arrived, under the command of La Bourdonnais. Madras surrendered almost without a blow, and the only settlement left to the English was Fort St David, a few miles south of Pondicherri, where Clive and a few other fugitives sought shelter. The nawáb, faithful to his policy of impartiality, marched with 10,000 men to drive the French out of Madras, but he was signally defeated by a French force of only four hundred men and two guns. In 1748 an English fleet arrived under Admiral Boscawen and attempted the siege of Pondicherri, while a land force co-operated under Major Lawrence, whose name afterwards became associated with that of Clive. The French successfully repulsed all attacks, and at last peace was restored by the treaty of Aix-la-Chapelle, which gave back Madras to the English (1748).

The first war with the French was merely an incident in the greater contest in Europe. The second war had its origin in Indian politics, while England and France were at peace. The easy success of the French arms had inspired Dupleix with the ambition of founding a French empire in India, under the shadow of the existing Mahometan powers. Disputed successions at Hyderabad and at Arcot supplied him with the opportunity that he lacked. On both thrones he placed nominees of his own, and for a short time posed as the supreme arbiter of the entire south. In boldness of conception, and in knowledge of Oriental diplomacy, Dupleix has had probably no rival. But he was no soldier, and he was destined in that sphere to encounter the "heaven-born genius" of Clive. For the English of Madras, under the instinct of self-preservation, were compelled to maintain the cause of another candidate to the throne of Arcot in opposition to the nominee of Dupleix. This candidate was Muhammad Alí, afterwards known in history as Wála-jah. The war that then ensued between the French and English, each with their native allies, has been exhaustively described in the pages of Orme. The one incident that stands out conspicuously is the capture and subsequent defence of Arcot by Clive in 1751. This heroic feat, even more than the battle of Plassey, established the reputation of the English for valour throughout India. Shortly afterwards Clive returned to England in ill-health, but the war continued fitfully for many years. On the whole, English influence predominated in the Carnatic, and their candidate, Muhammad Alí, maintained his position at Arcot. But the French were no less supreme in the Deccan, whence they were able to take possession of the coast tract called "the Northern Circars." The final struggle was postponed until 1760, when Colonel (afterwards Sir Eyre) Coote won the decisive victory of Wandewash over the French general Lally, and proceeded to invest Pondicherri, which was starved into capitulation in January 1761. A few months later the hill-fortress of Gingee (Chenji) also surrendered. In the words of Orme, "That day terminated the long hostilities between the two rival European powers in Coromandel, and left not a single ensign of the French nation avowed by the authority of its Government in any part of India."

Cliv[e]

Meanwhile the interest of history shifts with Clive to Bengal. The first English settlement in that part of India was Pippli in Orissa, to which the East India Company was permitted to trade in 1633, six years before the foundation of Madras. The river on which Pippli stood has since silted up, and the very site of the English settlement is now unknown and undiscoverable. In 1642 factories were opened at Balasore and Húglí (Hooghly), and in 1681 Bengal was erected into a presidency, as yet subject to Madras. The name of Calcutta is not heard of till 1686, when Job Charnock, the chief at Hooghly, was expelled by the deputy of Aurangzeb, and settled lower down the river on the opposite bank. There he acquired a grant of the three petty villages of Sutanati, Gobindpur, and Kálíghát (Calcutta), and founded the original Fort William in 1696.

Calc[utta]

At the time of Aurangzeb's death in 1707 the nawáb or governor of Bengal was Murshid Kulí Khán, known also

Ben[gal] naw[ábs]

in European history as Jafar Khán. By birth a Bráhman, and brought up as a slave in Persia, he united the administrative ability of a Hindu to the fanaticism of a renegade. Hitherto the capital of Bengal had been at Dacca on the eastern frontier of the empire, whence the piratical attacks of the Portuguese and of the Arakanese or Maghs could be most easily checked. Murshid Kulí Khán transferred his residence to Murshidábád (Moorshedabad), in the neighbourhood of Kásimbázár (Cossimbazar), the river port of all the Ganges trade. The English, the French, and the Dutch had each factories at Kásimbázár, as well as at Dácca, Patná, and Maldah. But Calcutta was the headquarters of the English, Chandarnagar of the French, and Chinsurah of the Dutch, all three towns being situated close to each other in the lower reaches of the Hooghly, where the river is navigable for large ships. Murshid Kulí Khán ruled over Bengal prosperously for twenty-one years, and left his power to a son-in-law and a grandson. The hereditary succession was broken in 1740 by Alí Vardi Khán, who was the last of the great nawábs of Bengal. In his days the Marhattá horsemen began to ravage the country, and the English at Calcutta obtained permission to erect an earth-work, which is known to the present day as the Marhattá ditch. Alí Vardi Khán died in 1756, and was succeeded by his grandson, Siráj-ud-Daulá (Surajah Dowlah), a youth of only eighteen years, whose ungovernable temper led to a rupture with the English within two months after his accession. In pursuit of one of his own family who had escaped from his vengeance, he marched upon Calcutta with a large army. Many of the English fled down the river in their ships. The remainder surrendered after a feeble resistance, and were thrown as prisoners into the "black hole" or military jail of Fort William, a room about 18 feet square, with only two small windows barred with iron. It was the month of June, in which the tropical heat of Calcutta is most oppressive. When the door of the prison was opened in the morning, only twenty-three persons out of one hundred and forty-six were found alive.

The news of this disaster fortunately found Clive returned to Madras, where also was a squadron of king's ships under Admiral Watson. Clive and Watson promptly sailed to the mouth of the Ganges with all the troops that could be got together. Calcutta was recovered with little fighting, and the nawáb consented to a peace which restored to the Company all their privileges, and gave them compensation for their losses of property. It is possible that matters might have ended here if a fresh cause of hostilities had not suddenly arisen. War had just been declared between the English and French in Europe, and Clive, following the traditions of his early warfare in the Carnatic, attacked and captured Chandarnagar. Siráj-ud-Daulá, exasperated by that breach of neutrality within his own dominions, took the side of the French. But Clive, again acting upon the policy he had learned from Dupleix, had provided himself with a rival candidate to the throne. Undaunted, he marched out to the battlefield of Plassey (Palási), at the head of about 1000 Europeans and 2100 sepoys, with 9 pieces of artillery. The Mahometan army is said to have consisted of 50,000 foot, 18,000 horse, and 50 pieces of cannon. But there was a traitor in the Mahometan camp in the person of Mír Jafar, who had married a sister of the late nawáb, Alí Vardi Khán. The battle was short but decisive. After a few rounds of artillery fire, Suráj-ud-Daulá fled, and the road to Murshidábád was left open.

The battle of Plassey was fought on June 23, 1757, an anniversary afterwards remembered when the mutiny was at its height in 1857. History has agreed to adopt this date as the beginning of the British empire in the East; but the immediate results of the victory were comparatively small, and several more hard-won fights were fought before even the Bengalis would admit the superiority of the British arms. For the moment, however, all opposition was at an end. Clive, again following in the steps of Dupleix, placed his nominee, Mír Jafar, upon the *masnad* at Murshidábád, being careful to obtain a patent of investiture from the Mughal court. Enormous sums were exacted from Mír Jafar as the price of his elevation. The Company claimed 10,000,000 rupees as compensation for losses; for the English, the Indian, and the Armenian inhabitants of Calcutta there were demanded the sums of 5,000,000, 2,000,000, and 700,000 rupees; for the squadron 2,500,000 rupees, and an equal sum for the army. The members of the council received the following amounts:—Mr Drake, the governor, and Colonel Clive 280,000 rupees each; and Mr Becker, Mr Watts, and Major Kilpatrick 240,000 rupees each. The whole amounted to £2,697,750. The English, deluded by their avarice, still cherished extravagant ideas of Indian wealth; nor would they listen to the ungrateful truth. But it was found that there were no funds in the treasury to satisfy their inordinate demands, and they were obliged to be contented with one-half the stipulated sums, which, after many difficulties, were paid in specie and in jewels, with the exception of 584,905 rupees. The shares of the council were, however, paid in full. At the same time the nawáb made a grant to the Company of the *zamíndárí* rights over an extensive tract of country round Calcutta, now known as the district of the Twenty-four Parganás. The area of this tract was about 882 square miles, and it paid a permanent revenue or quit rent of about £23,000. The gross rental at first payable to the Company was £53,000, but within a period of ten years it had risen to £146,000. Originally the Company possessed only the *zamíndárí* rights, *i.e.*, revenue jurisdiction. The superior lordship, or right to receive the quit rent, remained with the nawáb; but in 1759 this also was parted with by the Delhi emperor, the nominal suzerain of the nawáb, in favour of Clive, who thus became the landlord of his own masters, the Company. At that time also Clive was enrolled among the nobility of the Mughal empire, with the rank of commander of 6000 foot and 5000 horse. Clive's *jagír*, as it was called, subsequently became a matter of inquiry in England, and on his death it passed to the Company, thus merging the *zamíndárí* in the proprietary rights.

In 1758 Clive was appointed by the court of directors the first governor of all the Company's settlements in Bengal. From two quarters troubles threatened, which perhaps Clive alone was capable of overcoming. On the west the *sháhzáda* or imperial prince, known afterwards as the emperor Sháh Alam, with a mixed army of Afgháns and Marhattás, and supported by the nawáb wazír of Oudh, was advancing his own claims to the province of Bengal. In the south the influence of the French under Lally and Bussy was overshadowing the British at Madras. But the name of Clive exercised a decisive effect in both directions. Mír Jafar was anxious to buy off the sháhzáda, who had already invested Patná. But Clive in person marched to the rescue, with an army of only 450 Europeans and 2500 sepoys, and the Mughal army dispersed without striking a blow. In the same year Clive despatched a force southwards under Colonel Forde, which recaptured Masulipatam from the French, and permanently established British influence throughout the Northern Circars, and at the court of Hyderabad. He next attacked the Dutch, the sole European nation that might yet be a formidable rival to the English. He defeated them both by land and water; and from that time their settlement at Chinsurah existed only on sufferance.

Influence of E.I.C.

From 1760 to 1765, while Clive was at home, the history of the English in Bengal contains little that is creditable. Clive had left behind him no system of government, but merely the tradition that unlimited sums of money might be extracted from the natives by the mere terror of the English name. In 1761 it was found expedient and profitable to dethrone Mír Jafar, the English nawáb of Murshidábád, and substitute his son-in-law, Mír Kásim, in his place. On that occasion, besides private donations, the English received a grant of the three districts of Bardwán, Midnapur, and Chittagong, estimated to yield a net revenue of half a million sterling. But Mír Kásim proved to possess a will of his own, and to cherish dreams of independence. He retired from Murshidábád to Monghyr, a strong position on the Ganges, which commanded the only means of communication with the west. There he proceeded to organize an army, drilled and equipped after European models, and to carry on intrigues with the nawáb wazír of Oudh. The actual outbreak of hostilities with the English happened on this wise. The Company's servants claimed the privilege of carrying on private trade throughout Bengal, free from inland dues and all other imposts. The assertion of this claim caused frequent affrays between the customs' officers of the nawáb and those traders who, whether falsely or not, represented that they were acting on behalf of the servants of the Company. The nawáb alleged that his civil authority was everywhere being set at nought. The majority of the council at Calcutta would not listen to his statements. The governor, Mr Vansittart, and Warren Hastings, then a junior member of council, attempted to effect some compromise. But the controversy had become too hot. The nawáb's officers fired upon an English boat, and forthwith all Bengal was in a blaze. A force of 2000 sepoys was cut to pieces at Patná, and about 200 Englishmen in various parts of the province fell into the hands of the Mahometans, and were subsequently massacred. But as soon as regular warfare commenced Mír Kásim met with no more successes. His trained regiments were defeated in two pitched battles by Major Adams, at Gheriah and at Udha-nálá, and he himself took refuge with the nawáb wazír of Oudh, who refused to deliver him up. This led to a prolongation of the war. Sháh Alam, who had now succeeded his father as emperor, and Shujá-ud-Daulá, the nawáb wazír of Oudh, united their forces, and threatened Patná, which the English had recovered. A more formidable danger appeared in the English camp, in the form of the first sepoy mutiny. This was quelled by Major (afterwards Sir Hector) Munro, who ordered twenty-four of the ringleaders to be blown from guns, an old Mughal punishment. In 1764 Major Munro won the decisive battle of Baxár, which laid Oudh at the feet of the conquerors, and brought the Mughal emperor as a suppliant to the English camp.

Massacre of Patná.

Meanwhile the council at Calcutta had twice found the opportunity they desired of selling the government of Bengal to a new nawáb. But in 1765 Clive (now Baron Clive of Plassey, in the peerage of Ireland) arrived at Calcutta, as governor of Bengal for the second time, to settle the entire system of relations with the native powers. Two objects stand out conspicuously in his policy. First, he sought to acquire the substance, though not the name, of territorial power, by using the authority of the Mughal emperor for so much as he wished, and for no more; and, secondly, he desired to purify the Company's service by prohibiting illicit gains, and at the same time guaranteeing a reasonable remuneration from honest sources. In neither respect were the details of his plans carried out by his successors. But the beginning of our Indian administration dates from this second governorship of Clive, just as the origin of our Indian empire dates from his victory at Plassey. Clive's first step was to hurry up from Calcutta to Allahábád, and there settle in person the fate of nearly half India. Oudh was given back to the nawáb wazír, on condition of his paying half a million sterling towards the expenses of the war. The provinces of Allahábád and Kora, forming the greater part of the Doáb, were handed over to Sháh Alam himself, who in his turn granted to the Company the *díwání* or financial administration of Bengal, Behar, and Orissa, and also the territorial jurisdiction of the Northern Circars. A puppet nawáb was still maintained at Murshidábád, who received an annual allowance of about half a million sterling; and half that amount was paid to the emperor as tribute from Bengal. Thus was constituted the dual system of government, by which the English received all the revenues and undertook to maintain an army for the defence of the frontier, while the criminal jurisdiction vested in the nawáb. In Indian phraseology, the Company was diwán and the nawáb was nizám. As a matter of general administration, the actual collection of the revenues still remained for some years in the hands of native officials. In attempting to reorganize and purify the Company's service, Clive undertook a task yet more difficult than to partition the valley of the Ganges. The officers, civil and military alike, were all tainted with the common corruption. Their legal salaries were absolutely insignificant, but they had been permitted to augment them ten and a hundredfold by means of private trade and gifts from the native powers. Despite the united resistance of the civil servants, and an actual mutiny of two hundred military officers, Clive carried through his reforms. Both private trade and the receipt of presents were absolutely prohibited for the future, while a substantial increase of pay was provided out of the monopoly of salt.

Wa[rren] Ha[stings].

Lord Clive quitted India for the third and last time in 1767. Between that date and the arrival of Warren Hastings in 1772 nothing of importance occurred in Bengal beyond the terrible famine of 1770, which is officially reported to have swept away one-third of the inhabitants. The dual system of government, however, established by Clive, had proved a failure. Warren Hastings, a tried servant of the Company, distinguished alike for intelligence, for probity, and for knowledge of Oriental manners, was nominated governor by the court of directors, with express instructions to carry out a predetermined series of reforms. In their own words, the court had resolved to "stand forth as diwán, and to take upon themselves, by the agency of their own servants, the entire care and administration of the revenues." In the execution of this plan, Hastings removed the exchequer from Murshidábád to Calcutta, and for the first time appointed European officers, under the now familiar title of collectors, to superintend the revenue collections and preside in the civil courts. The urgency of foreign affairs, and subsequently internal strife at the council table, hindered Hastings from developing further the system of civil administration, a task finally accomplished by Lord Cornwallis.

Though Hastings always prided himself specially upon that reform, as well as upon the improvements he introduced into the collection of the revenues from salt and opium, his name will be remembered in history for the boldness and success of his foreign policy. From 1772 to 1774 he was governor of Bengal; from 1774 to 1785 he was the first titular governor-general of India, presiding over a council nominated, like himself, not by the Company, but by an Act of Parliament, known as the Regulating Act. In his domestic policy he was greatly hampered by the opposition of Francis; but, so far as regards external relations with Oudh, with the

Marhattás, and with Hyder Ali, he was generally able to compel assent to his own measures. His treatment of Oudh may here be passed over as not being material to the general history of India, while the personal aspects of his rule have been fully discussed in a separate article (vol. xi. p. 512). To explain his Marhattá policy, it will be necessary to give a short retrospective sketch of the history of that people.

Sivají the Great, as already mentioned, died in 1680, while Aurangzeb was still on the throne. The family of Sivají produced no great names, either among those who continued to be the nominal chiefs of the Marhattá confederacy, with their capital at Sátárá, or among the rájás of Kolhapur and Tanjore. All real power passed into the hands of the peshwá, or Bráhman minister, who founded in his turn an hereditary dynasty at Poona, dating from the beginning of the 18th century. Next rose several Marhattá generals, who, though recognizing the suzerainty of the peshwá, carved out for themselves independent kingdoms in different parts of India, sometimes far from the original home of the Marhattá race. Chief among these generals were the gáikwár in Guzerat, Sindhia, and Holkar in Málwa, and the Bhonslá rájá of Berar and Nágpur. At one time it seemed probable that the Marhattá confederacy would expel the Mahometans even from northern India; but the decisive battle of Pánipat, won by the Afgháns in 1761, gave a respite to the Delhi empire. The Marhattá chiefs never again united heartily for a common purpose, though they still continued to be the most formidable military power in India. In especial, they dominated over the British settlement of Bombay on the western coast, which was the last of the three presidencies to feel the lust of territorial ambition. For more than a hundred years, from its acquisition in 1661 to the outbreak of the first Marhattá war in 1775, the English on the west coast possessed no territory outside the island of Bombay and their fortified factory at Surat.

ssions the m- ny.

The Bombay Government was naturally emulous to follow the example of Madras and Bengal, and to establish its influence at the court of Poona by placing its own nominee upon the throne. The attempt took form in 1775 in the treaty of Surat, by which Raghunáth Ráo, one of the claimants to the throne of the peshwá, agreed to cede Salsette and Bassein to the English, in consideration of being himself restored to Poona. The military operations that followed are known as the first Marhattá war. Warren Hastings, who in his capacity of governor-general claimed a right of control over the decisions of the Bombay Government, strongly disapproved of the treaty of Surat, but, when war once broke out, he threw the whole force of the Bengal army into the scale. One of his favourite officers, General Goddard, marched across the peninsula from sea to sea, and conquered the rich province of Guzerat almost without a blow. Another, Captain Popham, stormed the rock-fortress of Gwalior, which was regarded as the key of Hindustán. Those brilliant successes atoned for the disgrace of the convention of Wargaum in 1779, when the Marhattás dictated terms to a British force, but the war was protracted until 1782. It was then closed by the treaty of Salbye, which practically restored the *status quo*. Raghunáth Ráo, the English claimant, was set aside; Guzerat was restored, and only Salsette and some other small islands were retained by the English.

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Meanwhile Warren Hastings had to deal with a more formidable enemy than the Marhattá confederacy. The reckless conduct of the Madras Government had roused the hostility both of Hyder Ali of Mysore and of the nizám of the Deccan, the two strongest Musalmán powers in India, who attempted to draw the Marhattás into an alliance against the English. The diplomacy of Hastings won over the nizám and the Marhattá rájá of Nágpur, but the army of Hyder Ali fell like a thunderbolt upon the British possessions in the Carnatic. A strong detachment under Colonel Baillie was cut to pieces at Pollilore, and the Mysore cavalry ravaged the country unchecked up to the walls of Madras. For the second time the Bengal army, stimulated by the energy of Hastings, saved the honour of the English name. Sir Eyre Coote, the victor of Wandewash, was sent by sea to relieve Madras with all the men and money available, while Colonel Pearse marched south overland to overawe the rájá of Berar and the nizám. The war was hotly contested, for Sir Eyre Coote was now an old man, and the Mysore army was well-disciplined and equipped, and also skilfully handled by Hyder and his son Tipú (Tippoo). Hyder died in 1782, and peace was finally concluded with Tipú in 1784, on the basis of a mutual restitution of all conquests.

It was Warren Hastings's merit to organize the empire which Clive founded. He was governor or governor-general for thirteen years, a longer period than any of his successors. During that time the English lost the American colonies, but in India their reputation steadily rose to its highest pitch. Within a year Hastings was succeeded by Lord Cornwallis, the first English nobleman of rank who undertook the office of governor-general. His rule lasted from 1786 to 1793, and is celebrated for two events—the introduction of the permanent settlement into Bengal, and the second Mysore war. If the foundations of the system of civil administration were laid by Hastings, the superstructure was erected by Cornwallis. It was he who first entrusted criminal jurisdiction to Europeans, and established the Nizámat Sadr Adálat, or supreme court of criminal judicature, at Calcutta; and it was he who separated the functions of collector and judge. The system thus organized in Bengal was afterwards transferred to Madras and Bombay, when those presidencies also acquired territorial sovereignty.

Corn-wallis.

But the achievement most familiarly associated with the name of Cornwallis is the permanent settlement of the land revenue of Bengal. Up to his time the revenue had been collected pretty much according to the old Mughal system. *Zamíndárs*, or Government farmers, whose office always tended to become hereditary, were recognized as having a right of some sort to collect the revenue from the actual cultivators. But no principle of assessment existed, and the amount actually realized varied greatly from year to year. Hastings had the reputation of bearing hard upon the *zamíndárs*, and was absorbed in other critical affairs of state or of war. On the whole he seems to have looked to experience, as acquired from a succession of quinquennial settlements, to furnish the standard rate of the future. Francis, on the other hand, Hastings's great rival, deserves the credit of being among the first to advocate a limitation of the state demand in perpetuity. The same view recommended itself to the authorities at home, partly because it would place their finances on a more stable basis, partly because it seemed to identify the *zamíndár* with the more familiar landlord. Accordingly, Cornwallis took out with him in 1787 instructions to introduce a permanent settlement. The process of assessment began in 1789 and terminated in 1791. No attempt was made to measure the fields or calculate the out-turn as had been done by Akbar, and is now done when occasion requires in the British provinces; but the amount payable was fixed by reference to what had been paid in the past. At first the settlement was called decennial, but in 1793 it was declared permanent for ever. The total assessment amounted to *sikka* Rs.26,800,989, or about $2\frac{3}{4}$ millions sterling. Though Lord Cornwallis carried the scheme into execution, all praise or blame, so far as details are concerned, must

Permanent settlement.

belong to Sir John Shore, afterwards Lord Teignmouth, whose knowledge of the country was unsurpassed by that of any civilian of his time. Shore would have proceeded more cautiously than Cornwallis's preconceived idea of a proprietary body and the court of directors' haste after fixity permitted.

Second Mysore war. The second Mysore war of 1790–92 is noteworthy on two accounts: Lord Cornwallis, the governor-general, led the British army in person, with a pomp and lavishness of supplies that recalled the campaigns of Aurangzeb; and the two great native powers, the nizám of the Deccan and the Marhattá confederacy, co-operated as allies of the British. In the result, Tipú Sultán submitted when Lord Cornwallis had commenced to beleaguer his capital. He agreed to yield one-half of his dominions to be divided among the allies, and to pay three millions sterling towards the cost of the war. Those conditions he fulfilled, but ever afterwards he burned to be revenged upon his English conquerors.

Wellesley. The period of Sir John Shore's rule as governor-general, from 1793 to 1798, was uneventful. In 1798 Lord Mornington, better known as the marquis of Wellesley, arrived in India, already inspired with imperial projects that were destined to change the map of the country. Mornington was the friend and favourite of Pitt, from whom he is thought to have derived the comprehensiveness of his political vision and his antipathy to the French name. From the first he laid down as his guiding principle that the English must be the one paramount power in the peninsula, and that native princes could only retain the insignia of sovereignty by surrendering the substance of independence. The subsequent political history of India has been but the gradual development of this policy, which received its finishing touch when Queen Victoria was proclaimed empress of India in 1877.

To frustrate the possibility of a French invasion of India, led by Napoleon in person, was the governing idea of Wellesley's foreign policy; for France at this time, and for many years later, filled the place afterwards occupied by Russia in the imagination of English statesmen. Nor was the possibility so remote as might now be thought. French regiments guarded and overawed the nizám of Hyderabad. The soldiers of Sindhia, the military head of the Marhattá confederacy, were disciplined and led by French adventurers. Tipú Sultán carried on a secret correspondence with the French directorate, and allowed a tree of liberty to be planted in his dominions. The islands of Mauritius and Bourbon afforded a convenient half-way house both for French intrigue and for the assembling of a hostile expedition. Above all, Napoleon Buonaparte was then in Egypt, dreaming of the conquests of Alexander; and no man knew in what direction he might turn his hitherto unconquered legions. Wellesley first addressed himself to the nizám, where his policy prevailed without serious opposition. The French battalions at Hyderabad were disbanded, and the nizám bound himself by treaty not to take any European into his service without the consent of the English Government,—a clause since inserted in every engagement entered into with native powers. Next, the whole weight of Wellesley's resources was turned against Tipú, whom Cornwallis had scotched but not killed. His intrigues with the French were laid bare, and he was given an opportunity of adhering to the new subsidiary system.

Third Mysore war. On his refusal war was declared, and Wellesley came down in state to Madras to organize the expedition in person, and watch over the course of events. One English army marched into Mysore from Madras, accompanied by a contingent from the nizám. Another advanced from the western coast. Tipú, after offering but a feeble resistance in the field, retired into Seringapatam, and, when his capital was stormed, died fighting bravely in the breach. Since the battle of Plassey no event so greatly impressed the native imagination as the capture of Seringapatam, which won for General Harris a peerage and for Wellesley an Irish marquisate. In dealing with the territories of Tipú, Wellesley acted with unusual moderation. The central portion, forming the old state of Mysore, was restored to an infant representative of the Hindu rájás, whom Hyder Ali had dethroned, while the rest was partitioned between the nizám, the Marhattás, and the English. At about the same time the province of the Carnatic, or all that large portion of southern India ruled by the nawáb of Arcot, and also the principality of Tanjore, were placed under direct British administration, thus constituting the Madras presidency almost as it has existed to the present day.

Ma[rhattá] con[fede]racy. The Marhattás had been the nominal allies of the English in both their wars with Tipú, but they had never given active assistance, nor were they secured to the English side as the nizám now was. The Marhattá powers at this time were five in number. The recognized head of the confederacy was the peshwá of Poona, who ruled the hill country of the Western Gháts, the cradle of the Marhattá race. The fertile province of Guzerat was annually harried by the horsemen of the gáikwár of Baroda. In Central India two military leaders, Sindhia of Gwalior and Holkar of India, alternately held the pre-eminency. Towards the east the Bhonslá rájá of Nágpur, sprung from the same stock as Sivají, reigned from Berar to the coast of Orissa. Wellesley tried assiduously to bring these several Marhattá powers within the net of his subsidiary system. At last, in 1802, the necessities of the peshwá, who had been defeated by Holkar, and driven as a fugitive into British territory, induced him to sign the treaty of Bassein, by which he pledged himself to hold communications with no other power, European or native, and ceded territory for the maintenance of a subsidiary force. This greatly extended the English territorial influence in the Bombay presidency, but led directly to the second Marhattá war, for neither Sindhia nor the rájá of Nágpur would tolerate this abandonment of Marhattá independence.

Wa[r] wit[h] Sin[dhia,] Ho[lkar,] and of N[ágpur]. The campaigns that followed are perhaps the most glorious in the history of the British arms in India. The general plan and the adequate provision of resources were due to the marquis of Wellesley, as also the indomitable spirit that could not anticipate defeat. The armies were led by Sir Arthur Wellesley (afterwards duke of Wellington) and General (afterwards Lord) Lake. Wellesley operated in the Deccan, where, in a few short months, he won the decisive victories of Assaye and Argaum, and captured Ahmadnagar. Lake's campaign in Hindustán was no less brilliant, though it has received less notice from historians. He won pitched battles at Alígarh and Láswárí, and captured the cities of Delhi and Agra, thus scattering the French troops of Sindhia, and at the same time coming forward as the champion of the Mughal emperor in his hereditary capitals. Before the year 1803 was out, both Sindhia and the Bhonslá rájá were glad to sue for peace. Sindhia ceded all claims to the territory north of the Jumna, and left the blind old emperor Sháh Alam once more under British protection. The Bhonslá forfeited Orissa to the English, who had already occupied it with a flying column, and Berar to the nizám, who gained a fresh addition by every act of complaisance to the British Government. The freebooter, Jaswant Ráo Holkar, alone remained in the field, supporting his troops by ravages through Málwá and Rájputána. The concluding years of Wellesley's rule were occupied with a series of operations against Holkar, which brought no credit on the British name. The disastrous retreat of Colonel Monson through Central India recalled memories of the convention of Wargaum, and of the destruction of Colonel

Baillie's force by Hyder Ali. The repulse of Lake in person at the siege of Bhartpur (Bhurtpore) is memorable as an instance of a British army in India having to turn back with its object unaccomplished.

The ambitious policy and the continuous wars of Lord Wellesley exhausted the patience of the court of directors at home. In 1804 Lord Cornwallis was sent out as governor-general a second time, with instructions to bring about peace at any price, while Holkar was still unsubdued, and Sindhia was threatening a fresh war. But Cornwallis was now an old man and broken down in health. Travelling up to the north-west during the rainy season, he sank and died at Gházípur, before he had been ten weeks in the country. His immediate successor was Sir George Barlow, a civil servant of the Company, who, as a *locum tenens*, had no alternative but to carry out faithfully the orders of his employers. He is charged with being, under these orders, the only governor-general who diminished the area of British territory, and with violating engagements by abandoning the Rájput chiefs to the tender mercies of Holkar and Sindhia. During his administration also occurred the mutiny of the Madras sepoys at Vellore, which, though promptly suppressed, sent a shock of insecurity throughout the empire.

Lord Minto, governor-general from 1807 to 1813, consolidated the conquests which Wellesley had acquired. His only military exploits were the occupation of the island of Mauritius, and the conquest of Java by an expedition which he accompanied in person. The condition of Central India continued to be disturbed, but Minto succeeded in preventing any violent outbreaks without himself having recourse to the sword. The Company had ordered him to follow a policy of non-intervention, and he managed to obey his orders without injuring the prestige of the British name. In his time the Indian Government first opened relations with a new set of foreign powers, by sending embassies to the Punjab, to Afghánistán, and to Persia. The ambassadors were all trained in the school of Wellesley, and formed perhaps the most illustrious trio of "politicals" that the Indian service has produced. Metcalfe was the envoy to the court of Ranjít Sinh at Lahore; Elphinstone met the sháh of Afghánistan at Peshávar; and Malcolm was despatched to Persia. If it cannot be said that any of these missions were fruitful in permanent results, at least they introduced the English to a new set of diplomatic relations, and widened the sphere of their influence.

The successor of Lord Minto was Lord Moira, better known as the marquis of Hastings, who governed India for the long period of nine years, from 1814 to 1823. This period was marked by two wars of the first magnitude, the campaigns against the Gúrkhas (Goorkhas) of Nepál, and the third and last Marhattá war. The Gúrkhas, the present ruling race in Nepál, are Hindu immigrants who claim a Rájput origin. The indigenous inhabitants, called Newars, belong to the Indo-Tibetan stock, and profess Buddhism. The sovereignty of the Gúrkhas dates only from 1767, in which year they overran the valley of Khatmandu, and gradually extended their power over all the hills and valleys of Nepál. Organized upon a sort of military and feudal basis, they soon became a terror to all their neighbours, marching east into Sikkim, west into Kumáun, and south into the Gangetic plains. In the last quarter their victims were British subjects, and at last it became imperatively necessary to check their advance. Sir George Barlow and Lord Minto had remonstrated in vain, and nothing was left to Lord Moira but to take up arms. The campaign of 1814 was little short of disastrous. After overcoming the natural difficulties of a malarious climate and precipitous hills, the sepoys were on several occasions fairly worsted by the unexpected bravery of the little Gúrkhas, whose heavy knives or *kukris* dealt terrible execution. But in 1815 General Ochterlony, who commanded the army operating by way of the Sutlej, stormed one by one the hill forts which still stud the Himálayan states, now under the Punjab government, and compelled the Nepál *darbár* to sue for peace. In the following year the same general advanced from Patná into the valley of Khatmandu, and finally dictated the terms which had before been rejected, within a few miles of the capital. By the treaty of Segauli, which defines the English relations with Nepál to the present day, the Gúrkhas withdrew on the one hand from Sikkim, and on the other from those lower ranges of the western Himálayas which have supplied the health-giving stations of Naini Tál, Massuri, and Simla. Meanwhile the condition of Central India was every year becoming more unsatisfactory. Though the great Marhattá chiefs were learning to live rather as peaceful princes than as leaders of predatory bands, the example of lawlessness they had set was being followed, and bettered in the following, by a new set of freebooters, known as the Pindhárís. As opposed to the Marhattás, who were at least a nationality bound by some traditions of a united government, the Pindhárís were merely irregular soldiers, corresponding most nearly to the free companies of mediæval Europe. Of no common race and of no common religion, they welcomed to their ranks the outlaws and broken tribes of all India,—Afgháns, Marhattás, or Játs. Their headquarters were in Málwá, but their depredations were not confined to Central India. In bands, sometimes numbering a few hundreds, sometimes many thousands, they rode out on their forays as far as Malabar and the Coromandel coast. The most powerful of the Pindhárí captains, Amír Khán, had an organized army of many regiments, and several batteries of cannon. Two other leaders, known as Chitu and Karim, at one time paid a ransom to Sindhia of £100,000. To suppress the Pindhárí hordes, who were supported by the sympathy, more or less open, of all the Marhattá chiefs, Lord Hastings (1817) collected the strongest British army that had been seen in India, numbering nearly 120,000 men, half to operate from the north, half from the south. Sindhia was overawed, and remained quiet. Amír Khán consented to disband his army, on condition of being guaranteed the possession of what is now the principality of Tank. The remaining bodies of Pindhárís were attacked in their homes, surrounded, and cut to pieces. Karim threw himself upon the mercy of the conquerors. Chitu fled to the jungles, and was killed by a tiger. In the same year (1817) as that in which the Pindhárís were crushed, and almost in the same month (November), the three great Marhattá powers at Poona, Nágpur, and Indore rose against the English. The peshwá, Báji Ráo, had long been chafing under the terms imposed by the treaty of Bassein (1802), and the subsequent treaty of Poona (1817), which riveted yet closer the chains of dependence upon the paramount power. Elphinstone, then resident at his court, foresaw what was coming and withdrew to Kirkee, whither he had ordered up a European regiment. The next day the residency was burned down, and Kirkee was attacked by the whole army of the peshwá. The attack was bravely repulsed, and the peshwá immediately fled from his capital. Almost the same plot was enacted at Nágpur, where the honour of the British name was saved by the sepoys, who defended the hill of Sítábaldi against enormous odds. The army of Holkar was defeated in the following month at the pitched battle of Mehidpur. All open resistance was now at an end. Nothing remained but to follow up the fugitives, and determine the conditions of the general pacification. In both these duties Sir John Malcolm played a prominent part. The dominions of the peshwá were annexed to the Bombay

Annexation of peshwá's dominions. presidency, and the nucleus of the present Central Provinces was formed out of the territory saved from the Pindhárís. The peshwá himself surrendered, and was permitted to reside at Bithúr, near Cawnpur, on a pension of £80,000 a year. His adopted son was the infamous Náná Sáhib. To fill the peshwá's place to some extent at the head of the Marhattá confederacy, the lineal descendant of Sivají was brought forth from obscurity, and placed upon the throne of Sátárá. An infant was recognized as the heir of Holkar, and a second infant was proclaimed rájá of Nágpur under British guardianship. At the same time the several states of Rájputána accepted the position of feudatories of the paramount power. The map of India, as thus drawn by Lord Hastings, remained substantially unchanged until the time of Lord Dalhousie. But the proudest boast of Lord Hastings and Sir John Malcolm was, not that they had advanced the *pomœrium*, but that they had conferred the blessings of peace and good government upon millions who had suffered unutterable things from Marhattá and Pindhárí tyranny.

Amherst. The marquis of Hastings was succeeded by Lord Amherst, after the interval of a few months, during which Mr Adam, a civil servant, acted as governor-general. Lord Amherst's administration lasted for five years, from 1823 to 1828. It is known in history by two prominent events, the first Burmese war and the capture of Bhartpur. For some years past the north-east frontier had been disturbed by the restlessness of the Burmese. The country that fringes the western shore of the Bay of Bengal and runs up the valley of the Irawadi, with a people of Tibeto-Chinese origin, has a history of its own, parallel to, but not altogether independent of, that of India. Tradition asserts that its early civilization was introduced from the opposite coast of Coromandel, by a people who still preserve a trace of their origin in their name of Talaing (*cf.* Telinga and Telugu). However this may be, the Buddhist religion, professed by the Burmese at the present day, certainly came direct from India at a very early date. Many waves of invasion from Siam in the south and from the wild mountains in the north have passed over the land. These conquests were marked by that wanton and wholesale barbarity which seems to characterize the Tibeto-Chinese race, but the civilization of Buddhism survived every shock, and flourished around the ancient pagodas. European travellers in the 15th century visited Pegu and Tenasserim, which they describe as flourishing marts of maritime trade. During the period of Portuguese predominance in the East, Arakan became the resort of loose European adventurers. With their help the Arakanese extended their power inland, occupied Chittagong, and (under the name of the Maghs) became the terror of the entire delta of the Ganges. About 1750 a new dynasty arose, founded by Alaungphaya or Alompra, with its capital at Ava, which still rules over Independent Burmah. The successors of Alompra, after having subjugated all Burmah, and overrun Assam, which was then an independent kingdom, began a series of encroachments upon British territory in India. As all peaceful proposals were contumeliously rejected, Lord Amherst was compelled to declare war in 1824. Little military glory could be gained by beating the Burmese, who were formidable only from the pestilential character of their country. One expedition with gunboats proceeded up the Brahmaputra into Assam; another marched by land through Chittagong into Arakan, for the Bengal sepoys refused to go by sea; a third, and the strongest, sailed from Madras direct to the mouth of the Irawadi. The war was protracted over two years. At last, after the loss of about 20,000 lives and an expenditure of £14,000,000, the king of Ava consented to sign the treaty of Yandabu, by which he abandoned all claim to Assam, and ceded the provinces of Arakan and Tenasserim, which were already in the military occupation of the British. He retained all the valley of the Irawadi, down to the sea at Rangoon.

First Burmese war.

Capture of Bhartpur. The capture of Bhartpur in Central India by Lord Combermere in 1827 wiped out the repulse which Lake had received before that city in January 1805. A disputed succession necessitated British intervention. Artillery could make little impression upon the massive walls of mud, but at last a breach was effected by mining, and the city was taken by storm, thus losing its general reputation throughout India for impregnability, which had threatened to become a political danger.

Bentinck. The next governor-general was Lord William Bentinck, who had been governor of Madras twenty years earlier at the time of the mutiny of Vellore. His seven years' rule (from 1828 to 1835) is not signalized by any of those victories or extensions of territory by which chroniclers delight to measure the growth of empire. But it forms an epoch in administrative reform, and in the slow process by which the hearts of a subject population are won over to venerate as well as dread their alien rulers. The modern history of the British in India, as benevolent administrators ruling the country with a single eye to the good of the natives, may be said to begin with Lord William Bentinck. According to the inscription upon his statue at Calcutta, from the pen of Macaulay, "He abolished cruel rites; he effaced humiliating distinctions; he gave liberty to the expression of public opinion; his constant study it was to elevate the intellectual and moral character of the nations committed to his charge." His first care on arrival in India was to restore equilibrium to the finances, which were tottering under the burden imposed upon them by the Burmese war. This he effected by reductions in permanent expenditure, amounting in the aggregate to 1½ millions sterling, as well as by augmenting the revenue from land that had escaped assessment and from the opium of Málwá. He also widened the gates by which educated natives could enter the service of the Company. Some of these reforms were distasteful to the covenanted service and to the officers of the army, but Lord William was always staunchly supported by the court of directors and by the Whig ministry at home.

Sati (suttee). His two most memorable acts are the abolition of *sati* (suttee) and the suppression of the *Thags* (Thugs). At this distance of time it is difficult to realize the degree to which these two barbarous practices had corrupted the social system of the Hindus. European research has clearly proved that the text in the *Vedas* adduced to authorize the immolation of widows was a wilful mistranslation. But the practice had been engrained in Hindu opinion by the authority of centuries, and had acquired the sanctity of a religious rite. The emperor Akbar is said to have prohibited it by law, but the early English rulers did not dare so far to violate the traditions of religious toleration. In the year 1817 no less than seven hundred widows are said to have been burned alive in the Bengal presidency alone. To this day the most holy spots of Hindu pilgrimage are thickly dotted with little white pillars, each commemorating a *sati*. In the teeth of strenuous opposition, both from Europeans and natives, Lord William carried the regulation in council on December 4, 1829, by which all who abetted *sati* were declared guilty of "culpable homicide." The honour of suppressing *Thagi* must be shared between Lord William and Captain Sleeman.

Thagi (Thuggism). *Thagi* was an abnormal excrescence upon Hinduism, in so far as the bands of secret assassins were sworn together by an oath based on the rites of the bloody goddess Kálí. Between 1826 and 1835 as many as 1562 Thags were apprehended in different parts of British India, and by the evidence of approvers the moral plague spot was gradually stamped out.

Two other historical events are connected with the administration of Lord William Bentinck. In 1833 the charter of the East India Company was renewed for twenty years, but only upon the terms that it should abandon its trade and permit Europeans to settle freely in the country. At the same time a legal or fourth member was added to the governor-general's council, who might not be a servant of the Company, and a commission was appointed to revise and codify the law. Macaulay was the first legal member of council, and the first president of the law commission. In 1830 it was found necessary to take the state of Mysore under British administration, where it has continued to the present year (1881), and in 1834 the frantic misrule of the rájá of Coorg brought on a short and sharp war. The rájá was permitted to retire to Benares, and the brave and proud inhabitants of that mountainous little territory decided to place themselves under the rule of the Company; so that the only annexation effected by Lord William Bentinck was "in consideration of the unanimous wish of the people."

calfe. Sir Charles (afterwards Lord) Metcalfe succeeded Lord William as senior member of council. His short term of office is memorable for the measure which his predecessor had initiated, but which he willingly carried into execution, for giving entire liberty to the press. Public opinion in India, as well as the express wish of the court of directors at home, pointed to Metcalfe as the most fit person to carry out the policy of Bentinck, not provisionally, but as governor-general for a full term. Party exigencies, however, led to the appointment of Lord Auckland. From that date commences a new era of war and conquest, which may be said to have lasted for twenty years. All looked peaceful until Lord Auckland, prompted by his evil genius, attempted to place Sháh Shujá upon the throne of Cabul, an attempt which ended in the gross mismanagement and annihilation of the garrison placed in that city. The disaster in Afghánistán was quickly followed by the conquest of Sind, the two wars in the Punjab, the second Burmese war, and last of all the Mutiny. Names like Gough and Napier and Colin Campbell take the places of Malcolm and Metcalfe and Elphinstone.

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han irs. For the first time since the days of the sultáns of Ghazní and Ghor, Afghánistán had obtained a national king in 1747 in the person of the Ahmad Sháh Duráni, who found his opportunity in the confusion that followed on the death of the Persian conqueror, Nádir Sháh. Before his death in 1773 Ahmad Sháh had conquered a wide empire, from Herat to Peshávar and from Kashmír to Sind. His intervention on the field of Pánipat (1761) turned back the tide of Marhattá conquest, and replaced a Mughal emperor on the throne of Delhi. But Ahmad Sháh never cared to settle down in India, and kept alternate state at his two national capitals of Cabul and Kandahár. The Duráni kings were prolific in children, who fought with one another for the succession to the death. At last, in 1826, Dost Muhammad, head of the powerful Barakzái family, succeeded in establishing himself as ruler of Cabul, with the subordinate title of amír (ameer), while two fugitive brothers of the Duráni line were living under British protection at Ludhiána, on the frontier of the Punjab.

The attention of the English Government had been directed to Afghán affairs ever since the time of Lord Wellesley, who feared that Zamán Sháh, then holding his court at Lahore, might follow in the path of Nádir Sháh, and overrun Hindustán. The growth of the powerful Síkh kingdom of Ranjít Sinh effectually dispelled any such alarms for the future. Subsequently, in 1809, while a French invasion of India was still a possibility to be guarded against, Elphinstone was sent by Lord Minto on a mission to Sháh Shujá to form a defensive alliance. Before the year was out, Sháh Shujá had been driven into exile, and a third brother, Mahmúd Sháh, was on the throne. In 1837, when the curtain rises upon the drama of English interference in Afghánistán, the usurper Dost Muhammad Barakzái was firmly established at Cabul. His great ambition was to recover Peshávar from the Síkhs; and when Captain Alexander Burnes arrived on a mission from Lord Auckland, with the ostensible object of opening trade, the Dost was willing to promise everything, if only he could get Peshávar. But Lord Auckland had another and more important object in view. At this time the Russians were advancing rapidly in Central Asia, and a Persian army, not without Russian support, was besieging Herat, the traditional bulwark of Afghánistán on the east. A Russian envoy was at Cabul at the same time as Burnes. The latter was unable to satisfy the demands of Dost Muhammad in the matter of Peshávar, and returned to India unsuccessful. Lord Auckland forthwith resolved upon the hazardous plan of placing a more subservient ruler upon the throne of Cabul. Sháh Shujá, one of the two exiles at Ludhiána, was selected for the purpose. At this time both the Punjab and Sind were independent kingdoms. Sind was the less powerful of the two, and therefore a British army escorting Sháh Shujá made its way by that route to enter Afghánistán through the Bolán Pass. Kandahár surrendered, Ghazní was taken by storm, Dost Muhammad fled across the Hindu Kush, and Sháh Shujá was triumphantly led into the Bala Hissár at Cabul in August 1839. During the two years that followed Afghánistán remained in the military occupation of the British. The catastrophe occurred in November 1841, when Sir Alexander Burnes was assassinated in the city of Cabul. The troops in the cantonments were then under the command of General Elphinstone (not to be confounded with the civilian Mountstuart Elphinstone), with Sir William Macnaghten as chief political adviser. Elphinstone was an old man, unequal to the responsibilities of the position. Macnaghten was treacherously murdered at an interview with the Afghán chief, Akbar Khán, eldest son of Dost Muhammad. After lingering in their cantonments for two months, the British army set off in the depth of winter to find its way back to India through the passes. When they started they numbered 4000 fighting men, with 12,000 camp followers. A single survivor, Dr Brydon, reached the friendly walls of Jalálábád, where Sale was gallantly holding out. The rest perished in the defiles of Khurd, Cabul, and Jagdalak, either from the knives and matchlocks of the Afgháns or from the effects of cold. A few prisoners, mostly women, children, and officers, were considerately treated by the orders of Akbar Khán.

First Afghan war.

Within a month after the news reached Calcutta, Lord Auckland had been superseded by Lord Ellenborough, whose first impulse was to be satisfied with drawing off in safety the garrisons from Kandahár and Jalálábád. But bolder counsels prevailed. Pollock, who was marching straight through the Punjab to relieve Sale, was ordered to penetrate to Cabul, while Nott was only too glad not to be forbidden to retire from Kandahár through Cabul. After a good deal of fighting, the two English forces met at their common destination in September 1842. The great *bázár* at Cabul was blown up with gunpowder, to fix a stigma upon the city; the prisoners were recovered; and all marched back to India, leaving Dost Muhammad to take undisputed possession of his throne. The drama closed with a bombastic proclamation from Lord Ellenborough, who had caused the gates from the tomb of Mahmúd of Ghazní to be carried back as a memorial of "Somnáth revenged." Ellenborough.

Lord Ellenborough, who loved military display, had his tastes gratified by two more wars. In 1843 the Mahometan rulers of Sind, known as the "meers" or amírs, whose only

Conquest of Sind. fault was that they would not surrender their independence, were crushed by Sir Charles Napier. The victory of Miáni, in which 3000 British troops defeated 20,000 Baluchís, is perhaps the most brilliant feat of arms in Indian history; but an honest excuse can scarcely be found for the annexation of the country. In the same year a disputed succession at Gwalior, fomented by feminine intrigue, resulted in an outbreak of the overgrown army which the Sindhia family had been allowed to maintain. Peace was restored by the battles of Maharájpur and Punneah, at the former of which Lord Ellenborough was present in person.

Hardinge. In 1844 Lord Ellenborough was recalled by the court of directors, who differed from him on many points of administration, and distrusted his erratic genius. He was succeeded by Sir Henry (afterwards Lord) Hardinge, who had served through the Peninsular War and had lost a hand at Ligny. It was felt on all sides that a trial of strength between the British and the Síkhs was at hand.

Rise of Síkhs. The Síkhs were not a nationality like the Marhattás, but a religious sect bound together by the additional tie of military discipline. They trace their origin to one Nának, an excellent and successful preacher, who was born in the neighbourhood of Lahore in the latter half of the 15th century, before the arrival of either Mughals or Portuguese in India. Nának was a religious reformer, like others that arose in the country about that time, who preached the abolition of caste, the unity of the Godhead, and the obligation of leading a pure life. From Nának ten *gurus* or apostles are traced down to Govind Sinh in 1708, with whom the succession stopped. Suffering continual persecution from the ruling Mahometans, which culminated in the reign of Aurangzeb, the Síkh religion maintained itself with extraordinary tenacity. At last the downfall of the Mughal empire transformed it into a territorial power, which possessed the only organization remaining in the Punjab. Even before the rise of Ranjit Sinh, offshoots from the Síkh *misls* or confederacies, each led by its elected *sardár*, had carved out for themselves feudal principalities along the banks of the Sutlej, some of which have endured to the present day. Ranjít Sinh, the founder of the Síkh kingdom, was born in 1780. In his twentieth year he obtained the appointment of governor of Lahore from the Afghán emperor, and from that time he set himself to the task of basing a personal despotism upon the religious fanaticism of the Síkhs. The *khálsá* or "the liberated" were organized into an army under European officers, which for steadiness and religious fervour has had no parallel since the "ironsides" of Cromwell. From Lahore as his capital he extended his conquests south to Múltán, west to Pesháwar, and north to Kashmír. On the east side alone he was hemmed in by the Sutlej, up to which river the authority of the British Government was advanced in 1804. Till his death in 1839 Ranjít Sinh was ever loyal to the engagements which he had entered into with Metcalfe in 1809. But he left no son capable of wielding his sceptre. Lahore was torn by dissensions between rival generals, ministers, and queens. The only strong power was the army of the *khálsá*, which since the disaster in Afghánistán burned to measure its strength with the British sepoys. The French generals, Avitable and Court, were foolishly ousted, and the supreme military command was vested in a series of *pancháyats* or elective committees of five.

Síkh campaign. In 1845 the Síkh army, numbering 60,000 men with 150 guns, crossed the Sutlej and invaded British territory. Sir Hugh Gough, the commander-in-chief, together with the governor-general, hurried up to the frontier. Within three weeks four pitched battles were fought, at Moodkee, Ferozshah, Aliwál, and Sobráon. The British loss on each occasion was heavy; but by the last victory the Síkhs were fairly driven into and across the Sutlej, and Lahore surrendered to the British. By the terms of peace then dictated the infant son of Ranjít, Dhulip Sinh, was recognized as rájá; the Jalandhar Doáb, or tract between the Sutlej and the Rávi, was annexed; the Síkh army was limited to a specified number; Major Henry Lawrence was appointed to be resident at Lahore; and a British force was detailed to garrison the Punjab for a period of eight years. Sir H. Hardinge received a peerage, and returned to England in 1848.

Dalhousie. Lord Dalhousie succeeded, whose eight years' administration (from 1848 to 1856) was more pregnant of results than that of any governor-general since Clive. Though professedly a man of peace, he was compelled to fight two wars, in the Punjab and in Burmah. These both ended in large acquisitions of territory, while Nágpur, Oudh, and several minor states also came under British rule. But Dalhousie's own special interest lay in the advancement of the moral and material condition of the country. The system of administration carried out in the conquered Punjab by the two Lawrences and their assistants is probably the most successful piece of difficult work ever accomplished by Englishmen. British Burmah has prospered under their rule scarcely less than the Punjab. In both cases Lord Dalhousie deserves a large share of the credit. No branch of the administration escaped his reforming hand. He founded the public works department, to pay special attention to roads and canals. He opened the Ganges Canal, still the largest work of the kind in the country, and he turned the sod of the first Indian railway. He promoted steam communication with England *via* the Red Sea, and introduced cheap postage and the electric telegraph. It is Lord Dalhousie's misfortune that these benefits are too often forgotten in the vivid recollections of the Mutiny, which avenged his policy of annexation.

Second Síkh war. Annexation of Punjab. Lord Dalhousie had not been six months in India before the second Sikh war broke out. Two British officers were treacherously assassinated at Múltán. Unfortunately Henry Lawrence was at home on sick leave. The British army was not ready to act in the hot weather, and, despite the single-handed exertions of Lieutenant (afterwards Sir Herbert) Edwardes, this outbreak of fanaticism led to a general rising. The *khálsá* army again came together, and once more fought on even terms with the British. On the fatal field of Chilianwála, which patriotism prefers to call a drawn battle, the British lost 2400 officers and men, besides four guns and the colours of three regiments. Before reinforcements could come out from England, with Sir Charles Napier as commander-in-chief, Lord Gough had restored his own reputation by the crowning victory of Guzerat, which absolutely destroyed the Síkh army. Múltán had previously fallen; and the Afghán horse under Dost Muhammad, who had forgotten their hereditary antipathy to the Síkhs in their greater hatred of the British name, were chased back with ignominy to their native hills. The Punjab henceforth became a British province, supplying a virgin field for the administrative talents of Dalhousie and the two Lawrences. Rájá Dhulip Sinh received an allowance of £50,000 a year, on which he retired as a country gentleman to Norfolk in England. The first step in the pacification of the Punjab was a general disarmament, which resulted in the delivery of no less than 120,000 weapons of various kinds. Then followed a settlement of the land tax, village by village, at an assessment much below that to which it had been raised by Síkh exactions, and the introduction of a loose but equitable code of civil and criminal procedure. Roads and canals were laid out by Colonel Robert Napier (afterwards Lord Napier of Magdala); and the security of British peace and the personal influence of British officers were felt to the furthest corners of the province. Thus it happened that, when the Mutiny broke out in 1857, the Punjab remained not only quiet but loyal, after only eight years' experience of English rule; while the North-Western Provinces, which had been British territory for more than half a century, rose in rebellion.

Second Burmese war. The second Burmese war of 1852 was caused by the ill-treatment of European merchants at Rangoon, and the insolence offered to the captain of a frigate who had been sent to remonstrate. The whole valley of the Irawadi, from Rangoon to Prome, was occupied in a few months, and, as the king of Ava refused to treat, it was annexed, under the name of Pegu, to the provinces of Arakan and Tenasserim, which had been acquired in 1826. Since annexation the inhabitants of

Rangoon have increased tenfold in number, and that port now ranks third in British India, being surpassed only by Calcutta and Madras. Lord Dalhousie's dealings with the feudatory states of India can only be rightly appreciated as part of his general policy. That rulers only exist for the good of the ruled was his supreme axiom of government, of which he gave the most conspicuous example by the practice of his own daily life. That British administration was better for the people than native rule followed from this axiom as a necessary corollary. He was thus led to regard native chiefs from somewhat the same point of view as the Scotch regarded the hereditary jurisdictions after 1745, as mischievous anomalies, to be abolished by every means practicable. Good faith must be kept with rulers on the throne and with their legitimate heirs, but no false sentiment should preserve dynasties that had forfeited all consideration by years of accumulated misrule, or prolong those that had no natural successor. The "doctrine of lapse" was merely a special application of these principles, though complicated by the theory of adoption. It has never been doubted that, according to Hindu private law, an adopted son entirely fills the place of a natural son, whether to perform the religious obsequies of his father or to inherit his property. In all respects he continues the *persona* of the deceased. But it was argued that the succession to a throne stood upon a different footing. The paramount power could not recognize such a right, which might be used as a fraud to hand over the happiness of millions to a base-born impostor. Here came in the maxim of "the good of the governed." The material benefits to be conferred through British administration surely weighed heavier in the scale than a superstitious and frequently fraudulent fiction of inheritance. The first state to escheat to the British Government in accordance with these principles was Sátárá, which had been reconstituted by Lord Hastings on the downfall of the peshwá in 1818. The last direct representative of Sivají died without a male heir in 1848, and his deathbed adoption was set aside. In the same year the Rájput state of Karauli was saved by the interposition of the court of directors, who drew a fine distinction between a dependent principality and a protected ally. In 1833 Jhánsi suffered the same fate as Sátárá. But the most conspicuous application of the doctrine of lapse was the case of Nágpur The last of the Bhonslás, a dynasty older than the British Government itself, died without a son, natural or adopted, in 1853. That year also saw British administration extended to the Berars, or the assigned districts which the nizám of Hyderabad was induced to cede as a territorial guarantee for the subsidies which he perpetually kept in arrear Three more distinguished names likewise passed away in 1853, though without any attendant accretion to British territory. In the extreme south the titular nawáb of the Carnatic and the titular rájá of Tanjore both died without heirs. Their rank and their pensions died with them, though compassionate allowances were continued to their families. In the north of India, Báji Ráo, the ex-peshwá who had been dethroned in 1818, lived on till 1853 in the enjoyment of his annual pension of £80,000. His adopted son, Nána Sáhib, inherited his accumulated savings, but could obtain no further recognition.

Annexation of Oudh.

The annexation of the province of Oudh is to be defended on very different grounds. Ever since the nawáb wazír, Shujá-ud-Daulá, received back his forfeited territories from the hands of Lord Clive in 1765, the very existence of Oudh as an independent state had depended only upon the protection of British bayonets. Thus, preserved alike from foreign invasion and from domestic rebellion, the long line of subsequent nawábs had given way to that neglect of public affairs and those private vices which naturally flow from irresponsible power. Their only redeeming virtue was steady loyalty to the British Government. Oudh has been called "the Garden of India" by an author[1] who endeavours to show that the evils of native rule were never so black as they have been painted. But at any rate that fair corner of the Gangetic basin, which now supports a denser population than any equal area on the surface of the globe, had been groaning for generations under anarchy for which each successive governor-general admitted that he was partly responsible. Warning after warning had been given to the nawábs (who had assumed the title of sháh or king since 1819) that they must put their house in order. What the benevolent Bentinck and the soldierly Hardinge had only threatened was reserved for Lord Dalhousie, who united honesty of purpose with decision of character. In this determination he had the full support of the court of directors at home. In 1856, the last year of his rule, he issued orders to General (afterwards Sir James) Outram, then resident at the court of Lucknow, to assume the direct administration of Oudh, on the ground that "the British Government would be guilty in the sight of God and man, if it were any longer to aid in sustaining by its countenance an administration fraught with suffering to millions." The king, Wájid Alí, bowed to irresistible force, though he ever refused to recognize the justice of his deposition. After a mission to England, by way of protest and appeal, he settled down in the pleasant suburb of Garden Reach near Calcutta, where he lived in the enjoyment of a pension of £120,000 a year. Oudh was thus annexed without a blow; but it may be doubted whether the one measure of Lord Dalhousie upon which he looked back himself with the clearest conscience was not the very one that most alarmed native public opinion.

The marquis of Dalhousie resigned office in March 1856, being then only forty-four years of age; but he carried home with him the seeds of a lingering illness which resulted in his death in 1860. Excepting Cornwallis, he was the first, though by no means the last, of English statesmen who have fallen victims to their devotion to India's needs. He was succeeded by his friend, Lord Canning, who, at the farewell banquet in England given to him by the court of directors, uttered these prophetic words: "I wish for a peaceful term of office. But I cannot forget that in the sky of India, serene as it is, a small cloud may arise, no larger than a man's hand, but which, growing larger and larger, may at last threaten to burst and overwhelm us with ruin." In the following year the sepoys of the Bengal army mutinied, and all the valley of the Ganges from Patná to Delhi rose in open rebellion.

Canning.

Mutiny.

The various motives assigned for the Mutiny appear inadequate to the European mind. The truth seems to be that native opinion throughout India was in a ferment, predisposing men to believe the wildest stories, and to act precipitately upon their fears. The influence of panic in an Oriental population is greater than might be readily believed. In the first place, the policy of Lord Dalhousie, exactly in proportion as it had been dictated by the most honourable considerations, was utterly distasteful to the native mind. Repeated annexations, the spread of education, the appearance of the steam engine and the telegraph wire, all alike revealed a consistent determination to substitute an English for an Indian civilization. The Bengal sepoys, especially, thought that they could see into the future farther than the rest of their countrymen. Nearly all men of high caste, and many of them recruited from Oudh, they dreaded tendencies which they deemed to be denationalizing, and they knew at first hand what annexation

[1] *The Garden of India, or Chapters on Oudh History and Affairs*, by H. C. Irwin, London, 1880.

meant. They believed it was by their prowess that the Punjab had been conquered, and all India was held quiet. The numerous dethroned princes, their heirs and their widows, were the first to learn and take advantage of the spirit of disaffection that was abroad. They had heard of the Crimean war, and were told that Russia was the perpetual enemy of England. They had money in abundance with which they could buy the assistance of skilful intriguers. They had everything to gain, and nothing to lose, by a revolution.

In this critical state of affairs, of which the Government had no official knowledge, a rumour ran through the cantonments of the Bengal army that cartridges had been served out greased with the fat of animals unclean alike to Hindu and Mahometan. After this, nothing could quiet the minds of the sepoys. Fires occurred nightly in the native lines; officers were insulted by their men; all confidence was gone, and only the form of discipline remained. On the afternoon of Sunday, May 10, 1857, the sepoys at Meerut (Mirath) broke into open mutiny. Their first mad frenzy marked by its excess the change from their usually quiet manners and orderly habits. They broke into the jail, and then ran through the cantonments, cutting down every European they met. At last they streamed off to the neighbouring city of Delhi, to stir up the native garrison and the criminal population of that great city, and to place themselves under the authority of the discrowned Mughal emperor. Meerut was the largest military station in India, with a strong European garrison of foot, horse, and guns, sufficient to overwhelm the mutineers before ever they reached Delhi. But just as the sepoys acted in irrational panic, so did British officers in but too many cases act with equally irrational indecision. The news of the outbreak was telegraphed to Delhi, and nothing more was done that night. The next morning the Mahometans of Delhi rose, and all that the Europeans there could do was to blow up the magazine. A rallying centre and a traditional name was thus given to the revolt, which forthwith spread like wildfire through all the North-Western Provinces and Oudh down into Lower Bengal. The same narrative must suffice for all, though each episode has its own peculiar story of sadness and devotion. The sepoys rose on their officers, without warning, and sometimes after protestations of fidelity. The Europeans, or persons of Christian faith, were massacred, sometimes also women and children. The jail was broken open, the treasure plundered, and then all marched off to some centre of revolt, to join in what had now become a national war. Only in the Punjab were the sepoys anticipated by the stern measures of repression and disarmament adopted by Sir John Lawrence and his lieutenants, among whom Edwardes and Nicholson were conspicuous. The Síkh population never wavered. Crowds of willing recruits came down from the Afghán hills. And thus the Punjab, instead of being itself a source of danger, was able to furnish a portion of its own garrison for the siege of Delhi. In Lower Bengal most of the sepoys mutinied, and then dispersed in different directions. The native armies of Madras and Bombay remained true to their colours. In Central India the contingents of many of the great chiefs sooner or later joined the rebels, but the Mahometan state of Hyderabad was kept loyal by the authority of its able minister Sir Sálar Jang.

Loyalty of Síkhs

The main interest of the sepoy war gathers round the three cities of Cawnpur, Lucknow, and Delhi. The cantonments at Cawnpur contained the largest native garrison in India; and in the immediate neighbourhood, at Bithúr, was the palace of Dandhu Panth, the disinherited heir of the last peshwá, whose more familiar appellation of Nána Sáhib will ever be handed down to the infamy of history. At first the Nána was profuse in his professions of loyalty, but as soon as the sepoys mutinied he put himself at their head, and was proclaimed peshwá of the Marhattás. The Europeans at Cawnpur, who numbered more women and children than fighting men, shut themselves up in improvised entrenchments, where they sustained a siege for nineteen days under the sun of a tropical June. At last, trusting to a safe conduct from the Nána as far as Allahábád, they surrendered their position, and to the number of four hundred and fifty individuals embarked in boats on the Ganges. Forthwith a murderous fire was opened upon them from the river bank. Only a single boat escaped, and but four men, who swam across to the protection of a friendly rájá, ultimately survived to tell the tale. The rest of the men were massacred on the spot; the women and children, numbering one hundred and twenty-five, were reserved for the same fate a few days later, when the avenging army of Havelock was at hand. Sir Henry Lawrence, the chief commissioner of Oudh, had foreseen the coming storm with a prophetic eye. He had fortified and provisioned the residency at Lucknow in good time, and thither he retired with all the European inhabitants and a weak British regiment on July 2. Two days later he was mortally wounded by a shell. But his example inspired the little garrison to hold out under unparalleled hardships and against enormous odds, until relieved by Havelock and Outram on September 25. But the relieving force was itself invested by fresh swarms of rebels, and it was not till November that Sir Colin Campbell, afterwards Lord Clyde, cut his way into Lucknow, and effected the final deliverance of the garrison. The siege of Delhi began on June 8, just one month after the original outbreak at Meerut. Siege in the proper sense of the word it was not, for the British army, encamped on the historic ridge, never exceeded 8000 men, while the rebels within the walls were more than 30,000 strong. In the middle of August Nicholson arrived with a reinforcement from the Punjab, but his own encouraging presence was more valuable than the reinforcement he brought. On September 14 the assault was delivered, and after six days' desperate fighting in the streets Delhi was again won. Nicholson fell at the head of the storming party. Hodson, the intrepid leader of a corps of irregular horse, hunted down and brought in as prisoner the old Mughal emperor, Bahádur Sháh, and then in cold blood shot down the emperor's sons with his own hand. After the fall of Delhi and the final relief of Lucknow the war loses its dramatic interest, though fighting went on in various parts of the country for eighteen months longer. The population of Oudh and Rohilkhand, stimulated by the presence of the begum of Oudh, the nawáb of Bareilly, and Nána Sáhib himself, had joined the mutinous sepoys *en masse*. In this quarter of India alone, it was the revolt of a people rather than the mutiny of an army that had to be quelled. Sir Colin Campbell in person conducted the campaign in Oudh, which lasted through two cold seasons. Valuable assistance was lent by Sir Jang Bahádur of Nepál, at the head of a numerous army of Gúrkhas. Town after town was occupied, fort after fort was stormed, until at length the last gun had been recaptured and the last fugitive had fled across the frontier by January 1859 In the meanwhile Sir Hugh Rose (afterwards Lord Strathnairn), with another army from Bombay, was conducting an equally brilliant campaign in Central India. His most formidable antagonists were the disinherited rání of Jhánsí, and Tántia Topí, whose military talent had previously inspired Nána Sáhib with all the capacity for resistance that he ever displayed. The rání died fighting bravely at the head of her troops in June 1858; Tántiá Topí, after doubling backwards and forwards through Central India, was at last betrayed and run down in April 1859.

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Suppr sion o mutin

The Mutiny sealed the fate of the East India Company, after a life of more than two and a half centuries.

[...]y's [...]ters. The Company received its original charter of incorporation from Elizabeth in 1600. Its political powers, and the constitution of the Indian Government, were derived from the Regulating Act of 1773, passed by the ministry of Lord North. By that statute the governor of Bengal was raised to the rank of governor-general; and, in conjunction with his council of four other members, he was entrusted with the duty of superintending and controlling the governments of Madras and Bombay so far as regarded questions of peace and war; a supreme court of judicature was appointed at Calcutta, to which the judges were appointed by the crown; and a power of making rules, ordinances, and regulations was conferred upon the governor-general and his council. Next came the India Bill of Pitt (1784), which founded the board of control, strengthened the supremacy of Bengal over the other presidencies, and first authorized the historic phrase "governor-general-in-council." The Act which abolished the Company's monopoly of trade (1833) also introduced several reforms into the constitution of the Indian Government, and added to the council an additional member, who might not be chosen from among the Company's servants, and was entitled to be present only at meetings for making laws and regulations; it gave the authority of Acts of Parliament to the laws and regulations so made, subject to the disallowance of the court of directors; it appointed a law commission; and it gave the governor-general-in-council a control over the other presidencies in all points relating to the civil or military administration. The charter of the Company was renewed for the last time in 1853, not for a definite period of years, but only for so long as parliament should ordain. On this occasion the number of directors was reduced, and their patronage as regards appointments to the civil service was taken away, to make room for the principle of open competition.

[...]nsfer [...]rown. The Act for the better government of India (1858), which finally transferred the entire administration from the Company to the crown, was not passed without an eloquent protest from the directors, nor without acrimonious party discussion in parliament. It enacts that India shall be governed by, and in the name of, the sovereign of England through one of the principal secretaries of state, assisted by a council of fifteen members. The governor-general received the new title of viceroy. The European troops of the Company, numbering about 24,000 officers and men, were amalgamated with the royal service, and the Indian navy was abolished. By the Indian Councils Act (1861) the governor-general's council and also the councils at Madras and Bombay were augmented by the addition of non-official members, either natives or Europeans, for legislative purposes only; and by another Act passed in the same year high courts of judicature were constituted out of the existing supreme courts at the presidency towns.

It fell to the lot of Lord Canning both to suppress the Mutiny and to introduce the peaceful revolution that followed. As regards his execution of the former part of his duties, it is sufficient to say that he preserved his equanimity undisturbed in the darkest hours of peril, and that the strict impartiality of his conduct incurred alternate praise and blame from the fanatics on either side The epithet then scornfully applied to him of "Clemency" Canning is now remembered only to his honour. On November 1, 1858, at a grand *darbár* held at Allahábád the royal proclamation was published which announced that the queen had assumed the government of India. This document, which has been called the Magna Charta of the Indian people, went on to explain the policy of political justice and religious toleration which it was her royal pleasure to pursue, and granted an amnesty to all except those who had directly taken part in the murder of British subjects. Peace was proclaimed throughout India on July 8, 1859; and in the following cold weather Lord Canning made a viceregal progress through the upper provinces, to receive the homage of loyal princes and chiefs, and to guarantee to them the right of adoption. The suppression of the Mutiny increased the debt of India by about 40 millions sterling, and the military changes that ensued augmented the annual expenditure by about 10 millions. To grapple with this deficit, Mr James Wilson was sent out from the treasury as financial member of council. He reorganized the customs system, imposed an income tax and licence duty, and created a state paper currency. The penal code, originally drawn up by Macaulay in 1837, passed into law in 1860, together with a code of civil and criminal procedure.

Recent administration. Lord Canning left India in March 1862, and died before he had been a month in England. His successor, Lord Elgin, only lived till November 1863, when he too fell a victim to the excessive work of the governor-generalship, dying at the Himálayan station of Dharmsálá, where he lies buried. He was succeeded by Sir John Lawrence, the saviour of the Punjab. The chief incidents of his administration were the Bhután war and the terrible Orissa famine. Lord Mayo, who succeeded him in 1869, carried on the permanent British policy of moral and material progress with a special degree of personal energy. The Ambálá (Umballa) darbár, at which Shere Ali was recognized as amír of Afghánistán, though in one sense merely the completion of what Lord Lawrence had begun, owed much of its success to the personal influence of Lord Mayo himself. The same quality, combined with sympathy and firmness, stood him in good stead in all his dealings both with native chiefs and European officials. His example of hard work stimulated all to their best. While engaged in exploring with his own eyes the furthest corners of the empire, he fell by the hand of an assassin in the convict settlement of the Andaman Islands in 1872. His successor was Lord Northbrook, whose ability showed itself chiefly in the department of finance. During the time of his administration a famine in Lower Bengal in 1874 was successfully obviated by Government relief and public works, though at an enormous cost; the gáikwár of Baroda was dethroned in 1875 for misgovernment and disloyalty, while his dominions were continued to a nominated child of the family; and the Prince of Wales made a tour through the country in the cold weather of 1875–76. Lord Lytton followed Lord Northbrook in 1876. On January 1, 1877, Queen Victoria was proclaimed Empress of India at a *dárbár* of unequalled magnificence, held on the historic "ridge" overlooking the Mughal capital of Delhi. But, while the princes and high officials of the country were flocking to this gorgeous scene, the shadow of famine was already darkening over the south of India.

Famine 1876-78. Both the monsoons of 1876 had failed to bring their due supply of rain, and the season of 1877 was little better. The consequences of this prolonged drought, which extended from the Deccan to Cape Comorin, and subsequently invaded northern India, were more disastrous than any similar calamity since the introduction of British rule. Despite unparalleled importations of grain by sea and rail, despite the most strenuous exertions of the Government, which incurred a total expenditure on this account of 11 millions sterling, the loss of life from actual starvation and its attendant train of diseases was lamentable. The total number of deaths from disease and want in the distressed tracts in excess of the normal mortality for the two years 1876–78 is estimated to have raised the death-rate by 40 per cent., or 5¼ millions. In the autumn of 1878 the affairs of Afghánistán again forced themselves into notice. Shere Ali, the amír, who had been hospitably entertained by Lord Mayo, was found to be favouring Russian intrigues. A British embassy was refused admittance to the country, while a Russian mission was received with honour. This led to a declaration of war. British armies advanced by three routes,—the Khaibar (Khyber), the Kuram, and the Bolán, and without much opposition occupied the inner entrances of the passes. Shere Ali fled to Afghán Turkestán, and there died. A treaty was entered into with his son, Yákub Khán, at Gandamak, by which the British frontier was advanced to the crests or further sides of the passes, and a British officer was admitted to reside at Cabul. Within a few months the British resident, Sir Louis Cavagnari, was treacherously attacked and massacred, together with his escort, and a second war became necessary. Yákub Khán abdicated, and was deported to India; Cabul was occupied in force, and an Afghán chief of the Duráni line was placed in the government of Kandahár with the title of wálí. At that crisis of affairs a general election in England resulted in a defeat of the ministry. Lord Lytton resigned with the Conservative ministry, and the marquis of Ripon was nominated as his successor in 1880. Since then, a British brigade received a defeat between Kandahár and the Helmand river from the Heráti army of Ayúb Khán, a defeat promptly and completely retrieved by the brilliant march of General Sir Frederick Roberts from Cabul to Kandahár, and by the total rout of Ayúb Khán's army on September 1, 1880. Abdurrahman Khán, the eldest male representative of the stock of Dost Muhammad, has now been recognized as amír of Cabul.

Afghan campaigns, 1878-80.

Governors-General of India under the East India Company, 1765–1858.

1765. Lord Clive.
1767. Harry Verelst.
1769. John Cartier.
1772. Warren Hastings.
1786. Lord (afterwards Marquis) Cornwallis.
1793. Sir John Shore (Lord Teignmouth).
1798. Sir Alured Clarke (*pro tem.*).
1798. Lord Mornington (Marquis Wellesley).
1805. Lord Cornwallis again.
1805. Sir George Barlow (*pro tem.*).
1806. Earl of Minto.
1813. Earl of Moira (Marquis of Hastings).
1823. John Adam (*pro tem.*).
1823. Lord Amherst.
1828. Lord William Cavendish Bentinck.
1835. Sir Charles Metcalfe (Lord Metcalfe).
1836. Lord Auckland.
1842. Earl of Ellenborough.
1844. Viscount Hardinge.
1848. Earl (afterwards Marquis) of Dalhousie.
1856. Earl Canning.

Viceroys of India under the Crown, 1858–1881.

1858. Earl Canning.
1862. Earl of Elgin.
1864. Sir John Lawrence (Lord Lawrence).
1869. Earl of Mayo.
1872. Lord Northbrook.
1876. Lord Lytton.
1880. Marquis of Ripon.

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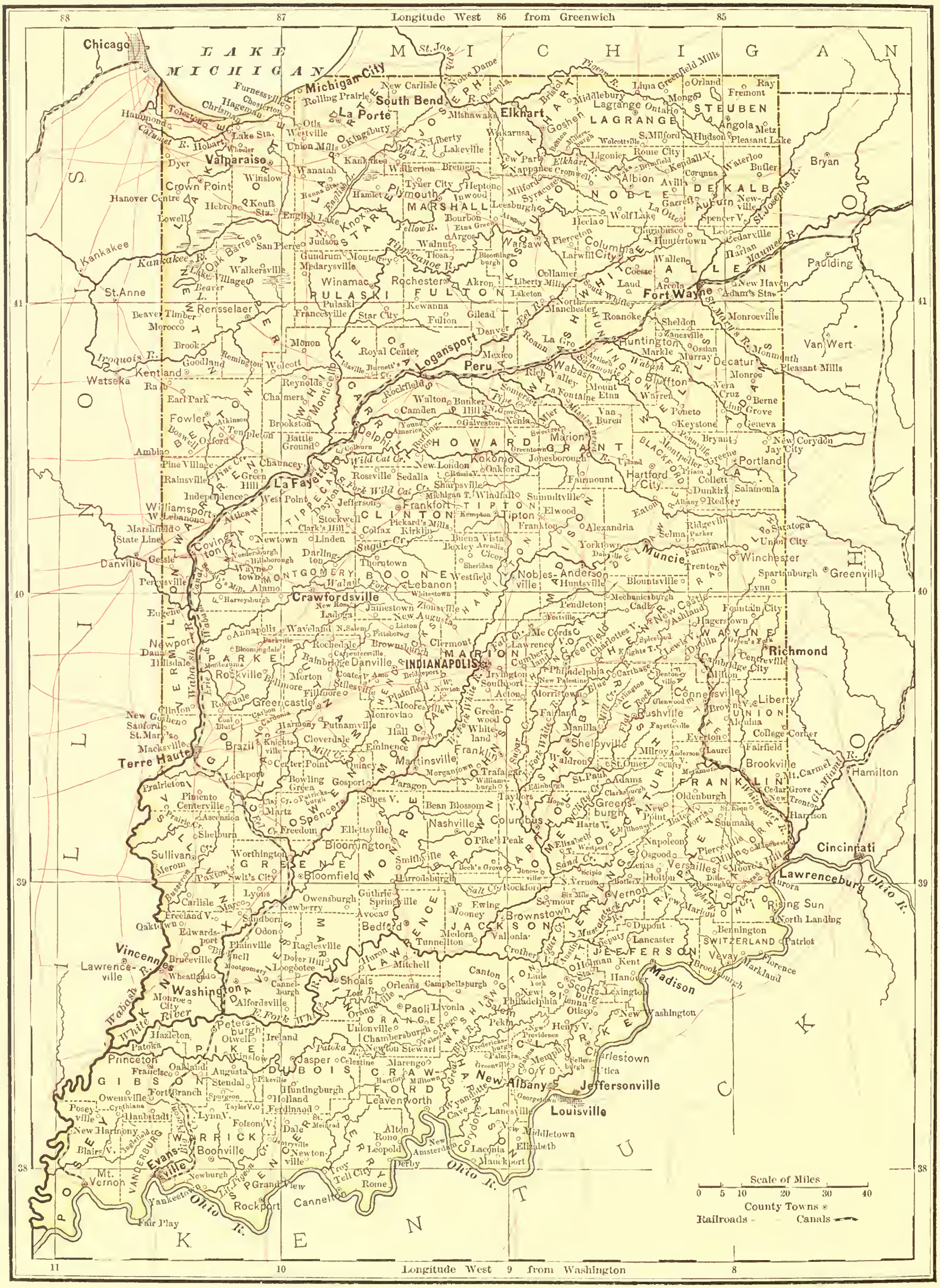
But in these departments also the process of subdivision has taken place, and different periods or aspects are now treated elaborately by specialists. (2) Aitchison's *Treaties and Engagements*, 7 vols., require a place by themselves. (3) The following are the leading works on the various periods, provinces, and races:—M'Crindle's *Ancient India of Megasthenes and Arrian*, and his *Navigation of the Erythræan Sea*; Dr J. Muir's *Original Sanskrit Texts*, 5 invaluable vols., 1868–72; Weber's *History of Indian Literature*, 1878; Professor Max Müller's *History of Sanskrit Literature*, and various works and essays; Professor Dowson's *Classical Dictionary of Hindu Mythology*. 1879; Sherring's *Hindu Tribes and Castes*; Fergusson's *Tree and Serpent Worship. Indian Architecture, Cave Temples*, &c.; the *Reports* of the Archæological Survey, by General Cunningham and Mr Burgess; Beame's edition of Sir H. Elliot's *Races of India*; Ward's *Hindus*; Abbé Dubois's *Manners and Customs of India*; Bishop Heber's *Journey*; Mrs Manning's *Ancient and Mediæval India*; Rájendra Lála Mitra's *Orissa*, and series of valuable antiquarian works; General Cunningham's *Ancient Geography of India*, 1871; B. H. Hodgson's *Essays on Indian Subjects*, 2 vols., 1880, and other works, specially on Nepál and Tibet; Bishop Caldwell's *Comparative Grammar of the Dravidian Languages*, the standard authority on southern India; Colonel Dalton's *Ethnology of Bengal*; R. Cust's *Linguistic and Oriental Essays*, 1880; H. H. Wilson's great series of works; Sir Henry Summer Maine's *Village Communities*; Birdwood's *Indian Arts.* (4) Works of a more local character:—*The Statistical Account of Bengal and Assam*, with the Gazetteers or District Manuals for Bombay, Madras, the North-West, the Central Provinces, Rájputána, Mysore, British Burmah, Ajmír, and other provinces; Colonel Malleson's and Mr Mackay's works on the native states and princes; Mr Lepel Griffin's *Punjab Rájás*; Stewart's *History of Bengal*; Dr Hooker's *Himálayan Journals*; Vigne's *Travels in Kashmír*, and *Ghazni, Kabul, and Afghanistan*; Ferrier, *History of the Afghans*; Conolly's *Overland Journey to India*; Sir Alexander Burnes's *Cabool*; Dr Bellew's reports; Wheeler's *Madras in the Olden Time*, and his other valuable works; Malleson's *History of the French in India*; Hunter's *Annals of Rural Bengal, Orissa, and Indian Musalmáns.* (5) Among works bearing on British rule—*The Fifth Report on the Affairs of the East India Company*; selections from the *Calcutta Gazette* in the last century; Kaye's *Administration of the East India Company*; Keene's *Fall of the Mughal Empire*; Owen's *India on the Eve of the British Conquest*; Thorne's *War in India*, 1802–1806; Malcolm's *India*. 1811; Prinsep's *British India*, 1813–18; Kaye's *Sepoy War*, and continuation by Malleson; Fawcett's *Indian Finance.* (6) Short works on Indian history and geography, by Roper Lethbridge, Pope, Marshman, Wheeler, and Meadows Taylor. (7) Biographies of Clive, Warren Hastings, Sir Philip Francis, Lord Teignmouth, Malcolm, Minto, Metcalfe, Combermere. Sir Henry Lawrence, and Sir Herbert Edwardes; also the *Wellington Despatches* referring to India, by Sidney Owen; Lord Ellenborough's *Letters*; and Kaye's admirable Indian biographies. (8) In fiction and poetry, Edwin Arnold's *Light of Asia* stands first. Meadows Taylor's *Confessions of a Thug*, and *Tara*; *Pandurang Hari*; H. Cunningham's *Dustypore*; and *The Afghan Knife*, form well-known examples of the Anglo-Indian novel. (9) Indian official reports:—*Annual Administration Reports* of the various presidencies and provinces; *District Settlement Reports* in the North-Western Provinces, Oudh, and the Punjab; *General Reports of the Board of Revenue, Madras; Survey and Settlement Reports of Bombay; Census Reports* for the various presidencies and provinces in 1871–72, and their condensation, *The Memorandum on the Census of British India* (1871–72), presented to parliament in 1875; *Annual Reports on the Trade and Navigation of British India; Report of the Bengal Royal Commission*, 1880. (10) Parliamentary Blue Books:—*The Annual Statistical Abstract relating to British India*; *Annual East India Finance and Revenue Accounts*; *Statements on the Material and Moral Progress of India.* (W. W. H.)

INDEX.

INDIANA

[Compiled according to Census of 1880 and latest surveys.]



INDIANA

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INDIANA, one of the Central States of the American Union, lies between 37° 47′ and 41° 50′ N. lat., and 84° 49′ and 88° 2′ W. long. It is bounded on the E. by the State of Ohio, from which it is separated by a line drawn due north from the mouth of the Great Miami river; on the S. by the Ohio river, separating it from Kentucky, between the mouths of the Great Miami and the Wabash; on the W. by Illinois, from which it is separated by the Wabash river from its mouth to a point where a line drawn due north from Vincennes last touches the western bank of that stream, thence north on that line to a point 10 miles north of the southern extreme of Lake Michigan; on the N. by a line drawn from that point due east until it intersects the eastern boundary, separating the State from Michigan. A small portion of Lake Michigan is included within the northern boundary. The coast-line is about 60 miles in length. Michigan City is the only lake harbour in the State. The extreme length of the State is 276 miles, with an average breadth of 145 miles; and the area is 33,809 square miles.

Topography.—Indiana occupies a broad table-land, for the most part level or gently undulating, except along the Ohio, where the plain has been deeply grooved by the affluent streams into hills and valleys. There are no elevations that could properly be termed mountains or mountain ranges. With the exception of a small portion which drains into the great lakes, the whole State inclines gently towards the south-west. The highest point (except a knob in Brown county) is found in the southern portion of Randolph county, and is 1253 feet above the sea; the lowest, at the mouth of the Wabash, is 370 feet. From careful surveys the mean altitude of the State is estimated at 735 feet above sea-level. It is well watered by numerous streams and rivers, but, with the exception of the Ohio and Wabash, few of them are navigable. The Wabash is the largest river that has its course mainly within the State; and, together with its branches, it drains three-fourths of the entire surface. It rises in the west of Ohio, and flows first in a north-west direction, and then south-west till it meets the boundary of Illinois, which it follows southward for more than 100 miles, till it falls into the Ohio, after a course of upwards of 500 miles. The Ohio forms the entire southern boundary of the State. The other principal rivers of Indiana are tributaries of the Wabash. The White River, the most important of these, is formed by the W. and E. Forks,—two rivers respectively about 300 and 200 miles long,—which unite about 100 miles above its confluence with the Wabash. The Maumee is formed by the St Joseph and St Mary in the north-east, and falls into Lake Erie. The Upper St Joseph, with its tributaries, passes through the northern counties, and falls into Lake Michigan. That portion south of the Wabash was originally covered with heavy forests of oak, beech, maple, walnut, ash, and other hard woods; north of that river was principally prairie, interspersed with small lakes.

Geology and Minerals.—Lower Silurian strata are well developed in the south-eastern part of the State, with a thickness of 800 feet. Next, to the west and north, in succession occur rocks of the Upper Silurian, with a thickness of 200 feet, and those of Devonian age, 180 feet thick. The last two formations spread over all the northern third of the State, deeply covered with glacial drift, and at points deeply eroded by ice and water flow of that age. The Coal-measures occupy over 7000 square miles in the western and south-western parts, furnishing seven workable seams, at a depth of 50 to 220 feet, and averaging 80 feet below the surface; the seams vary in thickness from 2½ to 11 feet, averaging 4½ feet; the quality is from fair to good; an area of 600 square miles in this field yields a superior "block" or splint coal. This, being free from sulphur and phosphorus, is used in blast furnaces as it comes from the mine, without coking, and is well adapted for the preparation of Bessemer steel. The Sub-Carboniferous or Mountain Limestone borders the Coal-measures on the south and east; it yields giant bands of choice limestone for building purposes, 30 to 50 feet thick, unlimited in extent, homogeneous, elastic to compensate for inequalities of temperature, and with endurance to bear the climatic changes. Near Leavenworth, in the southern part of the State, there is a remarkable calcareous cavern, the Wyandotte Cave. One of its chambers is 350 feet long and 245 in height. It abounds with stalactites and stalagmites of great variety and size.

Inexhaustible beds of fire clay, potter's clay, kaolin, and lime, as well as paving and building stone, are found in the southern parts of the State.

Agriculture is the chief branch of industry, the climate and soil being suited to the growth of cereals, fruits, and grasses. The following table, compiled from the report of the Bureau of Statistics, shows the production of the chief grain crops for 1880:—

	Acres.	Bushels.
Wheat	3,109,845	47,130,684
Indian corn	3,130,327	87,335,014
Oats	686,901	15,563,430
Rye	15,028	217,192
Barley	31,019	687,911

The meadow land amounted to 778,691 acres, and the hay produced was 1,221,164 tons. The same year the domestic animals numbered — horses 494,809, cattle 1,150,559, sheep 1,508,242, and hogs 4,253,586. There were 145,826 stands of bees, yielding 1,114,883 ℔ of honey.

Climate.—The climate is equable and healthy. In 1865 a United States signal station was established at Indianapolis, and the following meteorological tables have been compiled from the daily reports of this office. They indicate the temperature (in degrees Fahrenheit) and rainfall in inches during a period of fourteen years. The mean height of the barometer for the same period was 30·010 inches. The prevailing winds are from the south and west in summer, veering round to the north in winter.

Mean Monthly Temperature and Rainfall for Fourteen Years.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Temperature	31·3°	36·7°	41·8°	54·1°	64·4°	74·3°	77·7°	75·6°	67·9°	54·7°	41·6°	33·5°
Rainfall (inches)	3·75	3·00	4·50	3·66	4·47	4·36	4·57	3·17	3·68	2·37	2·94	3·51

Annual Mean Temperature and Rainfall.

	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.
Temperature	56·32°	56·46°	56·33°	55·56°	52·52°	55·25°	55·89°	52·75°	52·15°	55·04°	50·46°	53·20°	54·60°	55·40°
Rainfall (inches)	50·69	52·44	48·54	45·05	42·98	35·13	36·05	37·95	52·32	43·60	54·58	56·56	39·08	38·62

Manufactures, Communication, &c.—The manufacturing interests have increased rapidly during the last decade. The Bureau of Statistics reported the value of manufactured products for 1878 at $185,050,220, and the mercantile trade sales at $300,323,256. The increase of wealth is shown as follows by the appraisement for taxation :—

1850	$202,650,264
1860	411,042,424
1870	663,455,044
1880	767,387,172

On April 1, 1880, there were sixty-three railway corporations, working 4963 miles of railway in the State, traversing eighty-five counties, and appraised for taxation at $38,442,941. So completely does the railway system cover the State that one can go from the capital to almost any county and return the same day. The geographical position of the State is such that all the main railroad through-lines between the east and west have to cross Indiana.

Administration.—The State is divided into ninety-two counties, containing about 400 square miles each. The governor is elected for four years. The legislature, which meets biennally, consists of a senate of fifty, elected for four years, and a house of representatives of one hundred, elected for two years. The judges (five) of the supreme court are elected for six years. The State has thirteen representatives and two senators in Congress. All popular elections are by ballot. All elections by the legislature are *viva voce.* The State has no permanent debt. The constitution declares that no debts shall be incurred by the State except to meet casual deficits in the revenue, or to provide for the public defence, repel invasion, and suppress insurrection. On the organization of Indiana as a territory in 1800, Vincennes was made the capital ; when the State Government was formed in 1816, the capital was fixed temporarily at Corydon, until provision could be made for the permanent seat at Indianapolis, to which it was removed in 1824.

Education.—The foundation of the free school system was laid by Congress when, in admitting the State into the Union, the Government presented a section of land in each township to the inhabitants for free schools. A great advance was made in 1851, when in framing the new constitution it was provided that certain funds then belonging to the State, with all penal fines and forfeitures accruing, should constitute a common school fund, the principal to remain a perpetual fund, to be increased, but never diminished, and the annual income used for tuition only. This fund in 1880 amounted to $9,220,708, and is increasing. In the same year there were 9647 schoolhouses in the State, valued at $11,817,954. Of the children of school age (six to twenty-one) there were—males, white 354,761, coloured 7162; females, white 334,249, coloured 7386. Of these 511,283 attended the schools. The tuition revenue expended for the year ending June 30, 1880, was

Amount derived from State tax	$1,519,791·69
Interest on common school fund held by counties	204,145·30
State's interest on non-negotiable bonds	234,187·00
Amount derived from unclaimed fees	895·22
Congressional township revenue	198,247·66
Amount of local tuition tax	589,093·21
Proceeds of liquor licences	193,512·15
Total	$2,939,872·23

The State university is at Bloomington, and the State normal school at Terre Haute. The function of the latter is to fit its pupils to become teachers in the common schools. Perdue University, at Lafayette, is the State agricultural college. There are also a number of colleges, mainly under the control of religious societies, chief among which are Asbury University (Methodist) at Greencastle, Wabash College (Presbyterian) at Crawfordsville, Butler University (Christian) at Irvington (near Indianapolis), Notre Dame (Catholic) at South Bend, and Earlham College (Friend) at Richmond.

Population.—In point of population Indiana ranks as fifth State in the Union. The white inhabitants in 1765 are stated to have consisted of a few French families along the Wabash. The following table shows the population at decennial periods during this century :—

Year.	White.	Coloured.	Total.
1800	4,577	298	4,875
1810	23,890	630	24,520
1820	145,758	1,420	147,178
1830	339,399	3,632	343,031
1840	678,698	7,168	685,866
1850	977,154	11,262	988,416
1860	1,338,710	11,428	1,350,428
1870	1,655,837	24,560	1,680,637
1880			1,976,261

The return for 1880 shows a density of population of 57·8 persons per square mile.

The following are the chief towns, with population in 1880 :—Indianapolis, 75,074 ; Evansville, 29,280 ; Fort Wayne, 26,880 ; Terre Haute, 26,040 ; New Albany, 16,422 ; Lafayette, 14,860 ; South Bend, 13,279 : Richmond, 12,473 ; Logansport, 11,198 ; Jeffersonville, 10,422.

History.—Indiana originally constituted a part of New France. It was visited by the Jesuits as early as 1672. At the beginning of the 18th century the French opened a line of communication between the lakes and the Mississippi by way of the Maumee, Wabash, and Ohio rivers. Trading posts for barter with the natives were established at the head of the Maumee, where is now the city of Fort Wayne ; at Ouantenon, on the Wea Prairie, near the city of Lafayette ; and at Vincennes on the Wabash. Missionary stations were also established by the Jesuit fathers, in their endeavour to convert the Indians. At the close of the French war in 1763–4, the territory east of the Mississippi and north of the Ohio passed under British dominion. Pending the war between Great Britain and the American colonies, Colonel George Rogers Clark of Virginia, with an armed force, took possession of the territory, raising the American flag at Vincennes in 1778. By the treaty of 1783 between England and the United States this territory was recognized as belonging to the latter ; inasmuch as Virginia had fitted out Clark's expedition, she was entitled by the law of conquest to claim this vast dominion. During the colonial war Congress recommended the several States to cede their claims to unappropriated lands in the western country to the general government for the common benefit of the Union. Virginia, in pursuance of this request, yielded up her claims to the territory north-west of the Ohio. The deed of cession, executed on March 1, 1784, was signed by Thomas Jefferson, James Monroe, Arthur Lee, and Samuel Hardy. In 1787 Congress passed an ordinance for the government of the north-west territory, which provided, among other things, that not more than five States should ever be formed thereof, prohibiting slavery, and declaring that "religion, morality, and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall for ever be encouraged." This territory was subsequently divided into the States of Ohio, Indiana, Illinois, Michigan, and Wisconsin. Indiana was admitted into the Union as a State by Congress on April 19, 1816, being the sixth State received after the formation of the government by the thirteen original States and the adoption in 1787 of the present constitution. (A. C. H.)

INDIANAPOLIS, the capital of Indiana, is situated at almost the exact geographical centre of the State, in 39° 47′ N. lat., 86° 6′ W. long., 824 miles W. of New York by rail, and 194 miles S.E. of Chicago. It stands 721 feet above the sea-level, and 148 above Lake Erie.

On the admission of Indiana as a State into the Federal Union in 1816, Congress presented 4 square miles of public lands for its seat of government, to be selected by the State. The location was made in 1820 at the confluence of Fall Creek and White River. The site chosen was in the midst of the unbroken forest, 60 miles distant from the borders of civilization, and only reached by Indian trails. The name Indianapolis was given by an act of the Legislature on January 6, 1821 ; and Alexander Ralston was appointed to lay out the city. Selecting a slight mound near the middle of the ground as the centre of the proposed capital, Ralston laid out the town after the manner of Washington city, which he had helped to survey.

Four avenues radiate from the centre to the four corners of the city. The streets and avenues are 90 feet wide, except Washington, the main street, which is 120. The city has now outgrown its original limits, and extends 4 miles in length and 3 in width. It is built upon a level plain and surrounded by a fertile country. It was incorporated in 1836, and received a city charter in 1847. Its growth is shown by the following table:—

Year.	Population.	Assessed Value of Property.
1850	8,090	$2,326,185
1860	18,113	10,700,000
1870	48,244	25,981,267
1880	75,074	50,254,934

In 1847 the first railway entered the city. Within a few years thereafter other lines were constructed, until now twelve main lines converge in the Union Depôt. About one hundred passenger trains, connected with every part of the country, enter and depart daily. The numerous tracks being on a level with the surface of the streets, the obstruction and danger at the numerous crossings became very great on account of the increase of railway traffic, so that in 1877 a loop line, called the "Belt," had to be made passing round the city, to connect the various railroads. By means of it the "through freight cars" are conveyed past the city without blocking the traffic.

Indianapolis is in the centre of the swine-producing region, and pork packing is one of the chief industries of the city. The number packed in 1877 was 420,000 head; in 1878, 766,000; in 1879, 677,809. It is also largely engaged in the grain trade. The railways have been of greatest service to Indianapolis, compensating for its want of water transit. The manufacturing and mercantile interests, which are large and increasing, are the natural result of the city's extensive railroad connexions.

A system of graded free schools is maintained all the year. The city school property is valued at $1,041,000.

In 1871 a public library was established, and is supported by taxation, which now contains 36,461 volumes, and is rapidly increasing. The masonic temple, oddfellows' hall, post-office, U. S. arsenal, and chamber of commerce are handsome buildings. The Marion county court-house, standing on a public square in the heart of the city, was completed in 1877 at a cost of $1,411,524. The exterior is of Indiana limestone, the interior of iron and marble, with frescoed walls and ceilings. Its dimensions are 150 by 286 feet, and 240 feet to the top of the dome. The principal benevolent institutions of the State, viz., the institution for the education of the blind, that for the deaf and dumb, and the hospital for the insane, are located here; they are handsome and commodious buildings, the last having accommodation for 1313 patients. The State reformatory for women and girls, where all female offenders are imprisoned, adjoins the city. The institution is under the management of a board of control, composed of women chosen by the governor of the State. In 1877 the State began the erection of a new State house, to be completed in 1888, at a cost of $2,000,000. This will be one of the most imposing capital buildings in the United States.

By law the power to incur permanent debt is limited to a sum not exceeding 2 per cent. upon the assessed value of the property within the city; and the rate of taxation is limited to 90 cents per $100 for municipal purposes, 20 cents for public schools, and 2 cents for free libraries. (A. C. H.)

INDIAN ARCHIPELAGO. The East Indian Archipelago or Malay Archipelago, the largest island cluster in the world, lies to the south-east of Asia and to the north and north-west of Australia, and bears the impress in many of its most important characteristics, both natural and historical, of this twofold relation.[1]

Position and extent.

As the archipelago does not form a political unity, different writers assign it very different limits, according as they are influenced by one set of considerations or another. New Guinea to the east and the Philippines to the north are sometimes included and sometimes excluded; Sumatra is sometimes regarded as the most western member of the group, and sometimes that position is given to the Nicobar or the Andaman Islands. From the following survey of the extent of the archipelago the Malay Peninsula and New Guinea are excluded, but the Andaman Islands are admitted as having at least an ethnographical claim. The Balintong Strait, about the 20th parallel of N. lat., may be taken as the northern limit; and but for a small portion of the islands Timor and Sumba (Sandalwood Island), with their insignificant adjacencies, the southern limit might be stated as the 10th of S. lat. The Andaman Islands take us as far west as 93° E. long., the Aru Islands as far east as 135°. The equator passes through the middle of the archipelago; it successively cuts Sumatra, Borneo, Celebes, and Jilolo, four of the most important islands. To adopt Mr Wallace's graphic sentences (noting that he embraces New Guinea and the Solomon Islands), the archipelago "includes two islands larger than Great Britain; and in one of them, Borneo, the whole of the British Isles might be set down, and would be surrounded by a sea of forests. Sumatra is about equal in extent to Great Britain; Java, Luzon, and Celebes are each about the size of Ireland. Eighteen more islands are on the average as large as Jamaica; and more than a hundred are as large as the Isle of Wight."

The statistics of the area and population of the several islands can only be given approximately. The following table is based on statements contained in the sixth number of Behm and Wagner's *Die Bevölkerung der Erde* (Gotha, 1880):—

	Area.	Population.
	Sq. miles.	
I. Andaman and Nicobar Islands....	3,192	20,000
II. Sunda and Molucca Islands[2]... ...	655,720	27,343,000
(1) Borneo group............295,007 sq. m.	...	...
(2) Sumatra group..........179,458 ,,	...	...
(3) Java group............... 50,849 ,,	...	...
(4) Lesser Sunda group... 35,152 ,,	...	...
(5) South-Western group. 2,021 ,,	...	...
(6) Tenimber, Aru, and	...	...
Ke Islands............... 5,356 ,,	...	...
(7) Moluccas.................. 20,549 ,,	...	...
(8) Celebes group........... 77,250 ,,	...	...
III. Philippine Islands	114,096	7,450,000
Total	773,008	34,813,000

The total area is thus rather less than that of British India, and the population rather more than that of Great Britain and Ireland.

General appearance.

The islands of the archipelago nearly all present bold and picturesque profiles against the horizon, and at the

[1] For more detailed information respecting the several islands and groups of the archipelago the reader is referred to the separate articles BORNEO, JAVA, SUMATRA, PHILIPPINE ISLANDS, &c.

[2] Various subdivisions have been suggested of the great Sunda and Molucca groups, which may be described as the Indian Archipelago *par excellence*. Mr Wallace arranges them thus:—*The Indo-Malay Islands*—Borneo, Java, and Sumatra; *the Timor group*—Timor, Flores, Sumbawa, and Lombok; *Celebes*, with the Sulu Islands and Buton; *the Moluccan group*—Buru, Ceram, Batchian, Jilolo, and Morty, with the smaller islands of Ternate, Tidore, Makian, Kaióa, Amboyna, Banda, Goram, and Matabello. The Ke and the Aru Islands he treats along with New Guinea.

same time the character of the scenery varies from island to island and even from district to district. The mountains arrange themselves for the most part in lines running either from north-west to south-east or from west to east. In Sumatra and in the islands between Sumatra and Borneo the former direction is very distinctly marked, and the latter is equally noticeable in Java and the other southern islands. The mountains of Borneo rise rather in short ridges and clusters from the plain, like islands from the sea; the arrangement represented on even what are considered authoritative maps being, like much else in the cartography of the archipelago, the product of imagination. Nothing in the general physiognomy of the islands is more remarkable than the number and distribution of the volcanoes, active or extinct.[1] Running south-east through Sumatra, east through Java and the southern islands to Timor, curving north through the Moluccas, and again north from the end of Celebes through the whole line of the Philippines, they form as it were the rim of a great atoll (to use Dr Schneider's phraseology), rudely resembling a horseshoe narrowed towards the point. The loftiest mountain in the archipelago would appear to be the famous Kina Balu in Borneo; the loftiest of the volcanic peaks are Indrapura in Sumatra (12,255 feet), Semeru in Java (12,238), Gunong Agong in Bali (11,726), and Tamboro in Sumbawa (9324 feet).

An important fact in the physical geography of the archipelago is that Java, Bali, Sumatra, and Borneo, and the lesser islands between them and the Asiatic mainland, all rest on a great submerged bank, nowhere more than 100 fathoms below the surface of the sea, which may be considered a continuation of the continent; while to the east the depth of the sea has been found at various places to be from 1000 to 2500 fathoms. As the value of this fact has been particularly emphasized by Mr Wallace, the limit of the shallow water, which passes through between Bali and Lombok, and strikes north to the east of Borneo, has rightly received the name of Wallace's line. The Philippines, on the other hand, "are almost surrounded by deep sea, but are connected with Borneo by means of two narrow submarine banks."[2]

Geology. The geology of the archipelago has not been investigated even with the completeness attained in regard to the zoology and botany; but there is a very considerable collection of material in the publications of the mining engineers of the Dutch Government (*Jaarboek Mijnwezen Ned. O. Ind.*); and for the Philippines a valuable "Memoria geologico-minera" has been printed in the *Boletino* of the Commission of the Geological Map of Spain (Madrid, 1876). The results obtained by the Dutch engineers have been summarized by Dr Schneider, "Geologische Uebersicht über den holländ.-ostind. Archipel," in *Jahrbuch d. K.K. Geolog. Reichsanstalt*, Vienna, 1876, Bd. xxvi. There is a wide and varied representation of the azoic formations—gneiss, mica-schist, hornblende, &c., in Timor (which it may be remarked is geologically one of the best known of the islands), Ceram, Billiton, Banka, &c. Silurian rocks are found in Banka (where they contain the famous tin-mines), Billiton, and the Linga and Riouw archipelago; carboniferous limestone occurs in the north of Timor; the coal of Batchian is apparently similar to that of the English Carboniferous measures; and the Coal-measures of Borneo are thought by Van Dyk to be also Palæozoic. The Sumatran coal is of unascertained age. Permian rocks are present in Timor, Celebes, Pulo-Laut, and Sumatra. Of Secondary formations we find both Triassic and Jurassic rocks, the latter represented by Oolites in Timor, by a coralline limestone in Celebes. Cretaceous rocks occur in both these islands and in Celebes. Throughout the whole archipelago the Tertiary formations have a wide development both in their Eocene and their Miocene divisions. The latter is represented by foraminiferous limestone, and the former by nummulitic limestone. Lignite is freely distributed throughout the Tertiary strata of Java, Sumatra, and Nias. Among the rocks of economic importance may be mentioned granite of numerous kinds, syenite, serpentine, porphyry, marble (at least in southern Java), sandstones, and marls. Coal is worked successfully in Sumatra, Borneo, and Labuan. Diamonds are obtained in Borneo, garnets in Sumatra, Batchian, and Timor, and topazes in Batchian; antimony in Borneo and the Philippines; lead in Sumatra, Banka, Flores, and the Philippines; and copper and malachite in the Philippines, Timor, Borneo, and Sumatra. Iron is pretty frequent in various forms, and in some places might be successfully worked. Gold is not uncommon in the older ranges of Sumatra, Banka, Celebes, Batchian, Timor, and Borneo. Manganese could be readily worked in Timor, where it lies in the carboniferous limestone. Platinum is found in Landak and other parts of Borneo, and mercury in small quantities in Java.

Meteorology. The meteorology of the archipelago has hitherto been studied only in a very vague manner. For Batavia, indeed, there exists a mass of observations; and the observatory there is extending the region of its investigations. At the close of 1879 it had one hundred and twenty-five rainfall stations. A magnetic survey of the islands has been made by E. Van Rijckevorsel, whose report is published by the Academy of Sciences of Amsterdam. The most striking general fact is that, wherever that part of the south-east monsoon which has passed over Australia strikes, the climate is comparatively dry, and the vegetation is less luxuriant and luscious. The east end of Java, *e.g.*, has a less rainfall than the west; the distribution of the rain on the north coast is quite different from that on the south, and a similar difference is observed between the east and the west of Celebes. According to Dr Bergsma's *Rainfall of the East Indian Archipelago, First Year*, 1879 (which, like other publications of the Batavian meteorological office, is printed in English), at thirty-three stations out of fifty-nine the annual rainfall exceeded 100 inches, and at five stations 200 inches. The highest registration was 282 inches, at Padang Pandjang (Sumatra). The north-west monsoon, beginning in October and lasting till March, brings the principal rain season in the archipelago. The midday heat of the sun, it need hardly be said, makes itself powerfully felt. Exposure to its direct rays in Timor, for example, "at any time between 9 A.M. and 3 P.M.," says Mr Wallace (*Tropical Nature*), "would blister the skin in a few minutes almost as effectually as the application of scalding water," and Mr Moseley mentions that on wading into the sea at the Aru Islands he found the heat of the water actually greater than was at all pleasant. But at the same time the general climate cannot be said to be oppressive or unhealthy.

Vegetation. Most of the islands of the archipelago belong to that great forest-belt which, in the words of Mr Wallace, "girdles the earth at the equator, clothing hill, plain, and mountain with an evergreen mantle." In islands and districts where human civilization has been at work for centuries, the natural covering has in large measure given place to artificial tilth; and in Timor and several of the south-eastern islands the characteristics of New Guinea—luxuriant herbage and open park-like woodlands—are more or less strikingly predominant.[3] The

[1] A valuable list of these will be found in Junghuhn's *Java*, a work which contains many details in regard to various parts of the archipelago.

[2] Wallace, *Island Life*, 1880.

[3] Wallace, *Malay Archipelago*, p. 8.

field for botanical research in the archipelago is still vast and alluring. Among the very giants of the forest the unregistered species must be numerous; and, if we descend to the minor forms, it is a very poor collection that does not yield something absolutely new to science. The ferns, the pitcher plants, and the orchids are especially numerous, and have attracted particular attention. "The volcano of Pangerango in Java is said to have, for example, yielded three hundred species of ferns;" and Mr Burbidge, in a short excursion in Borneo in 1879, found upwards of fifty species that had not been previously obtained in the island.

For detailed information in regard to the flora, the reader may consult C. G. le Reinwardt, *Ueber den Character der Vegetation auf den Inseln des Ind. Archipels*, Berlin, 1828; Belanger, *Botanique du Voyage aux Indes Orientales*, 1825–1829, Paris, 1832; the various works of C. L. Blume (*Museum botanicum Lugd.-Bat.*, Leyden, 1849–51; *Collection des orchidées*, Amster., 1858, &c.); W. H. de Vriese, *Nouvelles Recherches sur la flore des possessions Neerland. aux Indes Or.*, Amst., 1845; Hasskarl, *Catalogus plantarum in horto botanico Bogoriensi cultarum*, Berl., 1844; F. Dozy and J. H. Molkenboer, *Bryologia Javanica seu descriptio muscorum frondosorum Arch. Ind.*, Leyden, 1844 58; H. Zollinger, *System. Verzeichniss der im Ind. Arch. 1842–1848 gesammelten . . . . Pflanzen*, Zurich, 1854; Miquel, *Flora van Nederlandsch Indië*, Amst., 1855, *Annales Musei Botanici Lugduno-Batavi*, 1869, and *Illustrations de la flore de l'Archipel Indien*, 1871 (continued by Suringar).

If we turn to the economical aspect of the vegetation, whether natural or cultivated, we cannot fail to be impressed by its varied resources. The list of fruits is a very extensive one; though unfortunately it is only with a very few of them that the untravelled European can have any practical acquaintance. Besides the orange, the mango, the mangosteen, the pomato or shaddock, the guava, the papaw, and the jack fruit, we have the rambutan, the tarippe or trap, the jintawan, the tampu, the bilimbing, the mamhangan, the langsat, the rambi, and the jambosa. The name at least of the durian is now well known (see Durian), and nearly as strange is the bawangutan (*Scordoprasum borneense*), of which the fruit, the leaves, and the branches have all a strong odour and flavour of onions.[1] Of what more distinctively deserve the name of food-plants the variety is equally notable. Not only are rice and maize (usually called *djagong* in the archipelago), sugar and coffee, among the widely cultivated crops, but the cocoa-nut, the bread fruit, the banana and plantain (usually called *pisang* in the archipelago), the sugar-palm (*Arenga saccharifera*), the tea-plant, the sago-palm, the cocoa-tree (which curiously yields the favourite beverage of the Sulu archipelago), the ground-nut, the *Caladium esculentum*, the yam, the cassava, and others besides, are of practical importance. The cultivation of sugar and coffee owes its development mainly to the Dutch; and to them also is due the introduction of tea. They have greatly encouraged the cultivation of the cocoa-nut among the natives, and it now flourishes, especially in the coast districts, in almost every island in their territory. The oil is very largely employed in native cookery. The sago-palm is most abundant in the island of Ceram, but is also found growing wild in Borneo, Celebes, Timor, and other islands of the Moluccas, in the Linga archipelago, and in parts of Sumatra. The product is mainly prepared for export. Pepper, nutmegs, and cloves were long the objects of the most important branch of Dutch commerce; and camphor, dammar, benzoin, and other products of a similar kind have a place among the exports. India-rubber and gutta percha are no longer obtained to the same extent as formerly.[2]

ogy.

To the naturalist the Indian archipelago is a region of the highest interest; and from an early period it has attracted the attention of explorers of the first rank. And yet the list of its living forms is far from being completely ascertained. The best known district is western Java, and Timor, the Moluccas, and the Papuan Islands have for the most part been well explored. Only parts of Sumatra, Borneo, and Celebes have been worked, and most of the other islands have yet to be dealt with.[3] Zoologically the archipelago belongs to two distinct regions—the eastern or Papuan, and the western or Malay or Indian. This latter region, according to August von Pelzeln ("Ueber die Malayische Säugethiere-Fauna" in *Festschrift zur Feier des Fünfundzwanzigjährigen Bestehens der K.K. Zool.-Bot. Gesellschaft in Wien*, Vienna, 1876), comprises southern China, Tibet, the Himalaya, and Further India, as well as the islands of the archipelago up to Wallace's line. He finds six genera of the *Quadrumana*, fourteen of the *Chiroptera*, five of the *Insectivora*, fourteen of the *Carnivora*, six of the *Rodentia*, of the *Edentata* one only (*Manis*), five of Ruminants, and three of Pachyderms. Sumatra indicates a connexion with the Malacca peninsula by *Nemorhœdus*, the elephant, *Gymnura*, and the tapir. *Pithecus*, *Tarsius*, and *Ptilocercus* seem peculiar to the Sunda Islands. The Philippines have *Semnopithecus*, *Macacus*, *Cynopithecus*, *Galeopithecus*, *Pteropus*, *Taphozous*, *Vespertilis*, *Viverra*, *Paradoxurus*, *Pteromys*, *Mus*, *Rusa*, and *Cervulus*.

In his various works Mr Wallace has made the English reader familiar with the most striking features of zoological distribution in the archipelago; and in his *Island Life*, especially, the ornithology receives particular attention. For details in regard to the mammals and birds, see Horsfield, *Zoological Researches in Java and the Neighbouring Islands*, 1834; Van Temminck, *Monographies de Mammologie*, 1827–1829 and 1835–1841; *Verhandelingen over de natuurlijke geschiedenis der Nederlandsche overzeesche bezittingen*, containing papers by S. Muller and H. Schlegel; zoological appendix to Belcher's *Voyage of H. M. Ship "Samarang,"* Lond., 1850; H. Schlegel, *Muséum d'hist. naturelle des Pays-Bas.: Revue méth. et crit. des Collections*, Leyden, 1863–76; Id., *Mém. sur les quadrumanes et les cheiroptères de l'archipel indien*, Amst., 1864; Id., *De Vogels van Nederlandsch Indië beschreven en afgebeeld*, Leyden, 1876; Von Rosenberg, "Overzichtstabellen voor de Ornithologie van den Indischen Archipel" in *Acta Scient. Ind. Neerland.*, part v.; T. Salvadori, "Catalogo sistematico degli uccelli di Borneo," in *Annali di Genova*. To the herpetology of the archipelago valuable contributions have been made by P. Bleeker, A. C. J. Edeling, and A. B. Meyer. Like so much else of value, their papers are mainly to be found in the *Nat. Tijds. van Ned. Ind.* For the fishes the great modern authority is Bleeker, whose principal work, however, was left unfinished (*Atlas ichthyologique des Indes orientales Neerlandaises*), and whose smaller contributions are scattered through more than a dozen periodicals.

Ethnology.

The ethnology of the Indian archipelago does not lack its difficult problems; but some outstanding features are easily described. There are at least two main native races, the brown long-haired Malay and the darker-skinned frizzly-haired Papuan. And to these more recent explorations make it almost certain that a third and probably more thoroughly aboriginal race—the Negrito—must be added, though even specialists who have had opportunities of direct observation are not unanimous in regard to this noteworthy element. The Malays are subdivided into an immense number of tribes and peoples in the most various stages of civilization, and broadly differenced from each other by physical and linguistic characteristics. Of chief note are the Malays proper, the Javanese, the Bugis, the Tagalas, and Bisayas, the people of the Moluccas, the Dayaks (mainly in Borneo), the Battaks of Sumatra, the Sulu islanders (closely similar to the tribes of northern Borneo). The Papuan race is chiefly to be found in the eastern section of the archipelago. Besides these three races, whose first connexion with the archipelago dates from before the dawn of history, we have a variety of intrusive elements, traceable by more or less strictly historical

[1] See Burbidge's interesting chapter in his *Gardens of the Sun*, 1880.

[2] Compare Musschenbroek, *Mededeelingen omtrent grondstoffen uit het oost. gedeelte van onzen Ind. Archipel*, Briel, 1880.

[3] See Professor Veth's valuable monograph, *Overzicht van hetgeen, in het bijzonder door Nederland, gedaan is voor de Kennis der Fauna van Nederlandsch Indië*, Leyden, 1879.

documents. A Hindu strain is evident in Java and others of the western islands; Moors and Arabs (that is, as the names are used in the archipelago, Mahometans from various countries between Arabia and India) are found more or less amalgamated with many of the Malay peoples; and the Chinese form, in an economical point of view, one of the most important sections of the community in many of the more civilized districts. Chinese have been established in the archipelago from a very early date: the first Dutch invaders found them settled at Jacatra; and many of them, as, for instance, the colony of Ternate, have taken so kindly to their new home that they have acquired Malay to the disuse of their native tongue. Chinese tombs are among the objects that strike the traveller's attention at Amboyna and other ancient settlements.

For the ethnology of the archipelago, see Meinicke, "Ueber die Völkerstämme des Ind. Archipelagus," in *Annalen der Erdkunde*, 1837; Spencer St John, "The Population of the Ind. Arch.," in *Journal of the Ind. Archipelago*, 1849; G. W. Earl, *The Native Races of the Ind. Arch.: Papuans*, Lond., 1853; Logan, "On the Ethnology of the Ind. Arch.," in *Jour. of Ind. Arch.*, 1847, 1850, 1851, 1853, 1854; and the rich collections in the *Tijdschrift v. Ind. T. L. en V. Kunde.* An excellent summary of the subject by A. H. Keane will be found as an appendix to Wallace's *Australasia* (Stanford's *Compendium of Geography and Travel*), Lond., 1879. See also the same writer's papers in *Nature*, 1881.

Languages.

There is a vast field for philological explorations in the archipelago. Of the very great number of distinct languages known to exist, few have been studied scientifically. The most widely distributed is the Malay, which has not only been diffused by the Malays themselves throughout the coast regions of the various islands, but, owing partly to the readiness with which it can be learned, has become the common medium between the Europeans and the natives. The most cultivated of the native tongues is the Javanese, and it is spoken by a greater number of people than any of the others. To it Sundanese stands in the relation that Low German holds to High German, and the Madurese in the relation of a strongly individualized dialect. Among the other languages which have been reduced to writing and grammatically analysed are the Balinese, closely connected with the Javanese, the Battak (with its dialect the Toba), the Dayak, and the Macassarese (see the writings of R. van Eck, H. N. van der Tuuk, A. Hardeland, and B. F. Matthes). Alfurese, a vague term meaning in the mouths of the natives little else than pagan, is more particularly applied by the Dutch philologists to the native speech of certain tribes in Celebes. The commercial activity of the Buginese causes their language to be pretty widely spoken,—little, however, by Europeans.

A general sketch of the languages of the archipelago will be found in *De Gids*, 1864, from the pen of Professor Veth. See also Robert Cust, *Sketch of the Modern Languages of the East Indies*, 1878. A bibliography of this department will be found in Boele van Neusbroek, *De beoefening der oostersche talen in Nederland en zijne overzeesche bezittingen* 1800–74 (Leyden, 1875).

Population.

The statistics of the population are, with the exception of those for a few limited areas, such as Java, of the most unsatisfactory character The estimate of Behm and Wagner in 1880 has been already stated,—34,813,000. This gives the comparatively sparse proportion of 45 to the square mile. The distribution, too, is extremely unequal. In Java we have as much as 364 to the square mile, and in the Philippines about 65, so that for the remaining islands the average is only about 15. It would appear that when left in their natural savage or semi-savage condition the natives increase very slowly in numbers, and in some cases hardly maintain their ground.

Political divisions.

Politically the Indian archipelago is subject to a sixfold division:—the independent native states and tribal territories, the Spanish possessions, the Portuguese possessions, the Dutch possessions, the English possessions, and the state of Sarawak. The Dutch are by far the most influential power in the archipelago. The Spanish authority is confined to the Philippines and the Sulu archipelago,—the latter rendered tributary to them by the native sultan in August 1878 in return for an annual subsidy of 2400 dollars. The English, if the island of Singapore be considered as belonging rather to the Malacca Peninsula, possess only the island of Labuan (19,350 acres), acquired in 1847,—though the establishment of the British Bornean Company in the north of the island may prove the beginning of a new acquisition. To the Portuguese are subject part of Timor and the island of Kambing, in all 6192 square miles. The Dutch on the other hand claim, besides an area of 149,820 square miles in western New Guinea, a total territory in the archipelago of 566,383 square miles, or forty-four times as much as the governing country. Of the really independent native states the largest is that belonging to the sultan of Brunei (Borneo); it is estimated to have an area of about 88,000 square miles

The Dutch territ[ory].

The Dutch divide their territory into two great divisions—(1) Java and Madura, and (2) the Outer Possessions. The former, which comprises also Bali and Lombok, is administratively divided into twenty-three residencies, which are subdivided into departments or assistant residencies. The Outer Possessions are organized in a similar manner, but several portions of them—the West Coast of Sumatra, Celebes and its dependencies, and Achin or Atjh—constitute governments with residencies under them. Of the other residencies the principal are those of the East and South-East coasts of Sumatra, Riouw and its dependencies, the island of Banka, Western Borneo, Southern and Eastern Borneo, Menado in the north of Celebes, Timor, Amboyna, and Ternate, the last being nominally the most extensive of all, from including an unusually large proportion of native territory.

The accusation frequently made against the Dutch that they furnished little information about their East Indian possessions has long ceased to have any foundation in fact. The Government publish at Batavia a large annual *Regerings Almanak voor Nederlandsch Indië* (that of 1880 contains upwards of 1200 pages); and every year there is presented to the Dutch parliament a voluminous *Koloniaal Verslag*, containing elaborate details on all departments of the administration. The *Tijdschrift voor Nederlandsch Indië* of Dr W. R. Baron van Hoëvell, continued by a society of statesmen and scholars (Zaltbommel), the *Bijdragen tot de Taal- Land- en Volkenkunde van Nederlandsch Indie* of the Royal Institute at the Hague, the *Indische Gids* (Amsterdam), and the *Indische Mercuur* (Haarlem), a monthly organ of trade, show the interest taken in Holland in the East Indian possessions. Of the numerous periodicals published at Batavia it is enough to mention the *Statistiek van den Handel*, the *Verslag van's lands plantentuin te Buitenzorg*, the *Tijdschrift van het Kon. Instituut voor Ingenieurs*; the *Verhandlingen* of the Batavian Society of Arts and Sciences, and the same society's *Tijdschrift voor Ind. Taal- Land- en Volkenkunde*; the *Ind. Militair Tijdschrift*, the *Natuurkundig Tijdsch.*, the *Geneeskundig Tijdsch.*, and *Tijdsch. voor Nijverheid en Landbouw.* Another Tijdschrift of the Ind. Agricult. Soc. is published at Samarang.

The population subject to the Dutch is partially indicated in the following table:—

	1877	Males in 1877.	1878
Java and Madura.			
European	28,672	15,586	29,998
Chinese	198,233	103,269	200,303
Arabs	9,379	5,115	8,839
Other Eastern foreigners ...	3,961	2,077	4,115
Natives	18,567,075	8,987,999	18,824,574
	18,807,320	9,114,046	19,067,829
Outer Possessions.[1]			
Europeans	7,688	3,988	8,028
Chinese	126,710	96,448	119,534
Arabs	4,634	2,299	4,708
Other Eastern foreigners ...	7,405	5,681	9,150

How rapidly the Chinese element is increasing is shown by the fact that in the five years 1874–78 permission to reside within Dutch territory was granted to 13,302 Chinese; while similar per-

[1] No accurate data are known for the native tribes of the Outer Possessions.

mission was obtained by only 749 "Europeans"[1] (including Armenians and Persians) and 1421 Arabs. Slavery was abolished in the strictly Dutch portions of the Indies on the 1st of January 1860, and under Dutch influence it is being abandoned by the native states.

Government. The functions of the governor-general of the Dutch possessions may briefly be described as those of a viceroy. He has command over the land and sea forces, and supreme supervision of all parts of the general administration. His also is the right of declaring war and peace, and of concluding treaties with the native princes and peoples. No sentence of death can be executed in time of peace without his authority, and he enjoys the right of mercy and amnesty within certain definite limits.

The governor-general is assisted by a council (*Raad van Nederlandsch Indie*), consisting of a vice-president and four members (all named by the king), assisted by a secretary. In relation to the executive the council is an advising body; but in the exercise of the legislative functions, and in certain definite cases, if the governor-general disagrees with his council, he must appeal to the king for direction. The council has its seat at Batavia, and meets every Friday.

The governor-general has besides a cabinet called the "general secretariat," the head of which is the general secretary (assisted by two Government secretaries), who acts as referee and adviser of the administration. Besides his strictly secretarial duties he compiles the *Staatsblad van Nederlandsch Indië* and the *Regerings Almanak voor Nederlandsch Indië* (published since 1816). A general chamber of accounts for the Dutch East Indies, consisting of a president and six members, has its seat in Batavia.

The administrative departments have undergone considerable changes from time to time. At present there are five directors—(1) of inland administration, (2) of education, religion, and industry, (3) of public civil works, (4) of finances, and (5) of justice, the last added in 1869. To the department of justice belong, not only the supervision of the courts and law business, but that of the *weeskamers* and *boedelkamers* or chambers of wardship and legacies, the granting of right of residence, the control of the press, and the right of public meeting. The supreme court has its seat at Batavia, and there is an elaborate and intricate system of subordinate courts of justice, European and native. It is only the chief officials that are Europeans, in accordance with the dominant policy in the whole constitution of the departments of inland administration and justice, that the relations of native with native should be left as much as possible in the hands of native courts. In all about two hundred native princes are tributary to the Dutch authorities.

Finance. To the department of finance belong (1) the taxes and resources of the colony, farmed or unfarmed, so far as they do not depend on some other department; (2) the control of public auctions; (3) the mint; and (4) various duties connected with the colonial budget and the colonial treasury. The custom of farming a large part of the revenue has long been in vogue, and despite the theoretical objections to the system, it has one great advantage, it pays. The sale of opium is one of the principal Government "farms." The cultivation of the poppy is absolutely forbidden in the archipelago, and the demand is satisfied by imports from British India and the Levant. From the Government supply so obtained the contractor is obliged to take a certain definite quantity at a high fixed price; beyond this he may purchase at ordinary cost price what he finds requisite. The total gain from this monopoly was £1,259,212 in 1879, though the local authorities are instructed to do all in their power to prevent the spread of opium-eating. The whole of what are called "the lesser resources" of the Government, consisting of a curious miscellany of taxes, do not yield a third of the opium revenue. Of the branches of the revenue not farmed, the chief are the customs or import and export duties. The average these yielded for the five years 1874-78 was £720,378. Two important taxes, known as the personal tax and the income tax, both levied on Europeans, were introduced in 1879.

The most striking feature in the administration of the Dutch East Indies is undoubtedly this that, instead of being a drain on the resources of Holland, the colony pays annually a most important contribution into the national exchequer. When these possessions were taken over by the mother country they were burdened with a large debt, and the financial state of the colony remained very unsatisfactory for many years; but on the introduction of the culture system in 1830 the aspect of affairs was speedily changed, and in the fourteen years from 1865 to 1878 there was a clear gain of about £18,000,000 from the colonial administration.

Army and navy. On December 31, 1878, the strength of the military forces in the East Indies was 38,106 men, of whom nearly one half were Europeans. This, however, does not include the militia corps, which were established in certain places. At the same date the East Indian navy comprised 27 ships and 154 cannon. The strength of the military marine was 2934 Europeans and 969 natives, while the vessels were manned by 2630 Europeans and 1012 natives.

There is an elaborate department of education, public worship, and industry; but it is astonishing how little has hitherto been accomplished in the European instruction and Christianizing of the natives.

Education. The educational organization consists of two departments—a European and a native; but it is only within recent years that the latter has begun to attract the active interest of the Government. For secondary European education the great institution is the Gymnasium Willem III. at Batavia. In 1878 there were 68 Government primary schools for Europeans in Java and Madura, and 28 in the Outer Possessions, with a total attendance of 7223 children. With the exception of certain medical colleges, all the institutions in the native department are for primary instruction. At the end of 1878 these schools numbered 376; 214 of them were in the Outer Possessions. In Java and Madura there is a grand total of 28,000 native children receiving vernacular education, and if the Outer Possessions are included the number must be more than doubled. There are nine training schools for native teachers, most of them established since 1870; and in 1879 four schools were opened for sons of the native princes and aristocracy.

Religion. The Protestant churches of the Dutch Indies compose a church union, administered very much according to Presbyterian usage. The number of preachers and assistant preachers is limited by Government, the former to 35 and the latter to 21, by a royal decree of 1863. The Roman Catholics are under a vicar-apostolic, who is also bishop of Batavia, and 20 of their ecclesiastics are paid by the state. Christianity has not as yet made much progress among the natives, the returns for 1878 showing only 174,462 native Christians, of whom 225 were Chinese. In Java and Madura the Christians do not number so much as 1 in 2300 of the population. Mahometanism is the religion of a large proportion of the natives, and is at present making more advances in relation to the heathen population than Christianity. The Dutch Government grants passes for about a shilling each to those who wish to make the pilgrimage to Mecca; and the numbers who set out in 1877, 1878, and 1879 respectively were 6893, 5632, and 5438, besides about 1500 from the native states.

Public works. The administration of the department of public works shows that the Dutch have not belied their European reputation for civil engineering and industrial activity in their Indian colony. The roads and bridges, canals and irrigation works, which they have executed in their central island win the admiration of foreign visitants. Java is the only island which has even the beginning of a railway system, but considerable progress has been made there; and the postal and telegraph services are being rapidly developed.

Imports. The total imports of private trade (including specie) amounted in 1876 to 116,392,762 florins (1 florin = 1s. 8d.), and in 1877 to 126,066,462; and at the same time 5,118,938 florins and 27,637,954 florins respectively were imported in name of the Government. Of the 109,177,424 florins of general imports (excluding specie) in 1876, 47,694,270 florins were from Holland, 33,042,854 from other countries outside of the archipelago, and no less than 27,632,294 from Singapore alone; and of the Government imports 2,207,611 florins were from Holland and 2,033,910 from Singapore. In 1877 cotton manufactures figure among the general imports for 43,566,127 florins, and yarns for 3,325,323; rice for 7,798,348; petroleum, 5,430,103; cigars, 2,892,369; tea, 2,405,511; coals, 2,268,520; and iron and iron goods 2,362,525. The opium is the most extensive of the Government imports.

Exports. The general exports (specie excluded) were 154,229,384 florins for 1876 and 161,863,449 for 1877; those of the Government, 51,168,108 and 57,116,672. In 1876 the more important articles showed as follows:—coffee (private trade) 34,347,870 florins, (Government) 54,208,868 florins; sugar, 62,583,164 florins; tobacco for the European market, 27,794,755 florins; gambir, 2,036,592; gutta percha, 1,651,292; benzoin, 582,581; dammar, 1,025,737; india-rubber, 83,171; gum copal, 128,075; indigo for the European market, 3,686,942; nutmegs, 2,815,787; cocoa-nut oil, 1,220,682; pepper, 1,883,349; rice, 2,292,907 florins.

History. The Portuguese were the first Europeans to visit the Indian archipelago. Prior to their appearance off Sumatra in 1509 under Diogo Lopez la Sequiera, a Hindu civilization, having its chief seat in Java, had flourished and waned, and Mahometanism had succeeded to a considerable share of its inheritance. In 1521, when the Portuguese name had become familiar in the islands, the Spaniards under Magellan made their appearance from the east. Hostilities ensued, which continued till the treaty of 1529, by which the boundary between Spaniards and Portuguese was fixed at 17° E. of the Moluccas,—a line which afterwards proved matter of dispute. The two powers were undisturbed except by an unimportant French expedition till 1596, when the Dutch reached what was destined to be the scene of their greatest colonial achievements. In that year Cornelis Houtman appeared before Bantam, the chief town of a powerful kingdom in Java, and his expedition was but the precursor of many others from Holland. The commercial success of these enterprises led in 1602 to the establishment of the Dutch East Indian Company, which obtained by Government

[1] The technical use of this name extends it to all except Arabs, Moors, Chinese, and generally all Mahometans and pagans, who are collectively classed as natives.

charter the monopoly of the Dutch trade of the countries between the Straits of Magellan and the Cape of Good Hope, with the right of concluding treaties, appointing governors, &c. The first fleet sent out by the new Company under Van der Hagen was instrumental in capturing the Portuguese fort of Amboyna, and the peace of Treves in 1609 set the Dutch free from interference on the part of the Spaniards. In the same year the states-general appointed a governor-general of the East Indies, giving the Company the right of appointing his successor, subject to their approval.

The instructions given to Pieter Both, the first governor, struck the key-note of that policy which has brought so much obloquy on the Dutch name, and prevented the better features of their colonial administration from being appreciated. He was to "give all endeavour in order that the commerce of the Moluccas, Amboyna, and Banda should belong to the Company, and that no other nation in the world should have the least part." When he came into power there were already Dutch forts at Jilolo, Ternate, and Batchian, and the people of Banda had granted the Dutch the monopoly of nutmegs. It was to the fourth governor (J. P. Coen, 1619–23 and 1627–29) that the Company were most indebted for their territorial aggrandizement. He was the founder of Batavia (1620), and the first to introduce a regular system of accounts in the affairs of the Company. During his rule a treaty was concluded between the English and Dutch companies, but unfortunately the goodwill which might have resulted from it was not of long duration. Specx (1629–32) gave a start to the trade with Japan, which afterwards grew to vast and various issues. The governorship of Van Diemen (1636–45) was signalized by a series of successes over the Portuguese, and the introduction of the first code of laws. The Dutch power in the archipelago extended rapidly during the latter part of the century. Peace was made with the Portuguese (1661), and various native kingdoms acquired. In the beginning of the 18th century the expense of the necessary military operations and general administration, with other causes, brought the colony into financial difficulties, and in the latter part of the century it was greatly damaged by the rapidly growing predominance of the English in India and Ceylon. The loss of their possessions in India, however, caused the Dutch to give more attention to the archipelago, and they continued to increase their territory. At the same time the state of the finances grew worse and worse, leading to the complete abolition of the Company's authority in 1800, when their possessions and liabilities were both appropriated by the nation. During the term of office of H. W. Daendels (1808–11), the English, who some years before had threatened Batavia and captured Ternate, made themselves masters of the Moluccas, and his successor Janssens was obliged in 1811 to surrender the colony and its capital to Lord Minto.[1] The British occupation lasted for five years, and during most of this time the post of governor-general was held by Sir Stamford Raffles, who acted perhaps too much on the supposition that the English occupation would be permanent, and was undoubtedly biased by strong prejudice against the Dutch, but at the same time did not forget Lord Minto's advice "to do as much good as he could." To the Dutch themselves this temporary government by the English did ultimate service. The example set by Raffles, when he showed so keen an interest in all that related to the country and the people, proved a stimulus to his Dutch successors; and the whole relation of the Government to scholarship and investigation has been placed on a more liberal and European footing. The restoration of the East Indian possessions to the Dutch was decided by the treaty of 1814, but was not carried out till 1816, when Baron van der Capellan became governor-general.[2] A variety of local disturbances followed the change of government, and a more serious war in Java (1825–30) required a special expedition from Holland. The year 1830 saw the beginning of that famous "culture" system, under Van den Bosch, to which so much of the financial success and peaceful administration of the modern Dutch government must be ascribed. In 1846 a new code of laws was introduced. The recent history of the colony may be briefly described as a gradual but steady extension of the authority of the Dutch Government, marked by a succession of revolts, disturbances, expeditions, skirmishes, and subjugations; a gradual but steady endeavour to develop the resources of the country; and, it may happily be added, an endeavour growing ever stronger and more enlightened to improve the condition of the subject races.

[1] See *Life of Lord Minto*.

[2] The following is a list of the Dutch governors from that date:—Godert A. G. P. Baron van der Capellan (19th August 1816 to 1st January 1826); Hendrik Merens de Kock (lieut.-gov.-gen., 1826 to 16th January 1830); Count Johannes van den Bosch (1830 to 2d July 1833); Jean Chrétien Baud (1833 to 29th February 1836); Dominique Jacques de Eierens (1836 to 1840, died 30th May); Carel S. W. Count van Hogendorp (1st June 1840 to 6th January 1841); Pieter Merkus (1841 to 15th February 1843, gov.-gen. till 1844, died 2d August); Joan Cornelis Reijnst (5th August 1844 to 30th September 1845); Jan Jacob Rochussen (1845 to 12th May 1851); George Isaac Bruce (died before his departure); Albertus Jacob Duijmaer van Twist (12th May 1851 to 22d May 1856); Charles F. Pahud (1856 to 2d September 1861); Arij Prins (2d September 1861); Ludolf Anne Jan Wilt, Baron Sloet van de Beele (19th October 1860 to 25th October 1866); Arij Prins (2d October 1866); Pieter Mijer (28th December 1866); James London (1st January 1872 to 26th March 1875); J. W. van Lursberge (26th March 1875).

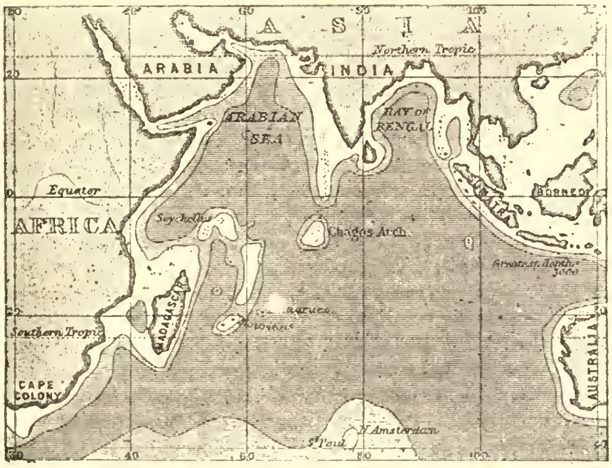
The literature connected with the East Indian archipelago is a vast and rapidly increasing one. For general information we have—J. Crawfurd, *History of the Indian Archipelago*, Edin., 1820, 3 vols.; J. H. Moor, *Notices of the Indian Archipelago*, Singapore, 1837; P. P. Roorda van Eysinga, *Handboek der Land- en Volkenkunde van Nederl. Indië*, 1841; A. J. van der Aa, *Nederlandsch Oost-Indië*, Amsterdam, 1845–57, 4 vols.; and the *Aardrijkskundig en statistisch Woordenboek van Nederlandsch Indië*, Amsterdam, 1869, to which Professor Veth, Jonkheer van Alphen, and other specialists were important contributors. Of works which contain the results of recent individual explorations, the most important are—Wallace, *The Malay Archipelago*, 3d ed., London, 1873; Rosenberg, *Die Indische Archipel*, Leipsic, 1878; Backer, *L'archipel indien*, Paris, 1874. Early notices of the archipelago are found in several Arabic writers. The first European to give any details is the Italian traveller Lodovico di Varthema, but little confidence can be placed in his narrative. Navarrete's *Coleccion de documentos*; Castanheda's *Historia de descobrimento*, Lisbon, 1833; Gaspar Correa's *Lendas* or *Legenda*; De Barros, *Asia*; Faria y Sousa, *Asia Portuguesa*, Lisbon, 1666; and A. de Morga, *The Philippine Islands, Moluccas, &c., at the close of the 16th century*, translated from the Spanish, Hakluyt Society, 1868, may be consulted for the early history; a critical *resumé* of which, from the pen of P. A. Tiele, is to be found in *Bijdragen tot de Taal- Land- en Volkenkunde van N. I.*, The Hague, 1878. *Facile princeps* among older Dutch works is Valentijn's voluminous and well-known *Oud en Nieuw Oost Indie*, Amsterdam, 1724–26. Dealing more restrictedly with the Dutch colony are G. Lant's *Geschiedenis van de vestiging, &c., in Indie*, Gron., 1852–60; Saalfeld, *Geschichte des Holländ. Colonialwesens in O. Ind.*, Gött., 1812; Gerlach, *Fastes militaires des In. Or.*, Zaltbommel, 1859; Du Bois, *Vies des gouverneurs-généraux*, Hague, 1763, with some good plans and views; Elout, *Bijdragen tot de Kennis van het Koloniaal beheer*, 1851, and other volumes of *Bijdragen* from his papers, published in 1863 and 1874; P. Myer, *Verzameling van instructien, ordonnancien, &c., voor de regering v. Ned. Ind.*, Bat., 1848; Boudewijnse and Van Goest, *De Indo-Nederlandsche Wetgeving*, 1816–57, Haarlem and Batavia, 1876–79; E. de Waal, *Nederlandsch Indië en de Staten-Generaal sed. de grondwet v.* 1814, Hague, 1860–61. A bibliography of the Dutch Indies was compiled by J. A. van der Chijs, *Proeve eener Nederlandsch Indische bibliografie*, 1659–1870, Batavia, 1875. (H. A. W.)

INDIAN CORN. See MAIZE.

INDIAN OCEAN. This designation is given to the portion of the oceanic area which extends northwards from the great southern water-zone, between the eastern coast of South Africa and the western boundary of the partially submerged Malayo-Australian continent. But whilst the Atlantic and Pacific extensions from the southern water-zone—the one dividing South Africa from South America, and the other forming the wide expanse of ocean between the western coast of South America and the eastern side of the Malayo-Australian continent—are prolonged into the land hemisphere as far as the north polar area, the Indian Ocean does not extend itself northwards beyond the Tropic of Cancer, where it is abruptly closed in by the great land mass of the Asiatic continent. The north-western boundary of its basin is formed by the south-eastern coast of Arabia, its north-eastern by the western coast of Burmah. But, between these two parts of its border, its basin is encroached on by the southward projection of the Indian peninsula, and is thus divided into two deep gulfs, of which the western is distinguished as the Arabian Sea, and the eastern as the Bay of Bengal. Now, looking to the fact that these gulfs must have been united, at no remote period, by a transverse band of sea, covering what is now the continuous alluvial plain of Northern India, we may consider the real northern border of this basin to be the great Himalaya range, the southern slope of which must have once formed its shore-line. It is remarkable that nearly the whole of its land-border is of considerable elevation,—being formed on the west by the mountainous ridge that flanks the great table-land of South Africa, on the north-west by the corresponding ridge which forms the south-eastern border of the elevated plateau of Arabia, whilst near its eastern margin there is a nearly continuous mountain range, that extends southwards from Assam to the extremity of the Malay Peninsula, and is thence prolonged through Sumatra and Java.

The Indian Ocean has no definite southern limit, but is considered to terminate at the parallel (about 38° S.) which stretches between the southernmost points of the African and Australian continents,—near which, about midway between these two extremes, lie the volcanic islands of St Paul and Amsterdam. And this seems the natural border of its basin, the sea-bed (as will presently appear) showing a distinct rise to the south of this parallel along a considerable part of it. The Indian Ocean is often spoken of as divided by the equator into a northern and a southern portion; and this division it will be convenient to adopt in the description of its current-system.

Depth and Islands.—The main basin of the Indian Ocean has an average depth of about 2500 fathoms, increasing to 3000 fathoms in the angle between Java and north-western Australia, which is the deepest part of it yet sounded. Its southern border is formed by a submarine plateau, which rises in some parts to within 1500 fathoms of the surface, and which forms the common foundation, not only of the islands already mentioned, but also of the Crozets, the Kerguelen group, Prince Edward's Islands, and the Heard Islands, all of which seem to have had a volcanic origin. This plateau, however, does not shut in the south-eastern portion of the basin; for a southward extension of the depression already described follows the trend of the western and southern coasts of Australia and the western coast of Tasmania, and is continuous with the deep channel (in some parts exceeding 2500 fathoms) between Australia and New Zealand. The western and north-western parts of the basin, on the other hand—as the number of their island-groups would lead us to anticipate—have a much less uniform depth. In the first place, the western border of the basin is encroached on by the great island of Madagascar, which must be considered as an outlying extension of the continental platform of South Africa, the Mozambique channel being comparatively shallow; and, although the bottom, at



Plan showing Depths of the Indian Ocean.
To 1000 fathoms, white; 1000 to 2000 fathoms, light shading more than 2000 fathoms, dark shading.

no great distance from its eastern coast, rapidly deepens to 2000 fathoms or more, yet this is only in a channel that separates Madagascar from a platform of about half that depth, on which are based the volcanic Mascarene Islands (Mauritius, Bourbon, and Rodriguez), and of which a northern extension forms the base of the Seychelles group. This platform then curves to the south-west, so as to pass round the north of Madagascar, forming the base of several coral islands, and thus comes into continuity with the bed of the Mozambique Channel, from which the Comoro group arises. To the north of this platform, the 2500 fathom line follows the trend of the African coast as far as Cape Gardafui, keeping outside the island of Socotra; and a bottom of more than 2000 fathoms (crossed by the telegraph-cable between Aden and Bombay) extends into the Arabian Sea as far as 15° N. lat. On the eastern side of that gulf, however, the declivity from the Indian coast-line to the deepest part of the basin is much more gradual; the Maldive and Laccadive groups of coral islands rising from a comparative shallow, which extends itself a little to the south of the equator. And about half way between this platform and that of the Seychelles the bottom rises into the bank which bears the Chagos archipelago, and which divides the communication between the deeper portion of the general basin and that of the Arabian Sea into two channels of no great width. Though the 2500 fathom line does not enter the Bay of Bengal, a considerable portion of it has a depth exceeding 2000 fathoms. Here, again, the declivity is more gradual along the eastern margin of the gulf; and the Andaman and Nicobar Islands arise from a comparatively shallow platform that stretches between the delta of the Irawadi and the north end of Sumatra.

Surface and Bottom Temperature.—The surface-temperature of the Indian Ocean is higher than that of either the Atlantic or the Pacific; and this difference shows itself especially in its northern division, on which the proximity of tropical land exerts an important thermal influence. For the mean annual temperature of the portion which lies between the equator and the Tropic of Cancer, including the Arabian Sea and the Bay of Bengal, is considerably above 80°, whilst that of the corresponding part of the southern division—lying between the equator and the Tropic of Capricorn—ranges from 80° to 70°, the average maximum temperature in the centre of the Arabian Sea being 87°. In July the thermal equator moves considerably to the north, and the surface-temperature sometimes rises in the Arabian Gulf and the Bay of Bengal to above 90°. In January, when the thermal equator lies to the south of the geographical, the temperature of these two gulfs falls below 80°, while that of the vast expanse which lies between the parallel of 10° N. and 25° S., has a temperature of 80° or upwards. In the southern hemisphere the January (summer) isotherm of 70° and the July (winter) isotherm of 60° correspond pretty closely with the border of the Indian Ocean,—the range of its temperature being thus very moderate.

The bathymetrical isotherms of the Indian Ocean have not yet been systematically worked out by temperature-soundings; but there is adequate evidence of the extension of the Antarctic underflow over the deeper portion of its sea-bed, even to the north of the equator. For the "Hydra" line of soundings between Aden and Bombay gave a bottom-temperature of 36°·5 at a depth of 1800 fathoms, the surface-temperature being 75°, while in the deep depression on the eastern side of the basin, almost immediately beneath the equator, Commander Chimmo met with a bottom-temperature but little above 32°.

Surface-Level.—A very remarkable effect is produced upon the coast-level of part of the northern division of the Indian Ocean, by the attraction of the great mountain-masses and high table-lands of Central Asia, uncompensated by that of any elevated land-mass to the southward, nearer than that which may lie behind the Antarctic ice-barrier. From the results of the great geodetical survey of India Archdeacon Pratt was able to deduce the very remarkable fact that the level of the sea at the mouth of the Indus is no less than 515 feet higher than at Cape Comorin.[1]

Currents.—The current-system of the Indian Ocean is clearly dependent upon the winds which prevail over its several parts,—the seasonal reversal of the monsoons in the northern part of its area producing a corresponding modification in the direction of the surface-movement of its water, whilst in the southern division the constancy of the south-east trade-wind keeps up through the whole year a strong westerly equatorial current. The north-east monsoon has, of course, while it lasts, the same effect as a north-east trade-wind would exert, in producing a general south-westerly drift over the northern division of the Indian Ocean, which manifests itself in a southerly flow along all the shores it meets, viz., the south-east coast of the Indian peninsula, the south-east coast of Arabia, and the east coast of Central Africa. Besides this, a special current-movement is produced by the action of the north-east monsoon on the surface-water of the China Sea, by the drift of which to the south-west it is forced into the channel between the Malay Peninsula and Sumatra, whence it issues into the Indian Ocean, through the Strait of Malacca, as a current that crosses the Bay of Bengal and impinges against the Coromandel coast of India. By this it is deflected southwards, along with the general drift already mentioned, and then courses round the southern angle of the great peninsula,—partly between Ceylon and the mainland, and partly along the outer coast-line of Ceylon,—into the Arabian Sea, where it merges into the general drift of the surface-water towards the African coast. The average rate of this current, as it issues from the Strait of Malacca, is 30 miles per day; along the south-east coast of India, 24 miles; on the east coast of Ceylon, 40 miles; and along the Arabian coast, 18 miles. But when the north-east gives place to the south-west monsoon, about the vernal equinox, the whole of this movement is reversed. The drift then commences from the African and Arabian coasts, and sets across the Arabian Sea, at the rate of about 24 miles a day, to the Malabar coast of India, along which a current flows in a southerly direction at the rate of about

[1] *Philosophical Transactions*, 1859, p. 795.

30 miles a day. This current rounds Cape Comorin and the southern coast of Ceylon, where it sometimes attains the rate of 45 miles a day, and passes into the Bay of Bengal, reinforcing the general north-east movement of its own water, circulating round the head of this gulf, and then undergoing a deflexion by the coast-line towards the entrance of the Strait of Malacca, into which it flows at the rate of from 20 to 24 miles per day. When the sun crosses the equator towards the south at the autumnal equinox, so that its heating power is exerted on South Africa, the indraught of air towards that continent reproduces the north-east monsoon; and this restores the westerly drift, which extends over the Indian Ocean as far as 5° S. lat., giving place at about that parallel to the equatorial counter-current.

The surface of the southern Indian Ocean, between the parallel of 10° S. and the Tropic of Capricorn (the precise limits varying with the season), is pretty constantly traversed by the south-east trade-wind, which gives a steady westward movement to its water, known as the south equatorial current, whose average rate is about 14 miles per day. This meets the eastern coast of Madagascar, and that of continental Africa to the north and south of it; and, its onward flow being thus checked and deflected southwards by the trend of the land, it forms a strong current which sets along the Natal coast towards Cape Colony. The strength of this current varies according as the north-east or the south-west monsoon is blowing; for the movement produced by the former reinforces it, while that produced by the latter weakens it, by deflecting northwards a portion of the water which the southern equatorial current brings to the coast of Africa, and drifting it towards the Indian peninsula. When flowing with its greatest force and velocity, the Natal current[1] is scarcely, if at all, inferior to the Gulf Stream where it issues from the Florida Strait. When passing Cape Corrientes, at the southern extremity of the Mozambique Channel, it is said to have a rate of 80 miles per day, and has been even said to rush, under a rare combination of impelling forces, with a velocity of 140 miles per day. Its rate gradually diminishes, however, until, off Cape Colony (where it is known as the Agulhas current), it has a velocity of about 50 miles per day. The warmth it carries has a very important influence in ameliorating the climate of Cape Colony; for this would otherwise suffer from the importation of the low temperature brought by the Antarctic current which there meets it.[2] When the Agulhas current is at its strongest, it carries a temperature of 79° as far west as the meridian of 15° E. But when the drift of the monsoon wind countervails that of the south-east trade, instead of reinforcing it, the temperature of the Agulhas current is lower and its force less. Whilst a portion of this current rounds the Cape and becomes a tributary of the South African current of the Atlantic (thus carrying away the excess brought into the basin of the Indian Ocean by the Malacca current), the principal part of it is deflected to the south and east, partly by the agency of the Antarctic current, but chiefly under the influence of the westerly winds or "anti-trades," that prevail throughout the southern water-zone which almost continuously girdles the globe between the parallels of 40° and 60° S. Thus there is here a pretty constant retrograde set of surface-water (corresponding with the southern connecting current of the South Atlantic), at the rate of about 24 miles a day, towards the western coast of Australia; and since, notwithstanding the reduction of its temperature, the water which has circulated in the Indian Ocean is still much warmer than that which forms the general mass of the easterly drift, it is probably through this excess (imparting a corresponding excess of vapour to the atmosphere above, which is condensed again by contact with the colder land) that the fogs are generated, for which the islands that lie in the course of this flow are notorious. On arriving at the shores of Australia, this drift is divided by the south-west projection of its coast-line into two streams, one of which continues its eastward course along the southern coast, whilst the other, turning northwards, forms the West Australian current, of which the greater part, when it reaches the head-water of the southern equatorial current, is drawn into it, and thus completes the circulation of the southern Indian Ocean.

Between the parallel of 5°, to which the influence of the monsoon winds extends, and that of 10° S., which is the usual northern limit of that of the southern trade, there is a "belt of calms," wherein there runs an equatorial counter current, which corresponds to that of the Atlantic, and is, like it, to be considered as a back-water flowing towards the source from which the currents to the north and south of it derive their supplies. (W. B. C.)

[1] This is commonly termed the Mozambique current; but, as the usual southerly direction of the surface flow in the Mozambique Channel is liable to reversal with the change from the north-east to the south-west monsoon, or even under the influence of local winds, the term Natal current (suggested by Mr Laughton) seems decidedly preferable.

[2] Some very curious temperature phenomena are produced on the Agulhas bank by the splitting up of the cold and warm currents, which form distinct bands and strata that do not mix for some time.

INDIANS, American. The application of the name Indians to the native peoples and tribes of the New World is an erroneous usage, originating in the belief of the Spanish discoverers of America that they had reached the eastern shores of Asiatic countries already partially known. As it happens, the name is now, even apart from the addition of American, customarily applied to the aborigines of the western hemisphere, while it is used with far less frequency as a collective name for the inhabitants of the great country of the East known from the remotest times as India.

Various questions in regard to the American Indians have been discussed in the article America. It is here intended to treat more particularly their ethnographical position, and to give what may be called a working classification of the races. This is followed by a separate notice of the present distribution and condition of the North American Indians.

It may be asserted with some confidence that there is nothing in the physical and mental condition of the aboriginal Americans which requires us to postulate for them a foreign origin. If man was evolved originally from several centres, America assuredly included one at least; if he sprang from a single pair, then we can even conceive that pair to have been first established in the New World, and the arguments brought forward in support of an Asiatic origin of the American would not lose their point if adduced in favour of an American origin of the Asiatic peoples.

Andreas Retzius, the founder of scientific craniology, arguing on insufficient materials, grouped all the American aborigines in two great divisions—(1) a western or highland, occupying the main ranges of the Rocky Mountains and Andes, with the intervening lands thence to the Pacific; and (2) an eastern, mainly lowland, whose domain stretched from the western uplands to the Atlantic seaboard. The former, being characterized by brachycephalous or round heads, he felt disposed to connect with the brachycephalous Mongolians and Malays of Asia and Australasia. The latter, being of a decided dolichocephalous or long-headed type, he traced to possible Berber and Guanche migrations from north-west Africa and the Canary Islands, doubtless because the historical arrival of the dolichocephalous Norsemen in the New World was of too recent date to serve his purpose. But Virchow ("Anthropologie Amerika's," in *Verhandlungen der Gesell. für Anthropologie*, 1877, p. 144–56) has amply shown that this classification is untenable, and it will be seen further on that there are long and round-headed types often intermingled in every part of the continent. Virchow himself, while denying the claim of the American race to be considered autochthonous, declines to commit himself as to the probable regions whence they may have reached their present habitat. The theory of an Asiatic immigration *via* Behring Strait has been somewhat revived since ethnologists have, so to say, rediscovered the lost Tchuktchis of the north-east coast of Siberia through Nordenskjöld's Swedish polar expedition of 1878–9. These Tchuktchis are supposed to form the connecting link between the races of the two worlds, and the supposition is strengthened by the *invention* of an American branch of the tribe. Professor Nordenskjöld himself remarks that "this race, settled on the primeval route between the Old and the New World, bears an unmistakable stamp of the Mongols of Asia and Eskimo and Indians of America" (Petermann's *Mittheilungen*, 1879, p. 330). But Lieutenant Palander of the same expedition says that "they undoubtedly descend from the Greenland Eskimo" (*ib.*), which would at once deprive them of all value as a connecting link, while Peschel (*Races of Man*, p. 391) much more probably allies them to the Itelmes (Kamtchadales), the two languages being "as closely related as is Spanish to Portuguese." W. H. Dall (*Contributions to American Ethnology*, vol. i., Washington, 1877) further points out that the Innuit (Eskimo) tongue, said to be spoken by the Tchuktchis, is merely a trading jargon, a mixture of Koriak, Tchuktchi, Innuit, English, Hawaiian, and others. It is also to be noted that the Samoyedes and other Asiatic Arctic peoples, assumed by many to be the progenitors of the Eskimo, are of Mongoloid stock and distinctly brachycephalous, while the Eskimo are the most dolichocephalous race on the globe next to the Kai Colos of Fiji (Flower). Thus the Eskimo, instead of being a connecting link, form an anthropological barrier between the populations of the two hemispheres at the very point geographically most convenient for effecting the transition.

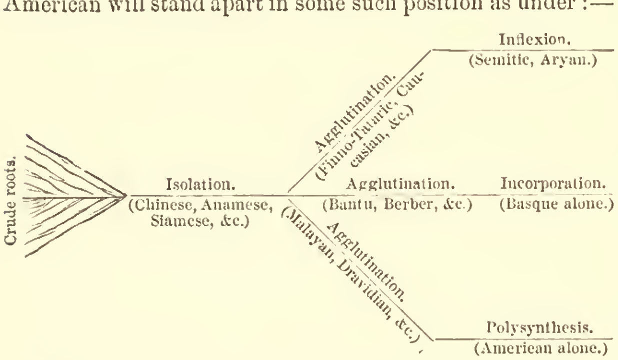
Nor would the question be much furthered by allowing the arrival of a few barbarous tribes *via* Behring Strait in prehistoric times. Their presence would leave the Aztec, Mayan, Peruvian, and other local cultures unexplained, except as independent developments. And more recent historic migrations of Chinese, Japanese, and other civilized peoples, otherwise involved in tremendous difficulties, would leave equally unexplained the primeval mound-building races of the Ohio valley and the still more ancient Brazilian races of the Santa Catharina and Santos shell-heaps. Because a stray vessel has been cast ashore on the western seaboard since the discovery of America, Virchow suggests the possibility of similar arrivals in remoter times. But if the Chinese arrived so recently as even 8000 years ago (an extreme supposition) in sufficient numbers to build up a civilization in Central America, the Chinese origin of such a civilization would to this day be as self-evident as is the Chinese origin of the neighbouring Japanese civilization. The foreign founders of these communities would necessarily have brought with them their arts, their domestic animals, their more useful plants and cereals, without which they must have themselves speedily perished or been absorbed in the surrounding native populations. But no trace of these things was found in the New World on its discovery. There was neither the rice of the Chinese, nor the wheat, barley, oats, or rye of the Western nations, nor the iron now proved to have been known to the ancient Assyrians and Egyptians, nor the horse, camel, ox, sheep, pig, dog, or poultry of the eastern hemisphere. Instead of these, there was little beyond one cereal (maize), one esculent root (potato), one feeble beast of burden (llama), limited to the uplands of the southern Cordilleras, one species of dog elsewhere unknown. Most of the useful plants and animals of the East have since been introduced, and flourish vigorously even in the wild state, a sufficient proof that they would have been propagated had they been introduced at an earlier epoch. The knowledge of metals was limited to copper, both wrought and, in Wisconsin, apparently cast (J. S. Butler), bronze, lead, gold, and silver. Otherwise most of the nations were at the discovery still in the Stone Age; and, although Virchow's assertion may be true that the most practised archæologist will fail to detect any material difference between the stone implements of the two hemispheres, this merely implies that the arts of Palæolithic and Neolithic man were pretty much the same everywhere.

Nor is there anything in the religions, systems of government, architecture, and other arts of the native Americans, by which they can be connected with the corresponding systems of the East. That the Toltec builders of the low obtruncated Mexican pyramids were a different people from the pyramid builders of the Nile valley, and that the mummies of the Ancon necropolis and other parts of Peru were of a different stock from the Egyptian mummies, is sufficiently evident from the texture of the hair alone. The hair of the old cultured races of America was the same as that of all the later American races, uniformly lank, because cylindrical in section. The hair of the old Egyptians, like that of the modern Fellahîn, is, on the contrary, uniformly wavy, because more or less oval in section. The religions, again, of the Red Man, we are told by Carl Schultz-Sellack, Oscar Loew, and other good observers, are "essentially astrological, based on star, sun, and moon worship," with which was often associated an intricate method of measuring time built on a series of twenty constellations" (*Zeitschr. für Ethnologie*, 1879, p. 209). "The sun," says Loew, "is the god of most Indian tribes. 'He diffuses warmth and nourishment for us and our animals; why shall we not worship him?' observed to me on one occasion Masayamtiba, a Moqui Indian (New Mexico)" (*ib.* p. 265). This Masayamtiba was a better philosopher than those ethnologists who seek for the origin of such a simple cult in the remote corners of the globe, rather than in the beneficial influence of the heavenly bodies which shine alike for all mankind. The four great gods of the Mayas, the "props of the heavens," answered to the four great Mexican gods of the four quarters of the compass, all being associated with the four elements of wind, water, fire, and earth. But to what does either system answer in the polytheistic creeds of the Hindus, Assyrians, Babylonians, or other nations of antiquity? There is something similar in the Neo-Buddhistic teachings; but Buddhism, even of the oldest type, is much too recent to explain anything in the religious worlds of Mexico or Yucatan. The hare is associated in America, in Asia, and even amongst the Bushmen of South Africa with the moon. But this association was obviously suggested independently by the spots which, especially in the first quarter of the moon seem to present the outlines of a hare on its form. Waitz (*Anthropology*, p. 255) well observes that a common belief in a universal flood, or in the periodical destruction of the world, whether by fire, water, storms, or earthquakes, and analogous or parallel lines of thought—taken individually—afford no proof whatever in favour of affinity, and even resemblances in several points possess only a secondary importance; for they may partly, under like conditions, arise spontaneously among peoples who have always lived in a state of separation, or may have partly resulted from periods of short intercourse between two different peoples.

In any case, these slight coincidences are of little account when weighed against the argument based on diversity of speech. The tremendous force of this argument, as applied to the American aborigines, is scarcely realized by anthropologists such as Waitz or Virchow, who have not cultivated philological studies, and it is significant that, in the already quoted paper by Virchow on the "Anthropology of America," the linguistic element is not even referred to. On the other hand, it has been greatly depreciated and even brought into contempt by the vagaries of certain etymologists, who discover affinities where there is nothing but the vaguest verbal resemblance.[1] Science has demonstrated beyond all cavil that, while differing widely among themselves, the American languages not only betray no

[1] It may be sufficient to refer to the series of papers by Mr John Campbell of Montreal on the "Hittites in America," which have recently appeared in the *Canadian Quarterly Journal of Science*, and which on the most fanciful grounds connect the native idioms not only with each other but with most of the known languages of the universe. Thus Iroquois and Peruvian are declared to be radically one, while the former is connected with Basque, Dakotan with Circassian, Accad with Japanese, and a general Khita linguistic family is made to include, besides all these, Choctaw, Cherokee, Aleutian, Fuegian, Aino, Kamtchadale, Tchuktchi, Haussa, Barabra, and many others in every part of the world.

affinity to any other tongues, but belong to an absolutely distinct order of speech. They are neither isolating or monosyllabic like the Indo-Chinese group, agglutinating like the Ural-Altaic, Bantu, or Dravidian, nor inflexional like the Semitic and Aryan. They come nearest in structure to the Basque, which is the only incorporating language of the Old World, but differ from it essentially inasmuch as their capacity of incorporating words in the sentence is not restricted to the verb and a few pronominal elements, but extends in principle to all the parts of speech. This faculty, which, with one or two doubtful exceptions, seems to be characteristic of every American idiom from Behring Strait to Cape Horn, has received the name of polysynthesis, literally "a much putting together." [1] Hence, in a comprehensive classification of articulate speech according to its inner mechanism, a special place must be reserved for the American group; and, if we assume as the most probable theory that all speech has slowly evolved from a few simple beginnings, passing successively from the state of crude roots to the isolating condition, and so onwards to the agglutinating and other orders, then in such a scheme the American will stand apart in some such position as under:—



Here it is not intended to imply that American derives from Malayan or Dravidian, but only from some now extinct agglutinating forms of speech of which Malayan or Dravidian may be taken as still surviving typical instances. The disappearance in America of all such assumed forms, unless the Otomi of Mexico is to be accepted as a solitary lingering specimen, argues both a very great antiquity and an independent evolution of the American languages. And as the course this evolution has taken differs entirely from that pursued by the idioms of the Old World, it follows that the first peopling of America, if from the Old World, must be thrown back to a time when all speech itself was in its infancy, to a time when slow diffusion might be conceived as equally probable from an eastern or a western starting-point. It is this feature of polysynthesis that gives the American race its first and greatest claim to be regarded as truly autochthonous, in the same sense that we regard the Mongolian and Caucasian races as truly autochthonous in Asia.

There is a general consensus amongst anthropologists that on the western continent we are in presence of two distinct original types, the brachycephalous and dolichocephalous. But these are no longer confined to separate geographical areas, as Retzius supposed. The very general practice of artificially flattening or otherwise deforming the skull has naturally caused less value to be attached to the craniological test in America than elsewhere. The practice has been traced back even to prehistoric times, and a clay figure recently found associated with the remains of a child by Reiss and Stübel in a grave in Ancon puts in a clear light the method adopted by the ancient Peruvians (*The Necropolis of Ancon*, Berlin and London, 1881, plate 90). Still, careful investigations have placed it beyond doubt that the normal skull both in North and in South America is now mesaticephalous, or of a type intermediate between the two extremes, a fact supposed to imply a general intermingling of the two primeval stocks. On the other hand, Virchow (*loc. cit.*, passim) shows perfectly normal ancient and recent crania from both sides of Greenland, from El Carmen on the Rio Negro, Patagonia, from the Botocudo tribe, East Brazil, from a tumulus of Santa Fé de Bogota, and even a Peruvian mummy exhumed at Pancatambo, all of which are distinctly, in some cases extremely, dolichocephalic. In the same way he produces brachycephalic skulls from the Brazilian shell-mounds of Santos and Santa Catharina, from the barrows of the Ohio valley mound-builders, from the Carib and Araucanian tribes, and from the Pampas of La Plata, the last mentioned of an extreme type, in close proximity to the extreme dolichocephalous specimens from Patagonia. Were it safe to argue from the analogy of Britain, where the dolichocephalic builders of the long barrows seem to have preceded and afterwards become intermingled with the brachycephalic builders of the round barrows (Dr Thurnam), the western continent might be supposed to have been successively occupied first by a long-headed and then by a round-headed race, which kept aloof in a few places, while more generally becoming fused in a normally mesaticephalic type. But we have in America no guide to the relative priority of the two forms of head, nor are there now any long-headed races on the eastern Asiatic seaboard whose ancestors might be taken as the precursors of the corresponding element in the West. The obvious alternative also remains, that the two forms may have become differentiated on the American continent, just as similar differentiations must, by those who do not accept the doctrine of fixity of species, be assumed to have taken place in Asia. For such an evolution America offered a more ample field even than Asia, for it is not confined to the northern hemisphere, but stretches from the Arctic nearly to the Antarctic Circle, presenting in this wide range almost every conceivable variety of climate, atmosphere, soil, and temperature.

We thus see that the two cranial forms do not necessarily militate against the possible primordial unity of the *homo Americanus*. This unity seems on the other hand implied in certain physical and mental features, common to all the native races. Of the physical traits the most important and uniform are—(1) the hair, which is always black, coarse, glossy, and long, like a horse's mane, round in transverse section and persistent to extreme old age; [2] (2) slight beard, but always straight, never wavy; [3] (3) eyes small, black, somewhat deep-set, always horizontal; [4] (4) eyebrows narrow, very arched, and black; (5) prominent cheek bones and nose, the latter often very long and aquiline. [5]

The native American being popularly spoken of as "The Red Man," it might be supposed that colour should be included in this brief list of common characteristics. But, notwithstanding the general impression, there is perhaps no

[1] Abel Hovelacque (*Linguistique*, Paris, 1877) has endeavoured to confound polysynthesis with agglutination; but A. H. Keane (Appendix to Stanford's *Central and South America*, 1878) has shown that the difference between the two is fundamental, and Prof. Sayce (*Science of Language*, 1880) has finally adopted this view.

[2] During the many years that he lived in South America, D'Orbigny assures us that he "never met a bald native of full blood" (*L'Homme Américain*, i. p. 128).

[3] The only known exception are the Guarayos, a Guarani tribe, originally from Paraguay, now in the Moxos missions, altogether a remarkable people, whose quasi-European complexion and appearance are heightened by a very full but always perfectly straight beard.

[4] Except amongst the Guaranis, the outer angle of whose eyes is generally pointed upwards, giving them a Mongolian cast.

[5] But this feature is not constant, for the nose of many Pampas and Guarani tribes is often very short, broad, and flat.

other region of the globe where so great a variety of colour prevails. The more general tints are a copper or cinnamon brown, and olive yellow; but the subjoined table of tribes, grouped according to their colour, shows that the extremes of a deep brown almost approaching a true black, and of a light or fair hue almost approaching a true white, also occur, altogether independently of latitude, climate, or elevation of the land:—

Leather Brown, Coppery, Cinnamon.	*Dark Brown to Blackish.*	*Olive-Brown and Yellowish.*	*Fair to Whitish.*
Iroquois: New York, Canada. Algonquins: north-east States, U.S.	Gualcuri, Pericui: Lower California. Charruas: Uruguay	Guarani: Brazil, Paraguay. Coroados (women): Minas Geraes Puris (women): Rio Janeiro.	Pehuenches, Boroanos: Chili, 35° to 40° S. Tocomonas: Beni river, Bolivia.
Chiriguanas (settled): Pilcomayo river. Coroados (men): Minas Geraes. Puris (men): Rio Janeiro.	Coast Arawaks: Guiana. Quichuas: Peru. Aymaras: Bolivian uplands.	Aucas: Chili, east slopes of Andes. Rangueles: Chilian pampas. Chiquitos: between Paraguay and river Negro.	Hydas: Queen Charlotte Islands. Cayawas: Rio Branco, river Mamore, Brazil. Pammas: Madeira river, Brazil.
Araucanians: Chili. Fuegians: Tierra del Fuego. Mataguayas: Gran Chaco.	Payaguas: Paraguay. Yaros: east side of Uruguay river. Charruas: Uruguay.	Otukes: north-east Bolivia. Tupi, Tupinamba: north-east Brazil.	Aguanos, Barbudes: Huallaga river. Inland Arawaks: Guiana.
Maropas, Apolistas: Moxos, Bolivia. Vilelas: Vermejo river, La Plata.	Puelches: Pampas, La Plata. Tehuelches: Patagonia. Changos: coast of Peru.	Moxos, Itonamas, Cayubabas: prov. Moxos, Bolivia.	Chiriguanas (wild): Pilcomayo river. Yuracares: Bolivian plains. Tacanas: Beni river, Bolivia.
Mbocobis, Tobis: Gran Chaco. Pilcomayo river. Abipones: west bank of upper Parana.	Atacameños: Tarapaca, Peru. Quichés: Guatemala lowlands Galibi: Guiana.	Botocudos: Brazilian coast range. Timucua, Seminoles: Florida.	Blackfeet: Saskatchewan river. Mandans: Middle Missouri. Guarayos: Moxos, Bolivia.
Dakotas: Upper Missouri. Apaches: North Mexico, Arizona. Quichés: Guatemala uplands.	Minnanes: between rivers Parana and Uruguay. Bohanes: Lower Urugnay river.	Eskimo: Arctic seaboard. Unalaskans, Akkhas: Aleutian Islands.	Mosetenos: river Beni, Bolivia. Guarives: Venezuela. Siriones: Moxos, Bolivia.

Similar tables might easily be drawn up of stature, varying from the dwarfish Eskimo, Fuegian (mean 5 ft. 1 in.), and Peruvian (mean 4 ft. 9 in.) to the gigantic Patagonian, the tallest race on the globe.

No less varied are the other physical traits, while the wide divergence of mental capacity is sufficiently indicated on the one hand by the Cherokees of the southern Alleghanies, who in 1824 invented a complete syllabic writing system, and who can reckon to a million and upwards, and on the other by the Chiquitos of the Bolivian lowlands, who, D'Orbigny assures us (*op. cit.*, ii. p. 163), "cannot get beyond one (tama), after which they have nothing but terms of comparison." The only real intellectual faculty common to all the American races is that implied by the peculiar polysynthetic mechanism of their speech. But beneath this general morphological structure, the substance of the languages themselves varies greatly in all that concerns their phonetic systems, vocabularies, relational forms, syntax, and methods of combination. While, for instance, the Thlinkeet of the extreme north-west Pacific seaboard, the Apache of Arizona, the Quichua of Peru, and the Aymara of the Bolivian uplands are amongst the very harshest and most guttural tongues in the world, the Otuke of the Bolivian plains, the Mohave of Arizona, the Chiquito of the upper Paraguay basin, the Samucu on the north frontier of Gran Chaco, and many Amazonian dialects are distinguished by great softness, often rivalling in euphony the most musical languages of the eastern hemisphere. The linguistic families differ from each other, not only in the measure to which their polysynthesis has been developed, but even in its very character, so that while some have scarcely yet arrived at a clear differentiation of verb and noun, others, like the Iroquois, have a purely verbal, others again, such as the extinct Timucua of Florida, an exclusively nominal inflexion. In the same way some are partial to prefixes, some to suffixes, some to infixes. Many of the Californian idioms seem to be still verging on the agglutinating stage, while the just-mentioned Timucua, the Aztec, Choctaw, Shoshone, Cree, Matlalzinca, and others of the Anahuac table-land, have reached the very acme of polysynthesis, in which all the parts of the sentence often become by indefinite composition and syncope fused into one interminable "bunch-word" of from ten to fifteen syllables and upwards. As these languages also differ entirely in their vocabularies, often possessing not a single root in common, it follows that they can be no more classed together than can for instance the various agglutinating tongues of the Caucasus or the Soudan.

It thus appears hopeless to look for any unity of details in the mental and physical faculties of the American aborigines. What they have in common is reducible to one physical and one mental quality, the universal texture and black colour of the hair, and their polysynthetic speech. These two properties point directly at primordial unity of origin; the endless varieties of detail argue a prodigious antiquity and an independent development of the race on the American continent. The variety renders the work of classification a labour of extreme difficulty and uncertainty. Amidst all these endless points of divergence, it seems impossible to find any common basis round which to group the various tribes and races, and the problem becomes further complicated by the fact that, while many of these tribes differ in speech, though evidently of one racial stock, others belonging to the same linguistic connexion present the widest physical discrepancies. Thus the Chiquitos and the Moxos peoples of Bolivia, obviously of one ethnical type, speak several fundamentally distinct languages. The same is true of the Moqui, Queres, Isletta, Tegua, Zuñi, and other New Mexican Pueblos, while the reverse phenomenon is presented by the Montagnais and Nasquapees of Labrador, both of whom speak closely related Cree dialects, yet differ so much in appearance that, "judging from their exterior, one would suppose them to belong to different families of the human race" (Hind's *Labrador*, i. p. 332). Within comparatively narrow areas occurs occasionally every conceivable element of confusion, as in California and the south-western States, occupied by the morally debased and physically degraded Pah-Utes, the tall and manly Mohaves, the ferocious Apaches, the mild and intellectual Indians of the New Mexican Pueblos, some fishers and hunters, some living on roots and berries, some skilled agriculturists, all speaking fundamentally distinct languages.

It is evidently impossible in such a case to adhere throughout to any one method of classification, and the following tentative survey is consequently based partly on the linguistic and partly on the ethnical elements, but partly also on mere geographical grounds. Fortunately there are in all the divisions of the continent a few great families, occupying vast regions, in which the ethnical and linguistic elements largely coincide. Foremost amongst these are the sub-arctic races and the Athabascans, Algonquins, and Dakotas in the north, the Maya-Quiché in the centre, and in the south the Caribs, Quichua-Aymaras, and Guaranis. These eight stocks cover jointly an area of not less than 11 millions of square miles, with a total aboriginal population of about four millions. But the seven millions of pure and mixed Indians occupying the remainder of the land, 5 millions of square miles in extent, are divided into a multiplicity of tribes, whose racial and linguistic affinities present problems the solution of which must long tax the utmost ingenuity of science. The total number of distinct languages alone is estimated at about 760, of which 430 are in the north and 330 in the south. In the northern division Balbi reckons, exclusive of California, thirty-two stock languages, far too low an estimate, while Rivero and Tschudi consider that of the southern idioms as many as four-fifths are radically distinct. But all such calculations are mere vague guesses at the truth; and in the present state of our knowledge it is impossible to form an estimate of the actual number of languages still current in Gran Chaco, Chiquitos, the Amazon valley, Central America, Mexico, California, the Columbia basin, regions where an extraordinary complexity of speech prevails. Nevertheless language forms on the whole perhaps the most convenient basis of classification, and without its aid it would have been impossible to determine the affinities of many wide-spread races, such, for instance, as that of the Arizona Apaches with the Canadian Chippewyans, or on the other hand to separate nations apparently closely related, like the Iroquois from their Algonquin neighbours, or the Araucanians from the Peruvians. The true relations of many tribes are, on the other hand, still doubtful, because of uncertainty regarding the languages they speak. Such are the Cheyennes, Blackfeet, and Arapahoes, classed by some with the Dakotas, by others more probably with the Algonquins. Such also are the so-called Diegueños (Kizh, Netela, and Kechi) of South California, oscillating between the Shoshone (Snake) and Yuma connexions, and the Pawnees of Nebraska and Kansas grouped by Bancroft with the Shoshone, but by Morgan regarded as an independent race. So close is the physical resemblance in these and many other cases that the question must ultimately be decided by a more exhaustive study of their languages.

The American races may be conveniently grouped under the following eighteen divisions :—

I. *Hyperborean Races.*—This division may on the whole be regarded as possessing a certain ethnical, linguistic, and geographical unity. Still the Aleutians differ so greatly in language, and in some respects in type, from the Eskimo proper that it seems desirable to class them separately. The *Eskimo* (or "Innuits," as they call themselves) are thus distributed by Dall :—

Kopagmut, mouth of the Mackenzie; Kangmâligmut, thence to Manning Point; Nūwukmut, about Point Barrow and Icy Cape; Kowagmut, east end of Hotham Inlet; Salawigmut, at Salawik river; Chuklukmut, Gulf of Anadyr, Asia, often confounded with the Tchuktchis, from whom they are entirely distinct; Okee-ogmut, the islands north of 63° N. lat.; Kikhtogamut, St Lawrence Island; Kaviagmut, between Kotzebue and Norton Sounds; Mahlemut, neck of Kadiak Peninsula; Unaligmut, from Norton Sound to mouth of the Yukon; Ekogmut, Yukon Delta; Magemut, from Yukon to Kuskokwim river; Kuskwogmut, Kuskokwim Bay; Nushagagmut, Bristol Bay, west to Cape Newenham; Ogulmut, north side of Alaska peninsula; Kanlagmut, south side of Alaska peninsula and Kadiak Island; Chugachigmut, Prince William's Sound to Atna river; Ugalakmut, from Atna river to Mount St Elias.

The last-named, the Ugalenzes of the Russians, call themselves Chilkhatmut, and are undoubtedly true Eskimo, although frequently confounded with the Thlinkeets, on whose domain they converge. The few Innuit tribes east of the Mackenzie have not been classified, but two of them, the Netchillik and Uquîsiksillik, were met by Lieut. Schwatka in 1879, who received from them some particulars regarding the remains of the Franklin expedition.

Of the Aleuts, whose collective name is "Ungungun," or "People," there are two divisions :—

1. *Unalashkans*, who call themselves Kagataya Kung'n ("Men of the East"), occupying the extremity of the Alaska Peninsula, as far as 160° W., and the Unalashka or Fox Islands. 2. *Atkhas*, occupying all the other Aleutian Islands.

II. *Thlinkeets.*—These form a distinct ethnical and linguistic group, occupying a compact geographical area along the Pacific coast from about Mount St Elias to the Simpson river, and including Sitka and the other adjacent islands. They are often called "Koloshes," a term of doubtful origin, but the national name is "T'linket," "man," or "T'linketantûkwan," "men belonging to all villages." The tribal divisions are :—

Yakutat, between Mounts St Elias and Fairweather; Chilkahtkwan, Chilkhaht river valley; Sitkakwan, Sitka Islands and part of Prince of Wales Islands; Stâkhinkwan, lower course of Stikine river; Takukwan and Skatkwan, Taku Inlet, Alaska; Hudsunu, Hood's Bay and Huchinu Rapids; Hiknu and Tungass, about Simpson river.

The Thlinkeet language seems to be completely isolated, showing nothing beyond the faintest verbal resemblance to the Aleut and more southern Hydah. It has a plural in *k*, and an instrumental form in *tch* or *tsh*, the combination of which produces a heaping up of final consonants, which none but the natives can pronounce. Thus *ass*, tree; *asstsh*, by a tree; *isk*, trees; *assktsh*, by trees. (See "Notes on the Sitkakwan Dialect," by J. Furnhelm, in *Contributions to American Ethnology*, vol. i.)

III. *Columbian Races.*—The general grouping of these is purely geographical, the main divisions largely ethnical and linguistic; the area, British Columbia, Queen Charlotte and Vancouver Islands, Washington, and Oregon. Here are five stock races speaking an immense number of dialects, which, owing to their extremely evanescent character, it is very difficult to classify. The Puget Sound district, in the north-west of Washington, is in this respect specially remarkable. But great light has recently been thrown on this Babel of tongues by the labours of G. Gibbs, published by Dall, in *North American Ethnology*, vol. i. p. 240. The five stock races with their chief tribal subdivisions are as follows :—

1. *Hydahs.*—The Kaigani of Prince of Wales Islands and north coast of Queen Charlotte Islands; the Klue, Kiddan, Ninstence, Skid-a-gate, Skid-a-gatee, Cumshe-was, and Chut-sin-ni of Queen Charlotte Islands; and the Tsimsians, including the Kispachloht of Fort Simpson, the Kl'kuskamoluk of river Naas, and the Kittistzu, Hailtzukh, Bilikûla, and Kwa-Kiûtl of Milbank Sound. 2. *Nutkas.*—The Ahts, including Pachînaht, Nitinaht, Ohyaht, Howchuklisaht, Klah-oh-quaht, Manohsaht, Nishquayaht, Ayhuttisaht, and Khahosaht, on the west coast of Vancouver Island, in their order going northwards; the Maka or Klasset, about Cape Flattery; and the Quoquoulth, Komux, Kowitchan, Klallum, Ukletas, Sokes, Pachina, and Sankaulutuch, of the east coast of Vancouver Island. 3. *Selish or Flat Heads.*—The Kwantlum and Haitlin or Tait, Fraser river below Fort Yale; the Kalispelm, Quarlpi, Spokane, Pisquouse, Soaiatlpi, of middle Columbia basin; the Nisqualli (including the Skokomish, S'hotlmamish, Sawamish, Segwallitsu, Puyallupahmish, Dwamish, Snohomish, Snokwalmu, Yakama, Skagit, Lummi, and S'klallam) of Puget Sound; the Chihalis or Tsihalis, Grey Harbour; and the Shushwaps (including Shewhapmuch, Kutenais, and Okanagan) of Upper Columbia. 4. *Sahaptins or Nez Percés.*—The Taitinapam, right bank of Columbia to Adam's Mount; the Klikatat, about Mount St Helens; the Yakima, Yakima Valley; the Walla Walla, Palouse, Tairtla, Cayuse, and Mollale of upper Clear Water and Snake rivers; and the Kamal and Lapwai of Idaho reserve. 5. *Chinuks.*—The Watlala, Sklilût, Kathlamet, Wakiakum, Klatsop, Klakama, Kalapuya, Yamkally, and Killamâk of lower Columbia basin, mostly extinct. Speech radically distinct, but now represented only by the Chinuk jargon.

The names of Nos. 1 and 2 are purely conventional. *Hydah* or *Haida* was originally applied by Francis Poole to the Queen Charlotte tribes, and was afterwards extended to all the members of that family. *Nutka*, from Nutka Sound, west coast of Vancouver Island, came gradually into use as the collective name of the eastern Vancouver tribes, and of some peoples on the opposite mainland ethnically related to them. But the languages differ so widely that they cannot be reduced to a common root. Though possessing great intelligence and even considerable artistic skill, shown especially in their wood and bone carvings and plastic works, these north-western nations betray an absolute incapacity for adapting themselves to civilized institutions. Sproat tells us that many of those who have been settled, under the most favourable circumstances, in different parts of Vancouver, simply die out through inanition, or from sudden change of life.

IV. *Californian Races.*—This is mainly a geographical grouping, but with three large ethnical and linguistic families—the Klamath, Pomo, and Runsien. Many of the others belong to the Shoshone, Athabascan, and Yuma connexions. But the rest form a chaos of tribes, generally of a debased physical and moral type, and speaking rude dialects which baffle all attempts at classification. They are all rapidly disappearing into the "reserves," or off the face of the land. The *Klamath* family, in the Klamath river basin, and thence eastwards to Nevada, comprises the Lutuami or Klamaths proper, the Cahroes and Euroes ("Upper and Lower Roes"), the Modocs, Yacons, Shastas, Weitspeks, Wishosks, Wallies, Yukas, and others stretching south to the Humboldt river. South of them are the *Pomos*, or "People," mainly in the Potter valley, including the Kahto, Choam, Chadela, Kalamet, Shebalne, Lama, Comacho, Socoa, Sanel, and the Gallinomero of the Russian River. Still further south are the *Runsiens* of Monterey Bay, with linguistic affinities stretching all along the coast northwards to San Francisco, and southwards beyond Cape Concepcion to the islands of San Miguel and Sta Cruz. The chief members of the group are the Eslenes, Olhones, Mipacmacs, Yolos, Talluches, Waches, Powells, and others about Lake Tulare. In the Napa valley is a small family including the Ulukas, Suskols, Kalayomanes, Myacomas, and Caymus; and in the Sacramento valley are the Secumne, Kosumne, Yasumne, Ochecumne, Chupumne, and some twenty others, whose tribal names all end in *umne*, and who may perhaps be regarded as forming a distinct linguistic group. But they will have vanished before the point can be settled.[1]

[1] In the eyes of certain ethnologists California has always been a favourite harbour of refuge for distressed Chinese or Japanese junks, whose crews are to be regarded as the founders of the arts, cultures, and empires of the New World. A recent attempt to revive this theory has been made by Lieutenant Wheeler (*Expedition through South California*, 1875), who found some apparently archaic Chinese hieroglyphics cut into the basalt rocks near Benton, South California. These have been published in Petermann's *Mittheilungen* (vol. xxiii. part 4, 1877) by Oscar Loew, who fancies he can decipher the Chinese symbol for *to*, *i.e.*, earth, and thence draws an argument in favour of the wild theory seriously advocated

V. *Shoshone and Pawnee Families.*—These form one ethnical, but apparently two linguistic groups, for L. H. Morgan regards the Pawnee as distinct not only from the Shoshone but from all other languages.

The *Shoshone* or *Snake* family occupies a wide domain, including most of Idaho, Utah, and Wyoming, besides parts of Oregon, Nevada, West Montana, Arizona, North Texas, South California, and New Mexico. There are six distinct groups :—

1. *Wininasht*, or *Western Shoshones*, Oregon and Idaho. 2. *Bannacks*, Oregon, Idaho, Nevada. 3. *Utahs* or *Utes*, with numerous subdivisions (Utes proper, Washoes, Pah-Utes, Gosh-Utes, Pi-Edes, &c.), Colorado, Utah, Nevada, Arizona, and South California. 4. *Comanches* or *Yetans*, three branches (Paducas, Yamparaks, and Tenawas), North Texas, New Mexico, North Mexico. 5. *Moqui*, New Mexico; all the seven Moqui pueblos except the Oreibe (Haro), in which the Tegua language is current. 6. *Diegueño* (Kizh, Kechi, and Netela), about S. Diego, the south-west corner of California; but by Gatschet these are now affiliated to the Yuma stock (*Zeitschr. für Ethnologie*, 1877, p. 365). The *Benemé* and *Cobaji* of south-east California are also included by Gatschet in the Shoshone family.

The *Pawnee* (*Pani*) area is confined to Kansas and Texas, besides the Pawnee reserve, Indian territory, with three main divisions :—

1. *Pawnees proper*, including the Chäuè, Kitkä, Skidi and Petähänerot, Kansas and Pawnee reserve, Indian Territory. 2. *Arikarees* or *Rikarees*, formerly in the Missouri Valley, 47° N. 3. *Wichitas*, upper course of Red and Canadian Rivers, Texas, with whom should be grouped the Kichai, Waccoe, and perhaps the Towiak, Towakoni, Wacho, and Caddo of Texas and Louisiana. To the same connexion probably belonged the extinct Adaize, Nachitoch, Chetimach, Attacapa, and others of Louisiana, figuring in Gallatin's synopsis as stock languages (Schoolcraft, iii. p. 401).

VI. *New Mexican Pueblos.*—This is a strictly ethnical family occupying a compact area in New Mexico, but according to W. C. Lane (Schoolcraft, v. p. 689) speaking six distinct languages sprung of one original stock, as under :—

1. *Queres*, current in the Acoma, Cochitimi, Kiwomi, Laguna, and four other pueblos. 2. *Tegua* or *Taywaugh*, current in the Nambe, Tesugue, San Juan, and three other pueblos, besides the Haro, a Moqui pueblo. 3. *Picori* or *Enaghmagh*, current in the Picori, Isletta, Taos, and five other pueblos. 4. *Jemez*, current in Jemez and Pecos only. 5. *Zuñi*, current in Zuñi only, and said to be a radically distinct language. 6. *Moqui*, a Shoshone dialect (see V. above), current in all the Moqui pueblos except Haro.

One of the most remarkable of existing linguistic phenomena is the number of widely diverging languages spoken in these twenty-six New Mexican pueblos, where the uniformity of institutions, agricultural habits, town life, and social intercourse might be supposed to establish a community of speech.

VII. *Yuma Stock.*—This linguistic and ethnical group in South Arizona and South California is named from the typical Yuma tribe formerly at the junction of the Gila and Colorado rivers. The family has been learnedly treated by A. S. Gatschet (*Zeitsch. f. Ethnologie*, 1877, pp. 341 and 366), who regards the Yuma as fundamentally distinct from all the surrounding forms of speech. The tribes are now mostly gathered in the three reserves of the Colorado river (right bank, 34° N.), San Carlos, Gila river, south-east Arizona, and Pima and Maricopa, South Arizona, with a joint population of 5249, to which must be added about 750 for those who are still independent, making 6000 for the whole race. Chief tribes :—

1. *Yavipai* or *Yampai*, formerly west and north-west of the Aztec Mountains. 2. *Konino* or *Casnino*, San Francisco Mountains; said to be extinct. 3. *Tonto* or *Tonto-Apache*, between the Green River and Aztec Mountains, distinct from the Tonto-Apaches of Athabascan stock. 4. *Maricopa* or *Cocomaricopa*, middle course of the Gila. 5. *Hualapai* or *Wallapai*, between the Colorado and Black Mountains. 6. *Mohave* or *Mojave*, properly *Hamukh-habi* ("Three Hills"), largest of all the Yuma tribes, both sides of the middle and lower Colorado. 7. *Yuma* or *Kutchan*, at junction of Colorado and Gila rivers. 8. *Cocopa* or *Cucapa*, at mouth of the Colorado. 9. *Comoyei* or *Quemeya*, collective name of all the Yuma tribes between the lower Colorado and the Pacific, including (according to Gatschet) the *Diegueños* (see V., No. 6), and the *Kitiwi* near San Tomas mission. 10. *Cochimi*, *Pericui*, and *Guaicuri* of lower California. Probably to the same family belonged the extinct *Cajuenches*, *Cucapas*, *Jalchedums*, *Noches*, *Cawinas*, *Niforas*, and others of South and East Arizona.

VIII. *Athabascan or Tinney Family.*—This is the most widespread ethnical and linguistic group in North America, comprising most of Alaska and the Canadian Dominion from the Eskimo domain to the Churchill river north and south, and from the Rocky Mountains to Hudson Bay west and east, besides isolated enclaves in Oregon, Arizona, New Mexico, Colorado, and North Mexico. The term *Athabascan* is geographical, from Lake Athabasca, a great rallying point of the northern tribes, while *Tinney*, suggested by Petitot, variously pronounced Tinné, Thynné, Déné, Tena, Itynai, Tanai, Dtinné, &c., and meaning "People," is the general tribal name. About the spelling, sound, and identification of the individual tribal names, the greatest confusion prevails. Thus *Kenai*, used by Francis Müller as the collective name of a distinct group, is supposed to be an Innuit word by Dall, who says that it should consequently be applied to no tribes of Tinney race. *Kolchaina* or *Kolshane*, figuring in most tables as a special tribe, appears to be a term vaguely applied by the Russians to all the interior Tinneys of Alaska, about whom they knew little or nothing. The Chippewyans of Lake Athabasca are constantly confused with the Algonquin Chippewas of Upper Canada, just as the Tonto-Apaches of Yuma stock are with the Tonto-Apaches of Athabascan stock. The Alaska division especially was in a chaotic state until Dall (*op. cit.*) surveyed the field anew, and supplied the subjoined corrected and apparently complete list :—

Kaiyuhkhotâna, lower Yukon and Kuskokwim rivers; Koyûkukhotâna and Unâkhotâna, right bank of lower Yukon; Kutchins or "People" (including the Tenan-Kutchin, Tananah river watershed; Tennuth Kutchin and Tatsah Kutchin, between the Yukon rapids and mouth of the Porcupine, extinct; Kutcha-Kutchin, about junction of Yukon and Porcupine; Natsit-Kutchin, from the Porcupine to Romanzoff Mountains; Vunta-Kutchin, from the Porcupine to the Arctic Innuits; Tukkuth-Kutchin, head-waters of the Porcupine; Han-Kutchin, Yukon river above Kotlo river; Tutchone-Kutchin, about White River; Tehânin-Kutchin, Kenai Peninsula; Abbato-Tena, Pelly and MacMillan rivers; Nehaunees, about source of Pelly river; Acheto-Tinneh, head-waters of Liard river; Daho-Tena or Sikannees, Liard river; Tâhko-Tinneh, Lewis river basin; Chilkaht-Tena, Lewis and Lebarge rivers; Ahtena, Atna river basin.

The other members of the Tinney family may be grouped in four geographical divisions as under :—

1. *Mackenzie Basin*: Sawessaw Tinney (Chippewyans), Lake Athabasca; Tantsawhoots of the Coppermine; Beavers, Dog-ribs, Strongbows, Red Knives, Hares, Sheep, Brushwood, and others enumerated by Petitot, whose theories are wild, but whose facts form a substantial contribution to science. 2. *New Caledonia*: the Tahkali or Tacullies, Mackenzie's Nagailers, and the Carriers of the Canadian trappers include the Nascotin, Nathliautin, Chilcotin, Taltotin, and several others. 3. *Oregon*: the Umpquas on the Umpqwa river, the Tlaskanai of the lower Columbia, and the Hoopahs near the north frontier of California. 4. *South-Western States*: the Apaches and Navajos, who roam over the region between Utah and Sonora.[1]

IX. *Algonquin Family.*—This ethnical and linguistic group, next in extent to the Tinneys, but far more important historically and numerically, stretches from the Tinney domain southwards to the latitude of South Carolina, and from the Atlantic to the Rocky Mountains. Most of the tribes on the Atlantic seaboard have either disappeared, migrated westwards, or been collected into the reserves. But many have acquired such celebrity in the stirring records of Indian warfare that the more noted with their original geographical domain will be included in the subjoined list of all the Algonquin races.

1. *Northern Branch*: Chippewas or Ojibways, Upper Canada and Michigan; Ottawas, Ottawa river valley (some now in Manitoulin Island, Lake Huron, others in Indian Territory); Nasquapees, interior of Labrador; Montagnais, south coast of Labrador; Crees or Knisteneaux, between Lakes Winnipeg and Athabasca north and south, and from Rocky Mountains to Hudson's Bay, west and east. 2. *Eastern Branch*: Abenakis, Maine, New Hampshire (later on, Lower Canada); Mikmaks, Nova Scotia, New Brunswick, and Lower Canada; Tarratines, New Brunswick; Etchemins or Milicetes, New Brunswick and Maine; Penobscots, Penobscot river, Maine; Passamaquoddies, East Maine; Amariscoggins, New Hampshire; Mohicans or Mohegans, Connecticut and New York; Naticks, Massachusetts (speech survives in Eliot's Bible); Pequods, Massachusetts, west of Cape Cod; Adirondacks, New York highlands; Manhattans, Manhattan Island, site of present city of New York; Leni-Lennappes or Delawares, Delaware, now in Indian Territory. 3. *Southern Branch*: Powhattans, Virginia and Maryland; Accomacs, Accomac river, East Virginia; Rappahannocks, Rappahannock river, Virginia; Panticoes, North Carolina, southernmost of all the Algonquin tribes; Shawnees, Pennsylvania, Kentucky, and Ohio, now in Indian Territory. 4. *Western Branch*: Illinois, Illinois river basin; Miamis, Great Miami river basin; Pottawattamies, Michigan; Kaskaskias, Kaskaskia river, Illinois, now in Indian Territory; Michigamies, south shore of Lake Michigan, named from them; Sacs or Sawkee and Foxes or Outtagaumi, middle course of Mississippi, now in Indian Territory and Nebraska reserves; Cheyennes, Lake Winnipeg (later on, Missouri and Platte rivers); Arapahoes, upper Arkansas and Platte rivers; Blackfeet, Saskatchewan forks, south to Maria's river; Ahahnelins, Milk river, Montana.

The linguistic affinities of the four last named are somewhat doubtful, but Albert Gallatin shows good grounds for connecting them with the Algonquin group.

X. *Wyandot-Iroquois Family.*—This is a distinct and historically famous group, allied ethnically to the Algonquins, and linguistically, Morgan thinks, remotely to the Dakotas. Their area is Upper Canada, about the great lakes, New York, and the Virginian highlands; they nowhere reach the Atlantic coast, and are everywhere surrounded by tribes of Algonquin stock. There are three main divisions :—

1. *Wyandots* or *Hurons*, including the Eries or Erigas, Ahrendahronons, and Attiwandoronk or "Neutral Nation," Canada. 2. *Iroquois*, or "Six Nations," chiefly in New York, a famous political confederacy collectively known as the *Ongwehonwe*, or "Superior Men," and comprising the Mohawks, Oneidas, Onondagas, Senecas, and Cayugas, besides the Tuscaroras, who joined the league from North Carolina in 1712. 3. *Monacans* or *Monahoacs* of Virginia, including the Nottoways, Meherries (Tutelos), and others, who later on joined the Iroquois confederacy.

XI. *Dakota or Sioux Family.*—This is an independent and widespread ethnical and linguistic group, whose proper domain is the western prairies between the Mississippi and Rocky Mountains east and west, and stretching from the Saskatchewan southwards to the Red River of Texas. The chief divisions are :—

1. *Dakotas proper*, of the Missouri basin. This term means "Allies," and includes the Isauntles, Yantons, Teetons, and Sissetons, each with several subdivisions. 2. *Assiniboines* or *Stone Indians*, known to the Dakotas as "Hoha," or "Rebels," because they withdrew from the confederacy about 1600, and settled in the Assiniboine river basin. 3. *Winnebagoes* ("Puans" of the Canadians),

in Charles Leland's *Fusang; or the Discovery of America by Chinese Buddhist Priests in the Fifth Century*. He also compares words from various Californian idioms with Japanese and Chinese, forgetting that these two languages themselves belong to two entirely different orders of speech, and have nothing in common beyond coincidences and borrowings.

[1] *Apache*, *i.e.*, "the men" (root *apa*, man), is a Yuma word, applied to the southern Tinneys, whose true name is *Sis Inday*, or "men of the woods." From the ending *che*, an attempt has been made by certain etymologists to connect these people with the Puelche, Huilliche, and other Patagono-Chilian tribes whose names end in the same syllable. But here *che* is the Araucanian "man," whereas in Yuma *che* is the definite article suffixed. Of the Apaches the chief tribes are the Coyoteros, Tontos, Lipans, Mescaleros, Pinaleños, Llaneros, and Gileños, so named by the Spaniards; the real tribal names are undetermined.

parent stock of the Omahas, Iowas, Kansas, Quappas or Arkansas, and Osages of the middle and lower Missouri basin. 4. *Upsarokas* or *Crows*, of the Yellowstone valley. 5. *Minnetarees, Hidatsa*, and *Mandans*, of the upper Missouri, of doubtful linguistic affinities, but by Morgan regarded as intermediate between the Dakotas and Appalachians. W. W. Matthews also affiliates the Hidatsa language to the Dakota family.

XII. *Appalachian Races.*—These form an ethnical and geographical grouping, including four distinct languages, which, however, according to Morgan, are remotely related to the Dakota; area, the south-east corner of the United States, westwards to Arkansas and Louisiana, northwards to Tennessee and South Carolina, all inclusive; name purely conventional, from the Appalachian or southern spurs of the Alleghanies. Here was a large linguistic family forming a powerful confederacy, of which the *Muscogees* or *Creeks* of Alabama were the centre. The other members were the *Seminoles* of South Alabama and Florida; the *Chickasaws* of Mississippi; the *Mobiles* of Florida West; the *Choctaws* of the lower Mississippi; the *Colusas* or *Coosadas, Alibamous, Appalaches, Uches*, and *Timucuas* (?) of South Carolina and Georgia. Of distinct speech were the *Natchez* of the lower Mississippi, who were said to have spoken three languages; the *Cherokees* or *Chelekees*, of the Appalachian slopes, and the *Catawbas* of South Carolina, supposed by some to be the Eries, or the neutral nation who disappeared from the lake region about 1656. All these races are either extinct, or have been removed to the reserves of Indian Territory, where two of the stock languages (Cherokee and Creek) are still current. Natchez and Catawba are extinct. Special interest attaches to the extinct Timucua language, formerly current along the east coast of Georgia and Florida southwards to and beyond Cape Cañaveral. It is a highly synthetic form of speech, regarded by Gatschet ("Volk und Sprache der Timucua," in *Zeitsch. f. Ethnologie*, 1877, p. 245) as a stock language, and possessing in the grammar, dictionary, and catechisms of Pareja, published in 1612–13 in Mexico, the oldest written records of any native tongue east of the Rocky Mountains. Gatschet gives a full account of its structure, which philologists will find extremely interesting.

XIII. *Mexican Races.*—This is a geographical grouping, the region comprising an exceptional number of radically distinct languages, and apparently three or four ethnical types. There is one large and important linguistic family, the Aztec-Sonora, which stretches southwards to Nicaragua, and for which Buschmann has sought affinities as far north as the Shoshone group. Its chief members are:—

1. *Aztec* or *Mexican proper*, widely diffused throughout the Nahua empire, overthrown by Cortez. 2. *Cora*, in the state Jalisco. 3. *Tarahumara*, in Chihuahua and Sonora. 4. *Cahita*, in Sinaloa and Sonora. 5. *Niquiran*, of Nicaragua. 6. *Tlascaltec*, of San Salvador. With these are probably related the *Pima* and *Opata* of Sonora and Sinaloa, the *Acaxee* of Durango, and the *Tubar* of Chihuahua.

The other chief stock or at least not yet classified Mexican tongues are the *Miztec* and *Zapotec* of Oajaca, *Tarasco* current in the old kingdom of Michoacan, *Matlalzinca* north of Anahuac, *Ceres* and *Cochita* of Sonora, *Tepecano* of Jalisco, *Zacatec* of Zacatecas, *Tamulipec* of Tamaulipas, and *Otomi*, an interesting form of speech still almost in the monosyllabic state, current in the mountains enclosing the Anahuac table-land. This is the more remarkable that most of the other Mexican languages are highly polysynthetic; but the attempt made to connect Otomi with Chinese has merely served to place their fundamental difference in a clearer light.

XIV. *Central American Races.*—Like the foregoing, this is a geographical grouping, with one wide-spread linguistic and ethnical family, the *Maya-Quiché* of Yucatan and Guatemala with an outlying branch in Vera Cruz and Tamaulipas. Of this family the chief members are the *Maya*, still generally current in Yucatan; *Zendal* and *Zotzil* of Chiapas; *Mam* and *Pokomam* of Vera Paz, Guatemala; *Huastec* of Vera Cruz and Tamaulipas; *Totonac* of Vera Cruz; *Quiché, Chol*, and *Zutugil* of Guatemala. The Mayas, like the Aztecs, possessed a writing system, of which three documents still survive,—the Dresden Codex, published in Lord Kingsborough's collection as an Aztec MS., the Mexican MS., No. 2 of the Paris National Library, and the Troano MS. in Madrid. Bishop Landa even credited them with the invention of an alphabet; but all attempts to interpret these documents by the key left by him have hitherto failed.

In Nicaragua and Honduras, besides the Aztec Niquiran, Squier (*Nicaragua*, ii. p. 308) reckons three distinct linguistic groups:—

1. *Melchora*, including the Wâlwa, Rama, Toaca, Poya, and Waikna or Mosco (Mosquito), collectively known as Bravos, probably of Carib stock, but with a mixture of Negro blood. 2. *Chorontega*, including the Dirian, between Lake Nicaragua and the Pacific; Nagrandan, north of the Dirian; Orotinan, about the Gulf of Nicoya. 3. *Chondal*, Chondales highlands, north and east side of Lake Nicaragua.

In Costa Rica and the peninsula of Panama there are a multiplicity of unclassified tribes, amongst whom are current at least five stock languages:—

(1) *Doracho* of Veraguas; (2) *Savaneric*; (3) *Bayano*, Rio Chapo, Pacific coast; (4) *Manzanillo* (San Blas), Atlantic coast, Costa Rica; (5) *Bribri*, a Costa Rica dialect, has been compared, but on slender grounds, with some West African tongues.

XV. *New Granada and Guiana Races.*—The confusion of tribes is continued southwards into the Colombian and Venezuelan Cordilleras; but, as we proceed eastwards along the Orinoco plains and through the Guianas, greater order seems to prevail. In New Granada itself there is at least one marked ethnical and linguistic group, the *Chibcha* or *Muisca* of Bogota, a civilized people, noted for their remarkable taste and skill in the execution of gold ornaments. Some of these works recently discovered and exhibited by Mr Powles at a meeting of the Anthropological Institute, London, excited universal surprise and admiration. This little known but extremely interesting people formed an important link in the chain of civilized and agricultural nations stretching along the western uplands from the New Mexican Pueblos, through the Aztecs of Mexico, Mayas of Yucatan, Dorachos of Veraguas, Chibchas of Bogota, and Peruvian Quichuas, to the Aymaras of Bolivia. Elsewhere in New Granada the tribes are almost past counting. In the southern province of Popayan alone ninety-four distinct languages were reckoned at the time of the conquest; and, although most of these are extinct, the unclassified races both here and in the north are still very numerous. The only large linguistic group is that of the *Salivi*, including the Betois, Eles, Yaruras, Atures (extinct), Quaquas, Macos, and others about the western head-streams of the Orinoco and in the Popayan highlands. Further east is the *Barré* family, including the Maypuri, Baniwa, Achegua, and many others in Venezuela and Guiana, besides some tribes as far south as Moxos in Bolivia. From the recent ethnological researches of Everard F. im Thurn (*British Guiana Museum*, Georgetown, 1878), there appear to be at least four independent linguistic groups in the Guianas:—*Warau* and *Arawack* in the coast region, *Wapiana* or *Wapisana*, with *Atorais*, in the savannah region, and *Carib* everywhere. At the time of the discovery the Caribs represented the conquering element in the West Indies, whence they have since disappeared, unless a few survive in Dominica (Vivien de Saint Martin). But they are still numerous, either pure or mixed with Negroes and others, from Honduras round the coast to the Amazon delta. They are represented in French Guiana chiefly by the *Galibi, Oyapok, Emerillon, Nuragwe*, and *Rucuyennes*, the last-mentioned on both sides of the Tumac-Humac range (Dr J. Crevaux in *Tour du Monde*, June 28, 1879). In British Guiana the Carib tribes are the *Ackawais* and *Caribisi* of the coast and forest regions, the *Arecumas* and *Macusis* of the savannah region. On the upper Orinoco are the *Carinas* or *Calinas*; in Dutch Guiana the *Kirikiricots, Acuria, Saramacca, Aukan*, and *Mataaric*; in Brazilian Guiana the *Pianghottos, Parechi, Daurais* (extinct ?), *Mandaucas, Masacas*; in Venezuela the *Tiverigotes, Guaraunos, Guayanos, Tamanacs, Avarigotes, Acherigotes, Piritus, Palencas, Chacopatas*, and many others. On the affinities of the Carib race great uncertainty prevails, some regarding them as an independent stock, some tracing them across the islands to the Allighewis or Alleghans, who are supposed to have been driven by the Algonquins from the Mississippi regions in the 10th century, while others, with D'Orbigny (*L'homme Americain*, vol. ii.), affiliate them with some show of probability to the Guaranis of Brazil.

XVI. *Peruvian and Bolivian Races.*—Here the grouping is strictly ethnical and linguistic in the Cordilleras and upland plateaus, which are mainly occupied by one great historical and civilized race, with two well-defined branches—*Quichua* of Peru and *Aymara* of Bolivia. Under the Incas Quichua, one of the most highly cultivated but also one of the harshest of American tongues, was current along both sides of the Cordilleras, from Quito on the equator southwards to the Araucanian domain about 30° S., but interrupted between 13° and 20° S. by the Aymara, which, like the northern Quiteño, seems to be an older and ruder form of the common stock language. Still more primitive forms were probably the extinct *Cara* and *Puruha* of Ecuador. But in this northern province, which was the last added to the empire (under the twelfth Inca Huaina-capac), there were said to be at the conquest forty other nations, speaking as many distinct languages, with three hundred different dialects. Of these a considerable number still people the banks of the Yapura, Putumayo, Pastassa, Napo, and other northwestern head-streams of the Amazons, the most noteworthy being the *Jivaros* of the Pastassa, the *Zapáros* of the upper Napo, the *Anguteras* and *Orejones* of the lower Napo, the *Colorados* and *Capayas* of the uplands east of Quito, and the *Copanes* of the upper Aguarico. The secret language of the Incas was apparently the Aymara of Lake Titicaca, the cradle of their race; and remotely connected with the same branch are probably the Olipe or Atacameño, between 19° and 22° S., and the Chango, between 22° and 24° S., although R. A. Philippi (*Reise durch die Wüste Atacama*, Halle, 1860) regards this latter as fundamentally distinct both from the Quichua and the Aymara.

Antisuyo, the eastern division of the old empire, stretching along the eastern slopes of the Peruvian and Bolivian Andes between 10° and 19° S., is occupied by five nations, the *Yuracares, Moceténes, Tacanas, Maropas*, and *Apolistas*, whom D'Orbigny (*op. cit.*, vol. i.) collectively calls *Antisians*, affiliating them to the Quichua-Aymara family, from which, however, they differ in speech and physique as profoundly as they do from each other. Hence the so-called *Antis* or *Antisians* of more recent anthropological works have no ethnical or linguistic unity, and, like *Chinchasuyo, Candisuyo*, and

Collasuyo, i.e., northern, western, and southern province, the term *Antisuyo* itself is purely geographical.

As we descend to the Bolivian lowlands, the confusion of races reaches its climax in the provinces of Moxos, Chiquitos, and Gran Chaco. Notwithstanding the disappearance of many tribes in recent years, E. D. Matthews (*Up the Amazon and Madeira*, 1879) still found in the Beni Missions, Moxos, besides the above-mentioned Maropas, six distinct tribes—*Cayubabas, Mobimas, Mojeños, Canichanas, Itonamas*, and *Baures*—"each having a language of its own." But the Baures would seem to be a branch of the Mojeños, who are again affiliated to the Maypuri of the Barre family (see XV.). Other nations in Moxos with distinct speech are the *Chapacuras* in the south-east, and the *Pacaguaras* and *Itenes* in the north.

Chiquitos is occupied by eleven distinct nations, all speaking radically different languages, but presenting a uniform physical type:—*Chiquitos* in the centre; *Samucus, Curaves, Tapiis*, and *Corabecas* originally in the south-east; *Saravecas, Otukes, Curuminacas, Covarecas, Curucanecas*, in the north-east; and *Paiconecas* in the north-west. The language of the Chiquitos, of whom there are endless subdivisions, is one of the richest and most widely diffused in South America, serving, like the Tupi in the east, as a sort of lingua franca in the Bolivian lowlands and the northern parts of Gran Chaco. The numerous tribes of this latter region seem to form an ethnical group related to the Chiquitos peoples, and like them speaking a great variety of distinct languages. The greatest confusion still prevails as to their mutual relations; but the main linguistic groups seem to be the *Mocobi-Toba* of the Salado and Vermejo rivers; the *Mataguaya*, including the *Vilelu, Lule*, and *Chanes* between the Pilcomayo and Vermejo; the *Abipone*, on the right bank of the Parana, between 28°–30° S.; and the so-called *Lengua* (properly *Juiaje*) in the centre of Gran Chaco, surrounded by Mocobi tribes. Here were also the extinct *Guaycurus* (probably akin to the Tobas), noted for their skill in horsemanship. Hence the term Guaycuru came to be applied generally to all the mounted Indians of Gran Chaco, and, though no longer the name of any particular tribe, it continues to figure in ethnographic works as a racial designation, increasing the confusion in a region already overburdened with obsolete or erroneous ethnical nomenclature.

XVII. *Brazilian Races.*—Here the grouping, with one great exception, is still mainly geographical. The exception is the widespread *Tupi-Guarani* ethnical and linguistic family, rivalling in extent the Athabascan and Algonquin of the northern continent, and including, besides a great part of Brazil, all Paraguay, about half of Uruguay, large enclaves in Bolivia, and, if the Carib is to be regarded as a branch, nearly all the Guianas and Venezuela. Of this race the two main divisions are the *Guarani*, from about the neighbourhood of Monte Video to Goyaz south and north, and stretching west and east from the Paraguay to the Atlantic, and the *Tupi* thence northwards to the Amazon and Rio Negro. The southern division may be regarded as nearly compact, but the northern everywhere encloses a number of races apparently of different stocks, while along the Amazon and its great tributaries the tribes are as numerous as they are diverse in speech and often in physique. Over 15 distinct peoples are mentioned on the Xinga river alone, 20 on the Tapajoz, as many on the Ucayali, 50 on the Japura. R. S. Clough (*The Amazons*, 1872) gives lists of 33 on the Purus, and of 37 on the Naupes, a tributary of the Rio Negro; over 100 different dialects are current on the Rio Negro itself (Martius), and as many as 234 tribal names occur in Milliet de Saint-Adolphe's *Diccionario Geographico do Imperio de Brazil* (Paris, 1863). Here the only means of communication is afforded by the *Lingoa Geral*, or "general language," which is based on the Tupi, and which has gradually become current throughout the empire.

Of the Guarani-Tupi stock the most representative races are the *Tupinambas*, formerly dominant on the coast of Para; the *Tupiniquins* of Espirito Santo; the *Petiguares* of the Paraiba; the *Tupuias* of Bahia; the *Tobajares* of Maranhão; the *Caetes* of Ceara; the *Obacatuaras* of the Rio S. Francisco; the *Mundrucus, Apiacas*, and *Mauhés* of the Tapajos; the *Tappés, Patos*, and *Minuanos* of Rio Grande do Sul; the *Piturunas* of the river Curitiba; the *Guanhanaris* of the Parana; the *Guarayos* and *Chiriguanos* of the upper Memoré, Bolivia; the *Omaguas* of the Yapura; the *Manaos, Juris, Tereccumas, Caripunas*, and nine others in the Rio Negro basin.

The Non-Guarani element in Brazil, often collectively known to the Tupis as *Tapuyas, i.e.*, "strangers" or "enemies," has hitherto baffled all attempts at classification. The best known groups, mostly linguistic, are the *Aimore* or *Botocudo* of the Aimore coast range; the *Pamacan*, widely diffused in Bahia and Minas-Geraes; the *Curys*, with many subdivisions in Rio Janeiro, Espirito Santo, and Minas-Geraes; the *Canecran*, with five branches in Para and Goyaz; the *Cairiri* or *Kiriri*, a large nation in the Borborema mountains, with two branches (*Velhos* and *Novos*) in Pernambuco, Parahiba, and Ceara, grouped by Martins with the Moxos of Bolivia, the Cunamares of the Jurua, the Majurunas of the Javary, the Manaos of the Rio Negro, and many others under the collective name of *Guck* or *Coco*; the *Gè* with diverse prefixes (Au-Gè, Canacata-Gè, Cran-Gè, Payco-Gè, Pontaca-Gè, &c.) in Maranhão and Para, with whom must be grouped the Timbiras of Goyaz ("fallavão o idioma dos Gamelleiros ou Timbiras," M. de Saint-Adolphe, i. p. 384); the *Vouré* of Matto Grosso, now united with the *Choco, Pipian*, and *Uman*, all of like speech; the *Carijos*, formerly very powerful in province São Paulo, now mostly fused with others; the *Carajas* and *Chambioas* of rivers Araguaya and lower Tocantins, Goyaz, and Para; the *Goya*, very numerous in Goyaz, to which province they give their name; the *Charruas*, formerly very powerful in the extreme south and in Uruguay, grouped by D'Orbigny with the Pampas Indians, and described by him as "peut-être la nation Americaine que l'intensité de la couleur rapproche le plus du noir" (ii. p. 85); the *Bororos*, formerly dominant over a vast region in Matto Grosso.

XVIII. *Austral Races.*—These occupy four geographical areas, to which correspond four distinct ethnical and linguistic groups:—

1. *Auca* or *Araucanian*, Chilian and Patagonian Cordilleras; type very uniform, and by D'Orbigny affiliated to the Peruvian; speech entirely distinct from all others, and spoken with little dialectic variety throughout the whole area. The numerous branches are generally indicated by a geographical terminology, as *Picunche*, "northern people," *Puelche*, "eastern people," *Huilliche*, "southern people," &c., the final syllable *che* signifying "people." But the official Chilian divisions are:—(*a*) *Motuche*, or *Arribanos, i.e.*, "highlanders," and *Abajinos* or "lowlanders," between rivers Malleco and Cautin; (*b*) *Larquenche* or *Costinos, i.e.*, "coast people," between rivers Lebu and Imperial; (*c*) *Huilliche*, or "southerners," in two divisions, south of rivers Cautin and Tolten. Total population, 24,360 unmixed Araucanians (Edouard Sève, *Le Chili tel qu'il est*, Valparaiso, 1876).

2. *Puelche*, occupying the Pampas region from the Saladillo to the Rio Negro; hence known to the Spaniards as the *Pampas* Indians. *Puelche* or eastern people is their Araucanian name, answering to the Patagonian *Yonec* and *Penck*. There is great uniformity of type and speech, the latter, like Araucanian, being distinct from all others. No well-recognized tribal divisions exist. The race is dying out or becoming absorbed in the general mass of the Argentine population.

3. *Patagonian*, the *Tehuelche, Chuelche*, or *Huilliche* (*i.e.*, "southerners") of the Araucanians; national name *Tsoneca*; area, Patagonia from the Rio Negro to Magellan Strait, and from the Cordilleras to the Atlantic. This is the tallest race on the globe, with mean height 5 feet 11 inches (Topinard, *Anthropology*, p. 320), and otherwise differing widely from all the American types, with which they have nothing in common except the structure of the hair and the polysynthetic form of their speech. The present race again seems distinct from the prehistoric in this region as represented by the skulls recently found by Moreno at El Carmen on the Rio Negro. These are highly dolichocephalous, whilst Dr A. Weissbach (*Zeitschr. für Ethnologie*, 1877, p. 8) represents the modern Tehuelches as amongst the most brachycephalous on the globe, approaching in this respect nearest to the chimpanzee type.

4. *Fuegians*, the *Pescherais* of some writers, Tierra del Fuego; no recognized collective national or tribal names; one ethnical type, entirely different from the Patagonian, and by D'Orbigny allied to the Araucanian; two apparently distinct languages, a northern and a southern variety, with no known affinities to any on the mainland or elsewhere. They probably occupy the lowest scale of culture in the American division of mankind,—in this respect corresponding to the Negritos and Bushmen of the eastern hemisphere.

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Modern History and Present Distribution of North American Indians.

It is only very recently that the number of Indians on the North American continent has come to be known with any degree of accuracy. The best estimates at present accessible, based on the reports of Indian agents and on the United States census for 1880, give the total number in the United States as 303,248. The number in British North America is estimated, more roughly, at 103,969, making a total for the continent, north of Mexico, of 407,217. The following table, which is compiled from the census returns for 1880, and from the reports for 1879 of the superintendents of Indian affairs for the United States and for the British Possessions, may be relied on as approximately correct:—

British Possessions.		Kansas	693
Ontario	15,941	Louisiana	807
Quebec	12,054	Maine	603
Nova Scotia	2,126	Massachusetts	341
New Brunswick	1,433	Michigan	17,045
Prince Edward's Island	266	Minnesota	17,893
Manitoba & N. W. Territory	30,227	Mississippi	1,811
Athabasca	2,398	Montana	20,825
British Columbia	35,154	Nebraska	4,494
Rupert's Land	4,370	Nevada	7,728
		New Mexico	22,860
Total	103,969	New York	5,820
		North Carolina	1,152
United States.		Oregon	5,854
Alabama	170	Pennsylvania	156
Arizona	24,753	South Carolina	113
Arkansas	144	Tennessee	238
California	16,581	Texas	869
Colorado	4,316	Utah	1,166
Connecticut	230	Washington	16,786
Dakota	31,707	Wisconsin	10,340
Idaho	6,248	Wyoming	2,272
Illinois	104		
Indiana	186	Total	303,248
Indian Territory	78,142		
Iowa	801	Grand total in N. America	407,217

The popular idea has always been that these races are fast disappearing, and that their total extinction is merely a question of time. This conclusion has recently been called in question by Colonel Garrick Mallory, of the United States army, in a paper read before the American Association for the Advancement of Science. From the evidence he presents it appears that, while many tribes have decreased in number, and some have even become extinct, others have increased very decidedly, leading to the probable conclusion that the Indian population of North America as a whole has not decreased greatly since the earliest occupation of the country by Europeans. It is at least certain that the Indians have been brought under various influences which tend to prolong and preserve life. The murderous inter-tribal wars have ceased; the people are now better housed, clothed, and fed; many of them have regular avocations; and they have medical attendance when sick.

The general policy of the United States Government, in its management of the Indian tribes within its borders, has been to treat with them as separate but subject principalities. It thus makes treaties with the different tribes, purchases land from them, &c. Its policy further is to place all the tribes upon reservations, whence they are prohibited from wandering, and which are forbidden ground to whites, thus isolating them from the rest of mankind. In return for land ceded by them to the United States most of the tribes receive yearly grants, which are paid in the form of supplies of food, clothing, arms, and ammunition. Under such conditions, the experiment of civilizing them is being attempted,—in the case of some tribes with success, in others, thus far, with utter failure. As, however, all stimulus to self support is wanting, it seems surprising that any tribe should have made perceptible advance at all, and the progress attained is therefore encouraging for future effort. The policy of the Dominion Government is almost precisely similar to that of the United States, but the results are very different in the two countries. While the United States have had almost continual trouble with their aboriginal inhabitants, Canada has had no Indian difficulties of importance. This is due in part to a difference in the practical working out of the policy, but more to differences in environment. The Indian service of the Dominion Government is composed of a trained body of men, who remain in it through life, who thoroughly understand the Indian character, and who become known and trusted by their charges. The members of the United States Indian service, on the other hand, are appointed by political or church influence, and are in many cases unfit for the work; they are changed also as the balance of political power passes from one party to another. The Dominion has always fulfilled the conditions of its treaties, and has always administered punishment promptly and severely when the necessity arose. The United States have broken treaty after treaty, or have neglected to fulfil their obligations to such an extent that most tribes no longer have confidence in the promises of the Government. In cases of outrages by Indians, it has, as a rule, been very slow and dilatory in punishment.

But undoubtedly the principal reason for the immunity the British Possessions have hitherto enjoyed from Indian wars lies in the fact that the Indians have not yet been crowded by the whites. While the area is larger than that of the United States, the Indian population is but about two-fifths as great, and the whites are but one-tenth. The Indians still hold their favourite hunting and fishing grounds; the game and fish have not yet sensibly decreased; and the whites do not yet so press upon them as to arouse their jealousy and suspicion. The history of the Indian tribes in the United States, from the time of the first occupation of the country by the whites, has been one of forced migrations, always westward, to make way for the repeated encroachments of civilization. As the result of a succession of disastrous wars and forced treaties, nearly all the aboriginal population formerly living east of the Mississippi has either been destroyed or removed beyond that river. In the British Possessions they have been more fortunate. The first settlements in the provinces were made by the French, who associated freely with the natives, intermarrying to a large extent. This produced a bond of union between them, the effects of which, in both peoples, are to be seen to the present day. The country being still but thinly peopled, the necessity for removing the Indians, in large numbers, has not yet arisen; and their treatment by the Dominion Government has been more humane and just than in the United States. In consequence of all this, most of them remain in or near their original homes. Excepting those tribes which have moved across the border from the United States, few, if any, have engaged in war against the whites. As long as the western country was the domain of the Hudson's Bay Company the interests of the traders were, to a large extent, identical with those of the natives. The Company furnished a ready market for furs and pelts, of which the Indians were quick to avail themselves; indeed, although it supported a large number of French trappers, by far its principal business was done with the natives.

Indians in the Dominion of Canada.—The general distribution of the tribes of the British Possessions is as follows. In the province of Ontario are found parts of the Six Nations, Wyandots, Chippewas, Minsees, Mississauguas, and others of Algonquin stock. In the province of Quebec are another part of the famous Six Nations, besides Abenakis, Montagnais, Milicetes, Micmacs, and other smaller tribes. In Nova Scotia and Prince Edward's Island are Micmacs, in New Brunswick a part of the same tribe and a few of the Milicetes. In Manitoba and North-West Territory, the Chippewas, Crees, Blackfeet, and Dakotas make up the aboriginal population. The Athabasca district is peopled by the Crees, Assiniboines, Chippewyans, and Beavers; while British Columbia and Rupert's Land contain a great number of small tribes, too numerous to be mentioned here.

Indians of the United States.—Of the numerous and powerful tribes which inhabited New England at the time of its first settlement, but few fragments remain.

A remnant of the once powerful *Penobscot* tribe is settled at Oldtown on the Penobscot river, in Maine, and in other parts of that State and in Massachusetts, and fragments of other tribes still exist.

The *Pequod* and *Mohegan* tribes were amongst the largest and most powerful. Their range was central Massachusetts and Connecticut. During the settlement of those States, these Indians were removed to western New York, where they rapidly became civilized and prosperous. But in 1857, their land being wanted, they were removed to Wisconsin, and placed on a poor reservation there. They now number barely one hundred men, women, and children.

The *Delawares*, when first discovered by the whites, were living on the banks of the Delaware river. Early in the 17th century the Dutch commenced trading with them, under friendly relations. Subsequently William Penn bought large tracts of land from them, moving the Indians inland. A war followed this purchase, the Delawares alleging they had been defrauded, but, with the assistance of the Six Nations, the whites forced them back west of the Alleghanies. In 1789 they were placed on a reservation in Ohio, and subsequently, in 1818, were moved to Missouri. Various removals followed, until, in 1866, they accepted lands in severalty, in the Indian Territory, and gave up the tribal relation. They are now living in civilized fashion, and have become useful and prosperous citizens. Their number is now between 1000 and 1100.

Iroquois, or *Six Nations*.—This powerful and celebrated confederation was composed originally of five tribes known as Mohawks, Oneidas, Onondagas, Senecas, and Cayugas. Later, the Tuscaroras were admitted into the league, which was then called the "Six Nations." At that time their total number was estimated at 11,650, including 2150 warriors. They were unquestionably the most powerful confederation of Indians on the continent. Their home was the central and western parts of New York State. In the war of the American Revolution they fought on the side of the English, and in the repeated battles their power was nearly destroyed. They are now scattered about on various reservations in New York State, Indian Territory, Wisconsin, and Canada. In 1870 they numbered altogether 13,669, having increased decidedly since the close of the Revolution.

The *Wyandots* or *Hurons* were an Iroquois tribe which lived originally on the shore of Lake Huron. They served as a shuttlecock between the Six Nations and the Sioux, being driven alternately east and west by them, until the end of the last century. In 1832 they removed to a reservation in Kansas. In 1855 many became citizens, while the small remaining fragment of this once powerful tribe removed to Indian Territory.

Chippewas or *Ojibways*.—This tribe, of the Algonquin family, formerly ranged over most of Michigan, Wisconsin, and Minnesota. They were constantly at war with the Dakotas and with their other neighbours. They sided with the English in the Revolution and in the war of 1812. At present the tribe is divided upon thirteen reservations in the above States, and is making gratifying progress in civilization. Their number is now above 20,000.

The *Menominees*, on the Menominee river, in Wisconsin, have never been moved from their original habitat. They served with the French in the war against the Foxes in 1712, and against the English up to 1763. During the Revolution and the war of 1812 they sided with the English. They are now living in a civilized manner, and are engaged very largely in lumbering. Their number is now about 1445, and is said to be diminishing rapidly.

The *Miamis* were first found in eastern Wisconsin, and were estimated at 8000 in number. They were a warlike race, continually engaged in broils with their neighbours, the Iroquois, Sioux, and French, in which they lost heavily. In the Revolution and the war of 1812, like most of the Indian tribes, they sided with the English. After the latter war they fought among themselves, reducing their numbers greatly. The tribe has now almost entirely disappeared, a few families only remaining, scattered over Indian Territory and Kansas.

The *Ottawas* lived originally on the northern shore of the upper peninsula of Michigan. In 1650 they were driven by the Iroquois beyond the Mississippi, only to be forced back by the Dakotas. Then they settled at Mackinaw, and joined the French in their operations against the English. During the Revolution they sided with the English. Most of them were finally moved to the Indian Territory, where they now are, reduced to a mere handful.

The *Pottawattamies* occupied a part of the lower peninsula of Michigan, whence they were driven into Wisconsin by the more powerful Iroquois. They were allied with the French in their wars against the Iroquois, and took part in Pontiac's conspiracy. In the wars between the colonists and the mother country they took the part of the latter. In 1838 most of them were removed to a reservation in Kansas. Of these the larger proportion have abandoned the tribal relation, and become citizens. Of the others, some are in Kansas, upwards of 300 are in Indian Territory, while the remainder are wanderers.

The *Seminoles* are a tribe of the Muskogee family; they originally inhabited the peninsula of Florida. About 1842, after a very disastrous war with the whites, lasting seven years, nearly all of them were removed to the Indian Territory, where they are now settled, are civilized, and are succeeding in the cultivation of the soil. They number about 2500.

The *Creeks* or *Muskogees* formed the most powerful tribe of the Muskogee family; they originally occupied a large part of Georgia, Alabama, and Florida. During the Revolution they fought against the colonists. A few years later they broke out again, but received a severe chastisement. Subsequently nearly all of them were removed to the Indian Territory, where they have made great progress in civilization and material prosperity. During the late civil war they were divided, part adhering to the Union and part joining the Confederacy. At present they number about 14,000.

The *Dakota* or *Sioux* nation is at present the most powerful of the Indian tribes in North America. Its warriors possess fine physique, great personal courage, and great skill in warfare. Though backward in adopting civilization, their intellectual powers contrast very favourably with those of most other tribes. The nation numbers 30,000 to 35,000 souls, divided into twenty-one bands or subtribes more or less independent of one another. At present they range over most of the unsettled portion of Dakota, eastern Montana, and north-eastern Wyoming, their reservations amounting altogether to 108,450 square miles. Until within a very recent period most of the bands of this tribe have resisted all efforts for civilizing them. At present, however, several of the bands are settling down to agricultural labour. Their history has, from the first, been one of war, their name a terror to their Indian neighbours as well as to the whites. Originally their range extended as far east as the State of Wisconsin, and thence west to the Rocky Mountains, its present limit. On the east they encountered the Chippewas, who at that time formed a powerful tribe, fully able to cope with them. By them the Sioux were driven back into Minnesota, after long continued warfare. In 1862 the bands inhabiting Minnesota fell upon the white settlers, and a terrible massacre ensued. The result of this was the removal of these bands from the State to Dakota, where they were placed upon reservations. The bands inhabiting the country farther west have been to a greater or less extent almost continually at war with the whites until 1877; and for many years the protection of the border settlements required the constant presence of large bodies of troops. In 1875 and 1876 the chief, Sitting Bull, at the head of a large body of warriors, maintained a successful resistance against all the troops which could be brought against him, and finally escaped across the boundary line into the British Possessions, with the bulk of his followers.

The *Arapahoes* originally ranged over the central portion of the plains between the Platte and Arkansas. This is a brave, warlike, predatory tribe. With the Sioux and Cheyennes, with whom they have ever been on terms of friendship, they have waged unremitting warfare upon the Utes. From time to time, also, the border settlements have received hostile attentions from them. The southern bands of the tribe have a large reservation in the western part of Indian Territory, while the northern bands have been placed on the reservation of the Shoshones in western Wyoming.

The *Cheyennes* are a tribe of the Algonquin family, which originally lived on the Cheyenne river, a branch of the Red River of the North, in Dakota. Driven westward by the Dakotas, they were found by early explorers at the eastern base of the Black Hills, in Dakota. Subsequently part of them moved south, and allied themselves with the Arapahoes. Within a few years they have all been collected on a reservation in the western part of the Indian Territory. Their whole history has been a series of wars against their red neighbours and the whites. They are a large, powerful, athletic race, mentally superior to most of the other tribes. Their occupations are war and hunting. Thus far they have made little or no progress in civilization. They number about 3600.

The *Arikarees, Gros Ventres*, and *Mandans* are three tribes which inhabit a permanent village at Fort Berthold, Dakota, on the Missouri. They have a partial civilization of their own, not acquired from intercourse with whites. They live in houses made of wood, covered and thatched with earth and straw. For sustenance they depend largely upon the produce of agricultural labour. Their total number is probably about 2000, the Arikarees being the largest tribe, and the Mandans the smallest. The Arikarees, Arikaras, or Rees, as the name is variously rendered, originally lived in the Platte valley, in Nebraska, with the Pawnees, to whom they are related. Within the present century they have made their way northward to their present location. The Mandans were first found living on the Missouri, at the mouth of Heart river, while the Gros Ventres, or Minnetarees, occupied three small villages at the mouth of Knife river. These three tribes were decimated by the small-pox in 1837, shortly after which event they joined together in one village at their present location.

The *Sacs* and *Foxes*, now one tribe, located in Indian Territory, were originally separate, living near Green Bay, Wisconsin. Driven on before the westward march of civilization, they moved first to Iowa, then to Missouri, and finally to their present location. A few still remain in Iowa, Nebraska, and Kansas.

The *Shawnees* or *Shawanoes*, supposed to have been primarily a part of the Kickapoo tribe, were first found in Wisconsin. Moving eastward, they came in contact with the Iroquois, by whom they were driven south into Tennessee. Thence they crossed the mountains into South Carolina, and spread northward as far as New York and southward to Florida. Subsequently they drifted northward, again came in contact with the Iroquois, and were driven over into Ohio. They joined in Pontiac's conspiracy, and during the Revolution fought under the English flag. After the latter war they commenced migrating westward, and finally accepted homes in Indian Territory, where they now are. In 1854 most of them abandoned tribal relations, and divided their lands in severalty. They are now in a civilized and prosperous condition.

The *Crows* or *Upsarokas* are a branch of the Dakota family occupying at present a large reservation in southern Montana, south and east of the Yellowstone river. Their original range included this reservation, and extended eastward and southward, while from their forays no part of the country for many hundreds of miles around was safe. A cowardly tribe, they have ever been noted as marauders and horse stealers. Though they have generally been crafty enough to avoid open war with the whites, they have not scrupled to rob them whenever opportunity offered. Physically they are tall and athletic, with very dark complexions. Their number is about 4200. They have made little if any progress in civilization, preferring to be supported by the Government.

The *Osages* were first found on the lower Missouri, whence they moved south to the Arkansas, and shortly after became allies of the French. After the usual succession of treaties and removals, they finally found themselves in Indian Territory, where they are now fast reaching a condition of self-support. They number about 2100 souls.

The *Kaw* or *Kansas* tribe was originally an offshoot from the Osages. Their original home was in Missouri, whence they were driven to Kansas by the Dakotas. They were moved from one reservation to another, until finally they were placed in Indian Territory, where they are rapidly becoming civilized. They numbered 360 souls in 1879.

The *Winnebagoes* are a branch of the Dakota family. At the time of the advent of the whites they formed the vanguard of the eastward migration of the Dakotas, and were living about Winnebago Lake and Green Bay in Wisconsin. They took up arms on the side of the French in the Franco-English wars, on the side of the English in the Revolution and the war of 1812. In 1820 they numbered about 4500, and inhabited their original home. A series of treaties followed, by which they were moved no less than six times, occupying reservations in various parts of Minnesota and Dakota. At present they are on the Omaha reservation in eastern Nebraska, and are prospering.

The *Otoes* and *Missouries*, which now form one tribe, under the former name, are a branch of the great Dakota family. They were early allies of the French. They now inhabit a small reservation in Nebraska, where they are making gratifying progress. They number but 457.

The *Omahas* were found on St Peter's river, in Minnesota, where they lived an agricultural life, supporting themselves from the soil. After a fatal visitation of the small-pox, which reduced their numbers terribly, they abandoned their village, and wandered westward to the Niobrara river in Nebraska. After a succession of treaties and removals, they are now located on a reservation in eastern Nebraska, where they are rapidly improving in civilization and pecuniary resources. They numbered 1100 in 1878.

The *Poncas* were originally part of the Omaha tribe, with whom they lived near the Red River of the North. They shared the common fate of the weaker tribes in this part of the country, being driven westward by the Dakotas. They halted on the Ponca river in Dakota, and there held their ground, but suffered severely from their hereditary enemies. After a succession of treaties and removals, they were placed on a reservation at the mouth of the Niobrara, where they took lands in severalty, and were prospering greatly, when they were forced to give up their lands and improvements and remove to Indian Territory. Naturally they were extremely dissatisfied with this change, and in 1878 a number of them left the reservation in Indian Territory and made their way back to the Omahas, their former neighbours. They were arrested for leaving the reservation, and were about to be returned to Indian Territory, when the case was taken up by able lawyers, and after a long trial the Indians were set free, it having been decided that they were United States citizens, and therefore not to be confined on reservations. The whole history of the Poncas is a tale of oppression by red men and white.

The *Pawnees* were formerly a brave, warlike tribe, living on the Platte river in Nebraska. Their history, until a recent date, is one of almost constant warfare with the Dakotas. In 1823 their village was burned by the Delawares, and shortly after the tribe lost heavily by the small-pox. In 1874 they moved to a reservation in Indian Territory, where they are making gratifying progress. They number 1440.

The *Caddos*, now located on a small reservation in Indian Territory, are but the remnant of a large tribe that formerly ranged over the Red River country, in Arkansas, northern Texas, and Indian Territory. They have well-managed farms, and are noted for industry and intelligence. Their number is 543.

The *Shoshones* or *Snakes* are a tribe inhabiting the country about the head of the Snake, Green, and Bighorn rivers, in Wyoming, Idaho, and northern Nevada, and distributed mainly on four reservations. They number about 6000. They are a mild, peaceful tribe, but until within a recent period have been involved in almost constant defensive warfare with their neighbours, the Crows and Blackfeet on the north, and the Cheyennes and Arapahoes on the south. The history of their relations with the whites has been one of almost unbroken peace.

The *Bannacks* are a small tribe of the Shoshone family, in the southern portion of Idaho. Their number is about 1000, divided between the Fort Hall and the Lemhi reservations. They have generally been friendly with the whites, although in 1866, and again in 1878, they broke out into hostilities. Very little progress has been made by the tribe.

The *Kiowas* are another tribe of the Shoshone family, a wild, roving people, ranging over the country about the Arkansas and Canadian rivers, in Indian Territory, Colorado, and New Mexico. Formerly their range was very much less restricted, extending from the Platte to the Rio Grande. They have the reputation of being brave warriors, but cruel and treacherous. In recent years they have made repeated raids upon the settlers in western Texas, which have been stopped by the imprisonment of their chief, Satanta. In 1869 they were placed on a reservation in the Indian Territory, which they appear to use only as headquarters for raids into the adjoining country. Their number is given as 1138, but this is undoubtedly too small.

The *Ute* or *Utah* tribe, which is composed of several bands, all acknowledging the authority of one head chief, inhabits reservations in the western part of Colorado and eastern Utah. They number about 4200. Averse to civilization, they have made little or no progress. They originally inhabited the whole mountain region of Colorado and northern New Mexico, whence they made inroads on the plains in pursuit of buffalo, and of their hereditary enemies the Sioux, the Cheyennes, and the Arapahoes. Their intercourse with the whites has been, almost without exception, characterized by friendship. The recent outbreak of the White River band, in 1879, is almost the only case on record. The rapid settlement of the State has driven them westward, and has deprived them of the fairest portion of their domain.

The *Apaches* are a branch of the Athabasca family which has wandered far from the parent region, and now range over large parts of New Mexico and Arizona. It is a powerful, warlike tribe, at war with the whites almost continually since the latter entered the country. A large part of the tribe is on the Fort Stanton reservation in eastern New Mexico, while another portion, under the chief Victoria, has for a long time been devastating the border settlements of New Mexico. The Tonto-Apaches, collected in large numbers on the San Carlos reservation in Arizona, where they are doing something at farming, are of Yuma stock. Besides these, there are several bands of Apaches scattered about on other reservations, or roaming without a fixed habitat, swelling the total to about 10,600 souls.

The *Navajoes* are another tribe of the Athabascan group which is far removed from the body of the family. They inhabit the northern part of Arizona and New Mexico, where they have a fine reservation. They have considerable native civilization, not a few of them engaging in agriculture, and in raising horses, sheep, and goats. They weave blankets, which are prized highly throughout the south-west. They are a fine athletic race, and excellent horsemen. While not an aggressive tribe, they have frequently been at war with the whites. They number now 11,850.

The *Nez Percés*, with the exception of a small portion in Indian Territory, inhabit a reservation in northern Idaho, which includes a part of their ancestral home. They are a fine race, physically and mentally. Until 1877 they had been at peace with the whites. In 1875, a portion of their reservation having been taken from them, owing to the alleged fact that they had not carried out the treaty stipulations, difficulties arose which, two years later, brought on a rupture, and the famous "Nez Percés" war. The disaffected portion of the tribe, numbering some 400 or 500, held out for several months against all the force the Government could bring against them, but were finally captured on the Sweet Grass Hills, in northern Montana. The malcontents were then placed on a reservation in the Indian Territory.

The *Modocs* are a small tribe, which lived in southern Oregon. They are known mainly from their stubborn resistance to the United States Government in 1872 and 1873, known as the Modoc war. This was caused by an attempt to place them upon a reservation. After some preliminary fighting, the Modocs retreated to the "Lava Beds," a basaltic region, seamed and crevassed, and abounding in caves. Here they made a stand for several months before they were finally subdued. During the war General Canby, commanding the troops, and Dr Thomas, a peace commissioner, were treacherously massacred by them while under a flag of truce. The leaders of this revolt were hanged, and the remainder removed to Indian Territory.

The *Pimas*, *Papagoes*, and *Maricopas* form a semi-civilized community, living on a reservation on the Gila and Santa Cruz rivers in Arizona. Originally they were distributed over the whole south-western portion of that territory. Missions were established among them at an early date by the Spanish Jesuits, and with very good success. At present they are mainly self-supporting, while a large proportion of them wear citizens' dress and live in houses. The three tribes now number 10,500.

Pacific Coast Indians.—The Indians upon and near the Pacific coast are divided into a great number of small tribes. Speaking generally, they are lower in the scale of humanity, both physically and mentally, than those of the interior. In northern California, Oregon, and Washington, their principal subsistence was, before the Government undertook their support, the salmon, which in spring crowded the rivers. They are mostly of a mild, peaceful disposition. The Indians of southern California were early taken in charge by the Jesuit missionaries, who Christianized and partly civilized them. Since the settlement of the State by Americans, they have, through neglect, to a large extent relapsed and become worthless members of society.

The name *Pueblo* (city) is used to designate a number of tribes of town-building Indians in New Mexico. They resemble one another very closely in their surroundings, and in their manners and customs; and their history has been the same. Subdued by Coronado in 1540, they made a successful revolt two years later, but were subdued again in 1586. In 1680 they made another unsuccessful revolt. When the country was ceded to the United States in 1848, these Indians were recognized as citizens, and have since remained so. Their houses are communal, generally but one structure for the whole village. They are sometimes built of stone, but oftener of adobe, several stories high, each story receding from the one below. The common plan is a hollow square, or curved figure, though in some cases the form of a pyramid is followed. Some of the towns are built upon high mesas, almost inaccessible, obviously for purposes of defence. These Indians retain their primitive form of government, each village electing a governor and council. They cultivate the soil, raising grain and vegetables for their own consumption, and keep large flocks of sheep and goats. Their number is about 9000.

The *Moquis* are a semi-civilized people living in seven towns on the plateau in northern Arizona. Our first accounts of them date from the expedition of Coronado in 1540. Their history is similar to that of the town-building Indians of New Mexico, except that after a successful revolt against the Spaniards, in 1680, they have remained independent. They are kind-hearted and hospitable, cultivate the soil, raising grain and vegetables, and possessing large flocks of sheep and goats. They weave very fine blankets, an art which they have taught several neighbouring tribes. The houses are built of stone, set in mortar, and for security are perched upon the summits of almost inaccessible mesas. The Moquis numbered 1780 in 1878.

INDIAN ANTIQUITIES.—The ancient remains of the Indians are coextensive with their occupancy of the country, but in general they teach but little concerning their life in prehistoric times. The Atlantic and Gulf coasts are lined with shell-heaps, indicating the sites of ancient villages. Spear or arrow heads are often ploughed up all over the country, relics, it may be, from some well-fought field.

At the copper mines on the northern peninsula of Michigan, there are many evidences that the Indians had been working. Excavations, some of considerable depth, have been found, and in them stone hammers, evidently used in extracting the native copper. Indeed, it is well known that this metal was a common article of commerce among them.

In the south-western territories, however, are found the most interesting remains of this people, in the form of towns, some of great magnitude and extent, built of stone set in mortar. These towns, which were evidently inhabited by a people closely resembling the Moquis and Pueblos, are found in south-western Colorado on the San Juan river and its branches, in north-western New Mexico, in south-eastern Utah, and over the greater part of Arizona. Certain regions appear to have been very densely populated. The largest towns are built in exposed situations, without special precautions for defence, and were plainly inhabited by a mild agricultural race, who were enjoying a period of peace. Others are perched upon high inaccessible mesas, with strong towers for defence and observation, while others, "cave dwellings," are merely walled-in niches in the cliffs of the cañons,—evidently the last refuge of a hunted, desperate people. Everywhere in the neighbourhood of these ruins are vast quantities of fragments of pottery, some of which is painted in the most elaborate designs. Wicker work and arrow and spear heads are also found in abundance. These extensive ruins, scattered over a large area of country, show that at some time in the past this region, now arid and desert, supported a large population of a degree of civilization fully equal to that of the Pueblos and Moquis of the present day, and in all probability their ancestors. (H. G.*)

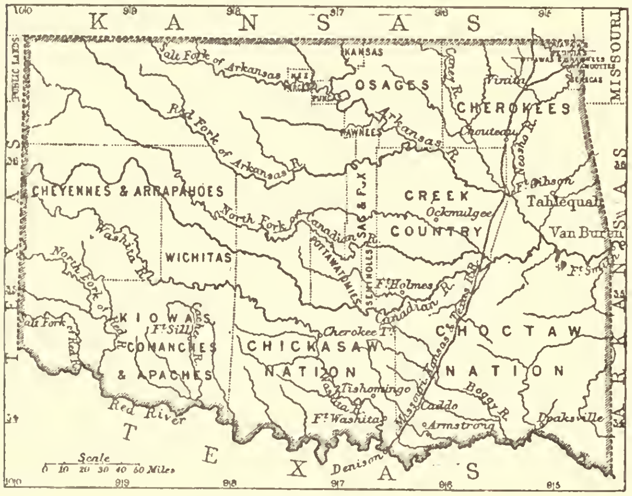
INDIAN TERRITORY

INDIAN TERRITORY is a tract of land in the southern central portion of the United States, which has been set apart as a reservation for the use of various tribes of Indians. It lies between the parallels of 33° and 37° N. lat. and the meridians of 17° and 23° W. long. of Washington (94° and 100° W. of Greenwich). It is bounded N. by Kansas, E. by Missouri and Arkansas, and S. and W. by Texas. The area is estimated approximately at 69,000 square miles. The eastern portion is fertile and well watered, having an annual rainfall of 40 to 50 inches, and a mean annual temperature of about 60° Fahr. The surface is mainly rolling prairie, with broad stretches of rich land along the streams, and an abundance of timber. This section of the territory is separated from the western part, which presents a different aspect, by a broad belt of forest, known as the "Cross Timbers," which extends nearly across the territory in a north and south direction, marking the outcrop of the Carboniferous formation. Its breadth ranges from 40 to 60 miles.

West of this singular strip of forest the country assumes the appearance of the "Great Plains,"—that long incline which stretches eastward from the base of the Rocky Mountains. The surface is a monotonous, rolling, treeless expanse. The valleys are shallow, and the dividing ridges are broad and slightly marked. The climate is comparatively dry, the average annual rainfall being but 20 to 25 inches; and irrigation is needed for the successful cultivation of most crops. The mean annual temperature is somewhat lower than in the east, while the contrast in this regard between summer and winter, day and night, becomes much more marked. Timber is found only in the river valleys, on the faces of bluffs, and among the hills.

The generally level surface of prairies and plains is broken in the southern and south-eastern parts of the territory by ranges and groups of hills, which rise from a few hundred to 1500 feet above the surrounding country. These hills, known as the San Bois Hills, Shawnee Hills, Wichita Mountains, &c., form a part of the Ozark Mountains, which extend eastward over into Missouri and Arkansas.

The principal rivers of the territory are the Arkansas with its branches, the Neosho, the Salt and Red Forks, and the Canadian, with its North Fork, and, in the southern part of the territory, the Red River, which forms the boundary with Texas, and its branch, the Washita. All these are of little or no importance as regards navigation. The eastern part of the territory is well watered, but the western part, except at times of flood, in late spring and early summer, has few flowing streams.



Map of Indian Territory.

The geology of the region is very imperfectly known, as no survey has been made, with the exception of two or three hasty reconnaissances. The general outline of the distribution of geological formations is as follows. The eastern third of the territory is occupied by the Carboniferous formation. In the south-eastern corner, near Red River, it is covered by the Cretaceous. In the eastern portion there are several outcrops of granite, marking the location of groups of the Ozark Hills. The western two-thirds of the territory are covered by Triassic and Jurassic beds, with the exception of the granite mass of the Wichita mountains. The mineral resources are almost totally unknown. It is highly probable that the territory contains extensive deposits of coal, and it is very possible that the precious metals may be found in the Ozark Hills.

The fauna and flora partake of the double character of the surface and climate. In the eastern part they tend toward subtropical types, while the western portion presents forms more or less peculiar to the arid plains. In the eastern part deer, and brown and black bears, are quite abundant, except in the neighbourhood of settlements; and wild turkeys are plentiful. In the western part antelopes and bison are the principal large game; wild horses are still occasionally met with; and various species of grouse, sage hens, owls, rattlesnakes, gophers, and prairie dogs are abundant. The vegetation of the eastern part is profuse, especially in the bottom lands. The forests present a great variety of species very similar to those found throughout the lower Mississippi valley; among them are several species of oak and pine, cypress, red cedar, black walnut, gum tree, &c. Among the wild fruits, which also present much variety, are plums, persimmons, grapes, &c. On the plains of the western part of the territory the principal natural productions are the grasses which, growing in tufts or bunches, are known collectively as bunch or buffalo grass. While this is the prevailing growth, in the more desert localities its place is usurped more or less by artemisia, cactus, and yucca.

Inhabitants.—Besides the Indians who originally inhabited this territory, the United States Government has from time to time moved thither entire tribes or parts of tribes, from more or less distant portions of the country, assigning to each tribe a definite area or "reservation." The immigrants now outnumber very largely the original occupants of the soil. The reservation is, to a certain extent, a prison-house. An Indian is not allowed to leave it without a pass from the agent; nor are whites allowed to settle on it, or even to visit it. Exception is made, however, in the case of white men who marry Indian women. In the case of most of the tribes, the Government holds in trust funds belonging to them derived from the sale of their original land. The income from these funds is paid in the form of subsistence and clothing, live stock, and tools. An agent is appointed for each tribe or group of tribes, for the purpose of regulating its relations with the Government, and of providing and issuing these supplies. With few exceptions, the Indians still retain the tribal organization, although, with their progress in civilization, their forms of self-government have undergone some changes. The five civilized tribes have, besides the principal and the subordinate chiefs, a council, which corresponds in many respects to the legislature of a State. They also have simple codes of laws, and courts to enforce them. The territory has no representation in the national government. For the enforcement of United States laws it is attached to the western judicial district of Arkansas.

It is difficult to obtain correct estimates of the number of Indians in the territory, as many of them lead a wandering life. No accurate census has been taken, and the only data available are the estimates made by the Indian agents. The report of Indian affairs for 1879 contains the estimates given in the following table, which also shows the areas of the different reservations:—

Tribes.	Pop.	Area, sq. miles.	Tribes.	Pop.	Area, sq. miles.
Cheyenne	3593	6715 (Cheyenne and Arapahoe)	Peoria, Miami	184	78
Arapahoe	1903				
Kiowa	1138	5800 (Kiowa, Comanche, Apache, Wichita)	Modoc	99	6
Comanche	1552		Wyandot	260	33
Apache	315		Ottawa	140	23
Wichita	209		Seneca	235	82
Kaw	360	2447 (Kaw, Osage, Quapaw)	Shawnee	800	20
Osage	2135		Sac and Fox	573	750
Quapaw	188		Kickapoo	390	...
Pawnee	1440	442	Pottawattamie	325	900
Ponca	530	301 (Ponca and Nez Percé)			
Nez Percé	370		Cherokee	20,000	7861
Waco	49	...	Creek	14,500	5025
Towaconie	155	...	Choctaw	16,500	10,450
Keechie	75	...	Chickasaw	7000	7267
Caddo	543	...	Seminole	2500	312
Delaware	81	...			

The total number, according to these estimates, is 78,142. The white population living in the territory is very small, consisting almost exclusively of the agents and their dependants, the garrisons at a few military posts, and the employees of the Missouri, Kansas, and Texas Railway, which crosses the eastern portion of the territory.

Several of the tribes, notably the Cherokees, Creeks, Choctaws, Chickasaws, and Seminoles, have made considerable advance in civilization. All the members of the above tribes wear the ordinary dress, live in houses, and are engaged in civilized pursuits. Their occupations are almost entirely farming and stock-raising, principally the former. They support schools, which are attended by a large proportion of the children of the tribes.

The following tables, taken from the report on Indian affairs for 1879, illustrate the progress made by these five tribes:—

	Population.	Number of houses occupied.	Number attending school.	Amount spent on education, 1879.	Number who can read.
Cherokees	20,000	4800	3200	74,000	16,000
Choctaws	16,500	4500	1400	30,000	11,000
Creeks	14,500	4300	800	28,356	3,500
Chickasaws	7,000	1900	650	22,000	2,600
Seminoles	2,500	750	200	2,500	550

Agricultural Products in 1879.

	Acres cultivated.	Wheat, bushels.	Oats and Barley, bushels.	Indian Corn, bushels.	Vegetables, bushels.	Hay, tons.
Cherokees	80,000	350,000	125,000	700,000	150,000	60,000
Choctaws	90,000	140,000	35,000	600,000	85,000	50,000
Creeks	60,000	65,000	20,000	95,000	60,000	50,000
Chickasaws	30,000	10,000	20,000	420,000	40,000	15,000
Seminoles	13,000	400	500	200,000	1,700	1,500

In 1878 there were 263,000 acres in the territory under cultivation by Indian labour; 503,000 bushels of wheat were produced, 3,038,000 of Indian corn, 220,000 of oats and barley, 339,000 of vegetables, and 120,000 tons of hay. The live stock consisted of 59,200 horses, 249,000 cattle, 189,400 swine, and 22,500 sheep.

The population of the five civilized tribes is almost entirely rural. There are no large towns. The principal settlements are Tahlequah, the capital of the Cherokee nation; Caddo in the Choctaw, Muscogee in the Creek, and Tishomingo in the Chickasaw country; and Vinita, a railroad town on the Missouri, Kansas, and Texas line. (H. G.*)

INDIA-RUBBER, or CAOUTCHOUC, consists of the dried coagulated milky juice of various trees and shrubs, belonging chiefly to the natural orders *Euphorbiaceæ*, *Moraceæ*, *Artocarpaceæ*, and *Apocynaceæ*. Although a milky juice is found in plants of many other families, it does not in all cases yield caoutchouc, nor do different species of the same genus yield an equal quantity or quality of that substance. On the other hand, there are many plants which afford a good rubber, but have not yet been sought out for commercial purposes. The milky juice of plants furnishing caoutchouc is contained chiefly in the middle layer of the bark, in a network of minute tubes known to botanists as laticiferous vessels. In the *Apocynaceæ* these vessels are found also in the inner bark, or bast layer. The milky juice above mentioned possesses the properties of a vegetable emulsion, the caoutchouc being suspended in it in the form of minute transparent globules, averaging, according to Adriani, $\frac{1}{12250}$ inch in diameter. Like other emulsions, it is easily coagulated by the addition of an acid or saline solution,—alum or salt water being commonly used for this purpose; but it is said by Mr Bruce Warren not to be coagulated by alcohol. The caoutchouc appears to be kept in suspension in the juice by means of ammonia; at least in some cases the fresh milk exhales an ammoniacal odour. Probably it is on this account that the addition of liquid ammonia prevents the juice from coagulating for a considerable length of time; and the ammonia is in certain districts added when the milk has to be carried some distance from the place of collection. The addition of salt water to the juice is to be deprecated, as it renders the caoutchouc very hygroscopic. The best rubber known is obtained by careful evaporation of the recently strained juice at a moderate heat. Trees are known to contain caoutchouc by the bark on incision yielding a milk that when rubbed between the fingers coagulates into an elastic fibre. The dried bark of such plants when broken shows between the two fractured surfaces of bark a number of silky fibres which can be stretched for some distance without breaking.

Caoutchouc differs from other vegetable products of like origin by possessing considerable elasticity, by being insoluble in water or alcohol, alkalies, and acids (with the exception of concentrated nitric and sulphuric acids). Although apparently simple in constitution, it contains, not only the elastic substance to which its commercial value is due, but a small quantity of an oxidized viscid resinous body soluble in alcohol. This latter substance varies in quantity in different kinds of rubber, those containing the smallest amount, such as the Pará and Ceara, being considered the most valuable, while those in which it is present in greatest proportion, such as the Guatemala and African rubbers, are the least esteemed. Rapid evaporation of the juice, or any means which prevents oxidation, tends to prevent the formation of this viscid resin.

The first notice of india-rubber on record was given nearly five hundred years ago by Herrera, who, in the second voyage of Columbus, observed that the inhabitants of Hayti played a game with balls made "of the gum of a tree," and that the balls, although large, were lighter and bounced better than the wind-balls of Castile (Herrera, *Historia*, dec. i. lib. iii. cap. iv.). Torquemada, however, seems to have been the first to mention by name the tree yielding it. In his *De la Monarquia Indiana*, published at Madrid in 1615, tom. ii., cap. xliii. p. 663, he says, "There is a tree which the [Mexican] Indians call Ulequahuitl; it is held in great estimation and grows in the hot country. It is not a very high tree; the leaves are round and of an ashy colour. This tree yields a white milky substance, thick and gummy, and in great abundance." He further states that the juice was collected and allowed to settle in calabashes, and was afterwards softened in hot water, or the juice smeared over the body and rubbed off when sufficiently dry. The tree mentioned byTorquemada has usually been identified as *Castilloa elastica*, Cerv., but the above account cannot apply to it, as that tree is described by Cervantes as one of the loftiest forest trees of the north-east coast of Mexico, and its leaves are not round but oblong-lanceolate. Torquemada mentions also that an oil was extracted from the "ulli," or rubber, by heat, possessing soft and lubricous properties, and of especial effect in removing tightness of the chest. It was also drunk with cocoa to stop hæmorrhage. Even at that early date the Spaniards used the juice of the ulé tree to waterproof their cloaks. This fact, however, apparently did not attract attention in the Old World, and no rubber seems to have reached Europe until long afterwards. The first accurate information concerning any of the caoutchouc trees was furnished by La Condamine, who was sent in 1735 by the French Government to measure an arc of the meridian near Quito.

In 1751 the researches of M. Fresnau, an engineer residing in Guiana, were published by the French Academy, and in 1755 M. Aublet described the species yielding caoutchouc in French Guiana. Nevertheless india-rubber remained for some time unknown in England except as a curiosity, for Dr Priestley, in the preface to his work on perspective, called public attention to it as a novelty for erasing pencil marks, and states that it was sold in cubical pieces of $\frac{1}{2}$ inch for 3s. each. India-rubber was not known as a product of Asia until 1798, when a plant, afterwards named *Urceola elastica*, Roxb., was discovered to yield it by Mr J. Howison, a surgeon of Prince of Wales Island, and soon afterwards Assam rubber was traced by Dr Roxburgh to *Ficus elastica*, Roxb. It was not, however, until the beginning of the 18th century that the india-rubber industry really commenced. The rapid progress which this has made during the last twenty years may be perceived by a glance at the following table :—

Imported into England in the year			1830,	464 cwts.
,,	,,	,,	1840,	6,640 ,,
,,	,,	,,	1850,	7,616 ,,
,,	,,	,,	1870,	152,118 ,,
,,	,,	,,	1879,	150,601 ,,

It has been computed that in 1870 there were in Europe and America more than 150 manufactories, each employing from 400 to 500 operatives, and consuming more than 10,000,000 ℔ of caoutchouc. The imports into the United States have largely increased during the last few years.

Botanical Sources, Modes of Preparation, &c.

Notwithstanding the fact that caoutchouc-yielding trees are found in a large belt of countries around the globe, including at least 500 miles on each side of the equator, yet the demand for the best qualities of india-rubber is in excess of the supply. The varieties which are almost exclusively used when great elasticity and durability are required are the Pará, Ceara, and Madagascar rubbers.

The principal forms of caoutchouc which are imported into Great Britain may be grouped under four heads, the order in which they are here placed indicating their respective values :—*South American*—Pará, Ceara, Pernambuco, Maranhão, Cartagena, Guayaquil; *Central American*—West Indian, Guatemala; *African*—Madagascar, Mozambique, West African; *Asiatic*—Assam, Borneo, Rangoon, Singapore, Penang, and Java. Of all these, the most important is the Pará, the imports of which, according to Messrs Hecht, Levis, & Kahn, have increased from 1670 tons in 1857 to 8000 tons in 1879. For this rubber and the Mozambique variety the demand increases every year,—an unerring indication of their value.

FIG. 1.—*Hevea brasiliensis.*

I. SOUTH AMERICAN.—*Pará rubber* is obtained chiefly from *Hevea brasiliensis*, Müll. Arg., a large euphorbiaceous tree upwards of [illegible] in height, branching from the base, and having trifoliate leaves, the leaflets being lanceolate and tapering at both ends (figs. 1, 2). Other species of *Hevea*, as well as *Micrandra siphonoides* and *M. minor*, Benth., all of which grow abundantly in the moist steamy valleys of the Amazon and its tributaries, are also used indiscriminately by the natives to furnish Pará rubber. These trees are found in different districts, but all flourish best on rich alluvial clay slopes by the side of rivers, where there is a certain amount of drainage, and the temperature reaches from 89° to 94° at noon and is never cooler than 73° at night, while rain is rarely absent for ten days together. The genus *Hevea* was formerly called *Siphonia*, and the tree named Pao de Xerringa by the Portuguese, from the use by the Omaqua Indians of squirts or syringes made from a piece of pipe inserted in a hollow flask-shaped ball of rubber.

The caoutchouc is collected in the so-called dry season between August and February. The trees are tapped in the evening, and the juice is collected on the following morning. To obtain the juice a deep horizontal incision is made near the base of the tree, and then from it a vertical one, extending up the trunk, with others at short distances in an oblique direction. Small shallow cups made from the clayey soil and dried in the sun are placed below the incisions to receive the milk, each cup being attached by sticking a piece of soft clay to the tree and pressing the cup against it. The juice, of which each tree yields only about 6 ounces in three days, has a strong ammoniacal odour, which rapidly goes off, and in consequence of the loss of ammonia it will not keep longer than a day unchanged, hence when it has to be carried to a distance from the place of collection 3 per cent of liquid ammonia is added. The juice is said by Bruce Warren to yield half its weight of caoutchouc, but 32 per cent. appears to be the usual quantity. To obtain the rubber the juice is heated in the following manner. A piece of wood about 3 feet long, with a flattened clay mould at one end of it, is dipped in the milk, or this is poured over it as evenly as possible. The milk is then carefully dried by turning the mould round and round in a white vapour obtained by heating certain oily palm nuts, those of *Attalea excelsa* being much preferred, and the vapour being confined within certain limits by the narrowness of the neck of the pot in which the nuts are heated. Each layer of rubber is allowed to become firm before adding another; a practised hand can make 5 or 6 ℔ in an hour. From whatever cause, the rubber thus prepared is the finest that can be obtained. The cakes when completed are, in order to remove them from the mould, slit open with a sharp knife, which is kept wet, and are hung up to dry. The flat rounded cakes of rubber made in this manner are known in the London market as "biscuits." They rarely contain more than 15 per cent. of moisture. The scrapings from the tree, which contain fragments of wood, are mixed with the residues of the collecting pots and the refuse of the vessels employed, and are made up into large rounded balls, which form the inferior commercial quality called "negrohead," and often contain 25 to 35 per cent. of impurity. An intermediate quality is known as "entrefine." Pará rubber is said to be sometimes adulterated with the juice of the Maçandaruba tree (*Mimusops elata*), which might account for the great differences that have been occasionally observed in the behaviour of Pará rubber in certain stages of manufacture, the coagulated juice of the *Mimusops* genus resembling gutta percha rather than caoutchouc.

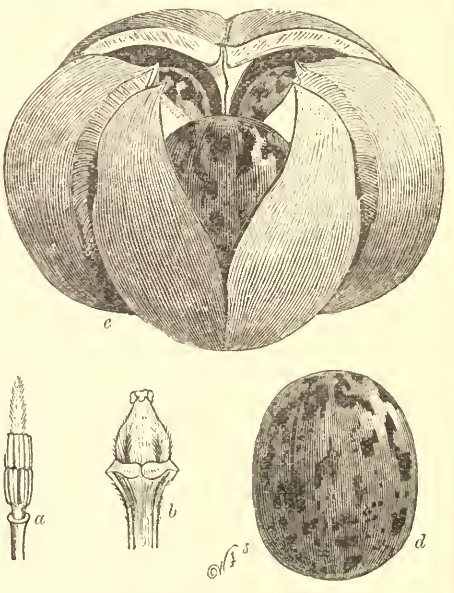


FIG. 2.—*Hevea brasiliensis.* *a*, male flower, and *b*, female flower (both enlarged, and with the floral envelope removed); *c*, ripe fruit, and *d*, seed (both natural size).

Previous to 1860 Pará rubber was exported only in small quantities, and then chiefly in the form of shoes; this variety ceased to be sent over in 1852. Occasionally "negrohead" has been imported in grotesque forms of animals, &c., and the better qualities in the shape of small bottles moulded in soft clay which has been afterwards washed out by water.

In British Guiana rubber is obtained from *Hevea paucifolia*, Müll. Arg.; in French Guiana from *H. Guayanensis*, Aubl., where it is known as "heve," "siringa," or "cahoutchou,"—the last being the probable origin of the name caoutchouc; and in Venezuela from *H. brasiliensis*, there called dápi or dápiche. None is exported to England from any of these localities. Small quantities of rubber intermediate in character between that of Pará and Pernambuco are occasionally imported from Maranhão. On account of its great value as a source of caoutchouc, the cultivation of the Pará rubber tree has been attempted in India; but it has been found to be too tropical a plant for cultivation in northern and central India, although suitable for Ceylon, Malabar, and South Burmah, according to recent reports. The seeds, which are about the size of a damson (fig. 2, *d*), soon lose their vitality, and cuttings do not thrive unless taken from the young wood.

Ceara rubber is considered almost next to the Pará in value, as it is a "dry" rubber, very elastic and free from stickiness; but it often contains a quantity of wood and foreign matter arising from the mode of collecting it, the loss in washing previous to manufacture amounting sometimes to 25 per cent. It is the produce of *Manihot Glaziovii*, Müll. Arg., a euphorbiaceous tree common in the province of Rio Janeiro, about 30 feet high, with a rounded head of foliage, and greyish-green 3- to 7-lobed palmate leaves, somewhat resembling the leaves of the castor-oil plant in shape and size (figs. 3, 4, 5). The trees are tapped, according to Mr R. Cross, when the trunk attains a diameter of 4 to 5 inches, *i.e.*, when they are about two years old. The mode of collecting the rubber is as follows. After brushing away the loose stones and dirt from the root of the tree by means of a handful of twigs, the collector lays down large leaves for the milk to drop upon. He then slices off the outer layer of the bark to the height of 4 or 5 feet. The milk, which exudes in many tortuous courses, some of it ultimately falling on the ground, is allowed to remain on the tree for several days, until it becomes dry and solid, when it is pulled off in strings, which are either rolled up into balls or put into bags in loose masses, in which form it enters commerce under the name of Ceara "scrap." The amount of Ceara rubber imported in 1879 amounted to 500 cwt. The attempts which have been recently made to cultivate this rubber plant in India have been attended with signal success. In Rio Janeiro it grows in a rocky or stony arid region, where a short underscrub is the only vegetation, and the atmosphere is hot and dry, the temperature ranging from 82° to 90° Fahr. It is, therefore, suited for cultivation where the *Hevea* will not grow. In Ceylon it has been found to thrive at an altitude of from 200 feet to 3000 feet above the sea level. At Zanzibar and Calcutta also it succeeds well. The seeds (fig. 5, *c*), which have a hard thick coat, take a year in germinating, unless the edges near the end bearing the caruncular projection are rasped off. Cuttings, provided they have a single bud, strike readily.

FIG. 3.—*Manihot Glaziovii.* (After H. Trimen, *Journ. Bot.*, Nov. 1880.)

Pernambuco or *Mangabeira rubber* is obtained from *Hancornia speciosa*, Gom., an apocynaceous tree common on the South American plateau in Brazil from Pernambuco to Rio Janeiro, at a height of 3000 to 5000 feet above the sea. It is about the size of an ordinary apple tree, with small leaves like the willow, and a drooping habit like a weeping birch, and has an edible fruit called "mangaba," for which, rather than for the rubber, the tree is cultivated in some districts. Only a small quantity of this rubber comes to England, and it is not much valued, being a "wet" rubber. It occurs in "biscuits" or "sheets." The caoutchouc is collected in the following manner. About eight oblique cuts are made all round the trunk, but only through the bark, and a tin cup is fastened at the bottom of each incision by means of a piece of soft clay. The cups when full are poured into a larger vessel, and solution of alum is added to coagulate the juice. In two or three minutes coagulation takes place, and the rubber is then exposed to the air on sticks, and allowed to drain for eight days. About thirty days afterwards it is sent to market. Pernambuco rubber, as is the case with most rubbers coagulated by saline solutions, contains a large quantity of water.

FIG. 4.—*Manihot Glaziovii.* Young leaf (half natural size); inflorescence (about half natural size); half-ripe capsule (real size).

Cartagena rubber comes from New Granada in the form of black sheets ¾ inch thick, having a somewhat rough or "chewed" appearance, and is more or less "tarry" or sticky. It also occurs in the form of strips or small pieces pressed together in bags. Its botanical source is not known, but is thought to be a pinnate-leaved tree, a portion at least being derived, it is supposed, from *Castilloa elastica*. It loses 35 per cent. of moisture when dried. The importation of Cartagena rubber into Great Britain has declined from 3518 cwts. in 1875 to 1679 cwts. in 1879.

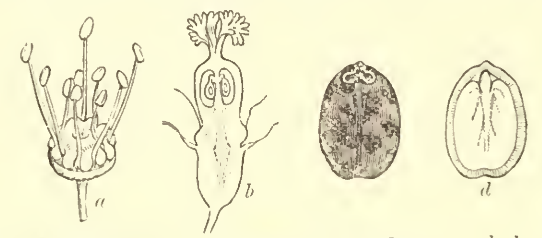


FIG. 5.—*Manihot Glaziovii.* *a*, male flower; *b*, female flower; *c*, seed; *d*, section of seed. (All natural size.)

Guayaquil rubber is imported from Ecuador in large flakes or lumps, of a whitish colour in the best kinds, the inferior sorts being porous and filled with a fœtid black liquid, having an odour of cow-dung, and staining the knife and hands. It is believed to be obtained from *Castilloa elastica*. The amount imported into Britain has diminished from 3815 cwts. in 1875 to 482 cwts. in 1879. In washing for manufacture it sometimes loses up to 40 per cent. of its weight. The bulk of the two last-mentioned rubbers is exported to the United States.

II. CENTRAL AMERICAN.—The source of all the principal rubbers exported from Central America is *Castilloa elastica*, Cerv., a lofty artocarpaceous tree, with a trunk 3 feet or more in diameter, and large hairy oblong lanceolate leaves often 18 inches long and 7 inches wide, those subtending the young branches being much smaller and more ovate (fig. 6). The tree grows most abundantly in a sporadic manner in the dense moist forests of the basin of the Rio San Juan, where the rain falls for nine months in the year. It prefers rich fertile soil on the banks of watercourses, but does not flourish in swamps. It is found also in Costa Rica, Guatemala, Honduras, Mexico, Cuba, and Hayti, and in Panama in company with another species, *C. Markhamiana*, Collins, and on the west coast of South America down to the slopes of Chimborazo, the Cordilleras of the Andes separating the *Castilloæ* from the *Heveæ* of Brazil, according to Mr R. Spruce.

Nicaragua rubber.—In Nicaragua the juice is collected in April, when the old leaves begin to fall and the new ones are appearing, during which time the milk is richest. The tree is tapped either in the same manner as the *Hevea*, or by encircling the tree with a simple

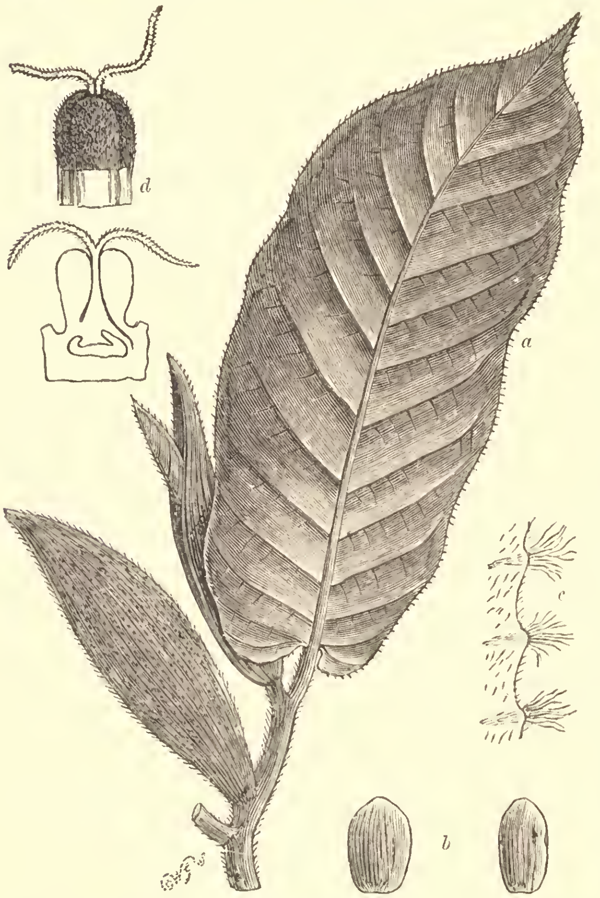


FIG. 6.—*Castilloa elastica.* *a*, young leaf (quarter real size); *b*, seeds (natural size); *c*, margin of leaf (enlarged); *d*, female flower and section of it (enlarged).

spiral cut at an inclination of 45°, or by two spirals in opposite directions if the tree be large. At the bottom of the spiral an iron spout about 4 inches long is driven into the tree, and the milk is received in iron pails. A tree 20 to 30 feet high to its first branches, and about 4 feet in diameter, is expected to yield 20 gallons of milk, each gallon giving about 2 lb of rubber. In the evening the milk is strained through a wire sieve and transferred to barrels. The milk is coagulated by the addition of the juice of the "acheté" plant (*Ipomœa bona-nox*, L.) or of another plant called "coasso." The strained juice of either of these plants, obtained by bruising the moistened herb and subsequent expression, is added to the milk in the proportion of about 1 pint to the gallon. If these plants are not procurable, two parts of water are added to one of the milk, and the mixture allowed to stand for twelve hours. The coagulum is next flattened out by a wooden or iron roller to get rid of the cavities containing watery liquid, and the sheets are then hung up for fourteen days to dry, when they weigh about 2 lb, the sheets being usually ½ to ¼th inch thick and 20 inches in diameter. When coagulated by water, the mass is placed in vats in the ground and allowed to dry, this taking place in about a fortnight. It is then rolled into balls. That which dries on the incisions in the tree is called bola or burucha, and is said to be highly prized in New York. The loss of Nicaragua rubber in drying is estimated at 15 per cent. It is exported chiefly from San Juan del Norte, or Grey Town, and the larger proportion goes to the United States. The *Castilloa* appears to be suitable for cultivation only in districts where the Pará rubber would grow equally well. The deciduous lateral shoots if planted will never grow erect.

West Indian rubber is the variety usually imported into England, but in comparatively small quantity only. It occurs in the form of blocks, the finest quality consisting of thin separable sheets, and the second of "scraps," usually conglomerated and containing fragments of bark. It is the best description of Central American rubber known. It is not, as its name seems to imply, produced in the West Indies, but derives its appellation from being brought over in West Indian steamers.

Honduras rubber rarely comes over to England; it is of good quality, and free from "tarry" matter.

Mexican rubber is imported into Liverpool in small quantity only. The imports of Mexican caoutchouc decreased from 1292 cwts. in 1875 to 158 cwts. in 1879.

Guatemala rubber is a very inferior kind and very unequal in quality; the best varieties are whitish, and the "lower" are black with a "tarry" appearance. It occurs in the form of sheets compacted together, from between which when pressed a thick resinous fluid exudes. This when evaporated leaves a hard resinous substance unaffected by hot water or steam. The rubber is collected from the trees as in Nicaragua, but it is poured on mats to dry, and the thin sheets are subsequently peeled off, folded into squares, and subjected to pressure to remove as much as possible of the contained moisture. The imports of india-rubber into England from the whole of Central America amounted only to 2080 cwts. in 1879, having decreased from 5809 cwts. in 1875. The greater proportion of Central American rubber is exported to New York, especially that from Nicaragua and Panama.

Siphocampylus Caoutchouc, Don., and *S. Jamesonianus*, D. C., Central American plants belonging to the natural order *Lobeliaceæ*, are also stated to yield rubber of good quality; and at the Philadelphia exhibition a rubber called Durango caoutchouc, obtained from a composite plant, was exhibited.

III. AFRICAN.—India-rubber is produced throughout equatorial Africa, the chief districts of export being the Gaboon, Congo, and Benguela on the west coast, and Madagascar, Mozambique, and Mauritius on the east. The Madagascar, Mauritius, and Gaboon rubbers are, it is believed, chiefly exported to France. Those which enter into British commerce are known as Mozambique, Madagascar, and African, although the imports are described as coming from the following districts in the blue books:—Senegambia and Sierra Leone 3808 cwts., West Coast 11,307 cwts., East Africa 7621 cwts., Cape of Good Hope 4241 cwts., Mauritius 570 cwts., Gold Coast 12 cwts. The above imports, which are for 1879, show an increase during the past five years, except in the case of Mauritius, Madagascar, and the Gold Coast. Africa, in respect of the large amount exported, may now be considered as taking the second place as an india-rubber producing continent.

Mozambique rubber, which is one of the most important varieties, occurs in the form of balls about the size of an orange, and "sausages," or spindle-shaped pieces, made up of slender strings of rubber wound around a piece of wood, which is eventually removed; or sometimes it occurs in smooth pieces of irregular size known as "cake" or "liver." *Madagascar rubber* consists of two qualities, the best of a pink and the inferior or "lower" of a black colour, and occurs in shapeless pieces.

The other kinds included under the general name of African are amorphous lumps called "knuckles" from Congo; small "negroheads" or "balls" of scrap, and smooth cakes from Sierra Leone; small square pieces like dice called "thimbles," and others more irregular in shape called "nuts," and "small negroheads" from the Portuguese colonies; "tongues," consisting of flat pieces, usually wet and sticky, from the Gaboon; and "balls" from Liberia African rubber as a rule possesses more adhesiveness and less elasticity than Pará rubber, and is inferior in value. Comparatively little is known of the plants yielding caoutchouc in Africa or of the mode of collection. In Angola, according to Dr Welwitsch, the natives either cut off a piece of bark, and allow the milky juice to run into a hole in the ground, or placing the hand against the trunk of the tree permit the milk to trickle down their arms, going from tree to tree until the arm is covered, when the rubber is rolled back towards the hand in the form of a ring. The wood of some of the trees, according to Mr Collins, contains a gum which, if the incision penetrates below the bark, mixes with the rubber and deteriorates it. In Madagascar, according to M. Coignet, rubber is obtained from the "Voà-héré" or "Voà-canja," *Vahea madagascariensis*, Boj., the "Voà-hiné, *V. comorensis*, Boj., and from *V. gummifera*, Lam. In Senegambia it is obtained from the "Anjouan," *Vahea senegalensis*, A. D. C. In Mauritius *Willughbeia edulis*, Roxb. (which is found also in Madagascar, and in Chittagong and Silhet in India), appears to be the chief source of rubber. All the above are climbing shrubs with opposite entire leaves and fleshy fruits.

In Central Africa, from Liberia on the one side to Zanzibar or the other, caoutchouc is collected from plants of genera nearly allied to *Vahea*, a few only of the species being known to botanists. In Angola, under the name of "Licomgue," in Golungo Alto and Cazengo, it is collected from *Landolphia owariensis*, Pal. de Beauv.; from *L. florida*, Benth., in Angola and Liberia, and from *L. Heudelotii*, D. C., in Senegal. At Kew there also exists a specimen of india-rubber from the west coast of Africa obtained from an undescribed species of *Carpodinus* with hairy leaves and stems. In the basin of the Gaboon and Congo it is obtained, according to Du Chaillu, from a climbing plant called *N'dambo*, which gives its name to dambonite, a peculiar substance contained in this kind of rubber (see p. 840). That some African caoutchouc is yielded by species of *Ficus* there can be no doubt. In Sierra Leone it is collected from *Ficus Brasii*, R. Br. In Liberia, according to Mr Thomas Christy, the finest rubber is obtained from *Urostigma Vogelii*, Miq., a tall tree with large handsome leaves, and lower qualities of rubber from other species, and from *Landolphia florida*, Benth. In Angola on the west, and at Inhambane on the east coast, rubber is also obtained from species of *Ficus*. In the island of Réunion caoutchouc is said to be obtained from *Periploca græca*, L.

IV. Asiatic.—The rubbers which enter English commerce from Asia include the Assam, Borneo, Rangoon, Singapore, Penang, and Java kinds.

Assam rubber is imported chiefly from Calcutta in baskets made of split rattans, weighing about 3 cwt. each, and covered with a gunny bag. The rubber is glossy, of a bright pink colour and mottled appearance, and occurs in the form either of small balls pressed together or of irregular masses called "slabs" or "loaf" rubber. The former, being more liable to adulteration, are less in demand by manufacturers. The imports into Liverpool in 1879 were 7000 cwts. Assam rubber is obtained from *Ficus elastica*, Roxb., a plant too well known as a window ornament to need description. A portion also is collected from *Urostigma laccifera*, Miq. *Ficus elastica* grows in the tropical rocky valleys of the Himalayas, between 70° and 80° E. long., where there is always a hot moist atmosphere, the temperature rising to 98° F. in the shade. The trees are tapped in the most careless manner. In the lower portion of the tree and in the large aerial roots, diagonal cuts penetrating to the wood are made, from 6 to 18 inches long, and in an elliptical form so as to be about 3 inches across the centre. The milk is received either in holes made in the ground or in leaves folded in the form of a funnel, that from the smaller cuts on the branches (for the collectors scarify every portion within reach) being allowed to dry on the tree. About 50 oz. of the milk collected in August gives 15 oz. of caoutchouc, but the percentage sometimes falls as low as 10 per cent. From February to April the milk is more scanty, but richer in caoutchouc, and is consequently best collected at that time. The milk is coagulated by pouring it into boiling water and stirring it until it is sufficiently firm to be carried about without being clammy; sometimes it is pressed, again boiled, and dried in the sun. In this way the "loaf" rubber in irregular masses is formed. The small "balls" are formed of the strings of rubber which have been allowed to dry on the tree.

Assam rubber, although fairly elastic, is much depreciated in value by the careless mode of collection, and often loses, by washing at the manufactory, as much as 35 per cent. of dirt, consisting of clay, sand, or bark. The exportation of caoutchouc from British India, exclusive of the Straits Settlements and Ceylon, in 1879 amounted to 9973 cwts., of which 7000 are estimated to have been produced in Assam. About three-fourths of the rubber exported from India goes to Great Britain, and the remainder to the United States.

In consequence of the reckless destruction of the trees, the cultivation of *Ficus elastica* has been commenced in Assam. It is calculated that the trees can be tapped at the age of twenty-five years, and that after fifty years they will yield 40 lb of caoutchouc each (worth £3, 4s.) every three years, it being injurious to their health to tap them more frequently.

Falay rubber is the product of *Cryptostegia grandiflora*, R. Br., an asclepiadaceous plant common on the coast of India; and from *Willughbeia edulis*, Roxb., and *W. martabanica*, D. C., a rubber is obtained in Chittagong; neither of these, however, is known in Britain as a commercial variety.

Borneo rubber comes to the Liverpool market in the form of balls or shapeless masses, internally of a white or pinkish colour, and very porous and spongy, the pores being usually filled with salt water, in consequence of which it often loses 20 to 50 per cent. of its weight in drying. The imports into Great Britain amounted in 1879 to 5000 cwts. Although Borneo rubber was first made known in 1798, it was not imported into England as an article of trade till 1864, when it appeared under the name of gutta susu, *i.e.*, in Malayan, milk-gum. The plant which yields Borneo rubber was identified by Roxburgh as *Urceola elastica*, Roxb., an apocynaceous climbing plant with a trunk as thick as a man's body, and having a soft thick bark. Mr F. W. Burbidge, who recently visited the island, states that there are three varieties of the rubber plant, known to the natives as "petabo," which yields the finest caoutchouc; "menoongan," which yields the largest quantity; and "serapit," from which the commonest rubber is obtained. The petabo variety, according to specimens at Kew, is referred to a species of *Leuconotis*. The rubber is obtained by cutting the plant into pieces varying from a few inches to 2 or 3 feet long, and allowing the juice to drain into buckets or jars, heat being sometimes applied to one end of the pieces when the juice flows slowly. The milk is coagulated by salt water. The Borneo rubber plant is probably one of the plants that would repay cultivation, as it grows rapidly, yields a supply of sap in three years, and after planting requires no attention.

In Sumatra, caoutchouc is obtained from *Willughbeia firma*, and is exported to Holland, but this variety is not known in England. Malacca rubber, which is not met with in English commerce, is said to be obtained from *Urceola elastica*, Roxb.

Rangoon rubber, and those of Penang and Java, are imported into England in small quantities only, and are irregular in appearance. From its physical characters, a portion at least of Rangoon rubber is believed to be the produce of a species of *Ficus*, probably *F. hispida*, L. Another caoutchouc-yielding plant, *Urceola* (*Chavannesia*) *esculenta*, Benth., belonging to the *Apocynaceæ*, has, however, been recently discovered in Burmah, some specimens of which at the age of five years have stems 6 inches in diameter, while the crown covers an area of 200 square feet. It has been recommended for plantations as an available source of rubber, the cost of cultivation being very slight after the first year, and the profit commencing in seven years, at which age the yield is calculated to be 3½ lb.

Penang rubber in character resembles the Assam, and may be also supposed to be obtained from a species of *Ficus*. Dr Wallich, however, has stated that its source is an asclepiadaceous plant, *Cynanchum ovalifolium*, Wright.

Java rubber is stated by Dr De Vrij to be obtained from *Ficus elastica*. Like the Assam rubber it is dark and glossy, but it is of a deeper tint, and has occasional reddish streaks. It is said to be prepared by allowing the juice to dry on the incisions made in the tree. Singapore, Java, and Penang rubbers are much alike in character, and may be classed with the Assam rubber, having a firm texture, mottled appearance, and bright polished surface, but varying in colour in a single sample from light yellowish-white to dark brown. Java rubber is also exported to France.

Caoutchouc is obtained in the Malay archipelago from *Alstonia costulata*, Miq.; and *Alstonia scholaris*, R. Br., is likewise reported to yield it. In Fiji it has been obtained from *Alstonia plumosa*, Labill. In North Australia caoutchouc has been prepared from *Ficus macrophylla*, Desf., and *F. rubiginosa*, Desf.; the last-named plant has been recommended by Baron Müller as suitable for cultivation, being a hardy species. None of the above rubbers are as yet known in British commerce as regular articles of trade.

Bibliography.—Collins, in *Journal of Botany*, 1868; *Journ. Soc. Arts*, vol. xviii. p. 86; Bevan, *British Manufacturing Industries*, 1877, p. 97–105, and *Report on Caoutchouc*, 1872; Markham, in *Journ. Soc. Arts*, p. 475, 1876; *L'Ingenieur Universel*, vol. ii. p. 187; Bernardin, *Classification de 100 Caoutchoucs et Guttaperchas*, Ghent, 1872; Christy, *New Commercial Plants*; Kurz, *Forest Flora of British Burmah*, vol. ii. p. 184. (E. M. H.)

Chemistry, Manufacture, and Industrial Uses.

The remarkable body known as india-rubber is composed of carbon and hydrogen alone, but its exact chemical nature is not by any means known with certainty. The analyses of Faraday indicate that its ultimate composition is 87·5 per cent. of carbon and 12·5 per cent. of hydrogen; but there appears to be good ground for regarding the substance as a polymer of the group $C_{10}H_8$, or as $(C_{10}H_8)_x$. There are, however, no data for estimating the value of x in this case. It will be noticed, too, that the formula given requires considerably less hydrogen than the proportion indicated by Faraday's analysis; but the difficulties of obtaining such a body as caoutchouc in a fit condition for analysis are so great as to render this discrepancy a matter of comparatively small import. The action of cold and heat on india-rubber presents many points of interest. When exposed to a temperature approaching 0° C., it gradually loses its softness and ready extensibility, and finally becomes rigid and inelastic; but its normal condition may be restored by submitting it either to a temperature of 35° or 40° C., or to a tension sufficient to stretch it to about twice its natural length. In the latter case it is probable that the change is really due to heat arising from the physical disturbance consequent upon the act of stretching. The effects of heat are more complex and varied than those of cold; and with caoutchouc at an ordinary temperature, say 15° C., the primary effect of heat is to increase its flexibility and elasticity. This is well illustrated by the fact that a strip of rubber stretched by a weight contracts when it is heated to a temperature of about 40° C. This diminution as regards length is, however, accompanied by a more than corresponding increase in thickness, on account of the expansion in volume due to an elevated temperature. When caoutchouc is exposed to a temperature ranging between 100° and 120° C., it becomes considerably softened, and almost entirely loses its elasticity; but, if of good quality, it slowly recovers its former condition under the influence of a moderate degree of cold. When, however, the heat is pushed to 150°, it becomes viscous, and at 200° it fairly melts, forming a thick liquid which possesses the same composition as ordinary caoutchouc, but has no tendency to resume its original condition even when exposed to cold for a prolonged period. At a still higher temperature, caoutchouc yields a variety of volatile hydrocarbons; and, on subjection to dry distillation in a retort, its conversion into these bodies is tolerably complete, only a trifling carbonaceous residue remaining behind. Among the most notable volatile products resulting from the dry distillation of caoutchouc may be mentioned *caoutchin*, an oil-like body having a composition and vapour volume corresponding to the formula $C_{10}H_8$, and boiling at 171° C.; and *isoprene*, another hydrocarbon oil identical in composition with caoutchin and with caoutchouc itself, and boiling at 38° C. Other hydrocarbon oils are also formed, as, for example, *heveene* and *caoutchene*,—these being members of the C_nH_{2n} series. The former boils at 228°, and the latter at 14°·5. The mixed products of the dry distillation of caoutchouc, often described under the name caoutchoucin, form an excellent but rather expensive solvent of this body. When exposed to the air, caoutchouc gradually oxidizes and undergoes deterioration; the oxidation is often much favoured by exposure to sunlight or to alternate conditions of dampness and dryness. The deteriorated caoutchouc is either somewhat soft and deficient in tensile strength, or brittle and resinous in its nature. Spiller found 27·3 per cent. of oxygen in a resinous product resulting from the decay of caoutchouc. Ozone rapidly attacks and destroys the substance.

Dilute acids or alkalies have little or no action on caoutchouc, but strong and hot sulphuric acid chars, and concentrated nitric acid rapidly oxidizes and destroys it. The moderate action of either chlorine, bromine, or iodine hardens or vulcanizes it; but, if allowed to act freely, they completely destroy it. The action of sulphur will be considered below.

Caoutchouc, when pure, is odourless and nearly white, and possesses a specific gravity of ·915. It is porous and cellular in texture, and absorbs from 10 to 25 per cent. by weight of water when long soaked in it. Alcohol is similarly taken up. Up to this point caoutchouc has been referred to as if it consisted of one substance only; but as a matter of fact all ordinary samples contain two distinct modifications, viz., the hard or fibrous and the soft or viscous. These two caoutchoucs are identical in composition, and similar as regards general properties and reactions. On subjecting a piece of raw caoutchouc, however, to the action of such a solvent as cold benzol, the essential difference between the two forms manifests itself. The fibrous or hard constituent merely swells up to many times its original bulk, but the viscous yields a true solution. In a high class rubber, such as that imported from the province of Pará, the former modification is the principal factor; in a caoutchouc of low quality, such as "African tongue," the latter. Freshly cut surfaces of caoutchouc unite together firmly, and this circumstance is due to the presence of the viscous variety; vulcanization, by hardening this, destroys the adhesive property.

Certain liquids, such as benzol and its homologues, carbon disulphide, petroleum, ether, volatile oils, chloroform, and melted naphthalene, dissolve caoutchouc more or less perfectly; but unless the substance has been subjected to the process of mastication, its fibrous constituent appears, not to dissolve in the strict sense of the term, but rather to swell up, forming a paste analogous to starch which has been acted on by hot water. Carbon disulphide and chloroform, however, exercise a more powerful solvent action on the fibrous parts of india-rubber than benzol or essential oils; and Payen has found that carbon disulphide to which 5 per cent. of absolute alcohol has been added forms one of the best solvents. One part of masticated caoutchouc dissolved in thirty parts of this solvent forms a liquid which can be filtered through paper, and which leaves a film of exquisite tenuity and purity when allowed to dry on a level glass plate.

Most fatty matters exercise a remarkable destructive action on caoutchouc, causing it to become first soft, and afterwards hard and brittle. It has often happened that traces of fatty oils in the liquids employed for dissolving india-rubber, or fatty matters in the textile basis, have led to the destruction of waterproof goods. A like cause has in many cases led to the rapid deterioration of the caoutchouc threads in elastic webbing.

In the industrial working of india-rubber, the first matter to be attended to is the removal of the various impurities present in the crude material. These are in some cases natural products which have originated with the caoutchouc, while in other cases they owe their presence to careless collection or to adulteration. Among the impurities of the former class may be mentioned various gum-like or mucilaginous matters, and acid products arising from their decay or oxidation. A remarkable volatile body, which is probably of the nature of a polyatomic alcohol, has been discovered by Gerard[1] in the crude caoutchouc from the Gaboon. This substance, called by the discoverer *dambonite*, has a composition corresponding to the formula $C_4H_8O_3$, is sweetish to the taste and soluble in water, and crystallizes in needles which melt at 190° C. and volatilize between 200° and 210°. The admixtures may range from fragments of bark or wood to stones or large lumps of clay, such as are sometimes introduced into negrohead rubber,—hay or a similar substance being also placed inside to make the mass about equal in specific gravity to the genuine article. Alum and sulphuric acid are often employed to effect the coagulation of the juice; and traces of the latter remaining in the rubber appear, in some instances, to work mischief.

All the above-mentioned impurities are in actual practice very efficiently removed by the following process. The lumps of crude caoutchouc are first softened by the prolonged action of hot water, and then cut into slices by means of a sharp knife,—generally by hand, as thus any large stones or other foreign substances can be removed. The softened slices are now repeatedly passed between grooved rollers, known as the washing rollers (fig. 7), a supply of hot or cold water being made to flow over them. Solid impurities speedily become crushed, and are carried away by the water, while the rubber takes the form of an irregular sheet perforated by numerous holes. The washed product contains in its pores a notable proportion of water, which is removed by hanging the rubber for some days in a warm room. It is now ready either for incorporation

[1] *Compt. Rend.*, lxvii. p. 820, and *Zeitschrift für Chem.*, 1869, p. 66.

with sulphur and other solid bodies, or for agglomeration into solid masses by means of the masticating machine,—an apparatus which consists of a strong cylindrical cast-iron casing, inside which there revolves a metal cylinder with a fluted or corrugated surface. Some of the rubber having been placed in the annular space between the inner cylinder and the outer casing, the former is made to revolve; and the continued kneading action to

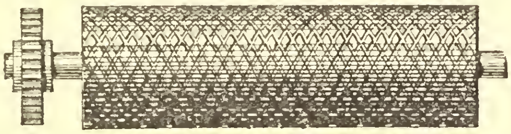


Fig. 7.—Roller of Washing Machine.

which the rubber is subjected works it into a solid mass, something like a gigantic sausage. Before commencing the mastication it is generally necessary to warm the apparatus by means of steam; but as the operation proceeds the heat produced requires to be moderated by streams of cold water flowing through channels provided for the purpose. The inner cylinder is generally placed somewhat excentrically in the outer casing, in order to render the kneading more perfect than would otherwise be the case.

To convert the masticated rubber into rectangular blocks, it is first softened by heat, and then forced into iron boxes or moulds. The blocks are cut into thin sheets by means of a sharp knife, which is caused to move to and fro about two thousand times per minute, the knife being kept moistened with water, and the block fed up to it by mechanical means. Cut sheets are largely used for the fabrication of certain classes of rubber goods,—these being made by cementing the sheets together with a solution of rubber in coal-naphtha or benzol. Most articles made of cut sheet rubber would, however, be of very limited utility were they not hardened or vulcanized by the action of sulphur or some compound of that element. After vulcanization, rubber is no longer softened by a moderate heat, a temperature of 160° C. scarcely affecting it, nor is it rendered rigid by cold, and the ordinary solvents fail to dissolve it. It must, however, be distinctly understood that it is not the mere admixture but the actual combination of sulphur with india-rubber that causes vulcanization. If an article made of cut sheet be immersed for a few minutes in a bath of melted sulphur, maintained at a temperature of 120° C., the rubber absorbs about one-tenth of its weight of that element, and, although somewhat yellowish in colour from the presence of free sulphur, it is still unvulcanized, and unaltered as regards general properties. If, however, it be now subjected for an hour or so to a temperature of 140° C., true combination sets in, and vulcanized caoutchouc is the result. When a manufactured article has been saturated with sulphur in the melted-sulphur bath, the heat necessary for vulcanization may be obtained either by high-pressure steam, by heated glycerin, or by immersion in a sulphur-bath heated to about 140° C. In this last case absorption of the sulphur and its intimate combination with the rubber occur simultaneously. Cut sheets, or articles made from them, may be saturated by being laid in powdered sulphur maintained for some hours at about 110° C. Sheets sulphured in this way can be made up into articles and joined together either by warming the parts to be united, or by means of india-rubber solution; after which the true vulcanization, or "curing" as it is termed, can be brought about in the usual way. Another method of vulcanizing articles made from cut sheet rubber consists in exposing them to the action of chloride of sulphur. Either they are placed in a leaden cupboard into which the vapour is introduced, or they are dipped for a few seconds in a mixture of one part of chloride of sulphur and forty parts of carbon disulphide or purified light petroleum. Vulcanization takes place in this instance without the action of heat; but it is usual to subject the goods for a short time to a temperature of 40° C. after their removal from the solution, in order to drive off the liquid which has been absorbed, and to ensure a sufficient action of the chloride of sulphur. Treatment with a warm alkaline solution is afterwards advisable, in order to remove traces of hydrochloric acid generated during the process. Another very excellent method of vulcanizing cut sheet goods consists in placing them in a solution of the polysulphides of calcium at a temperature of 140° C. Rubber employed for the manufacture of cut sheets is often coloured by such pigments as vermilion, oxide of chromium,

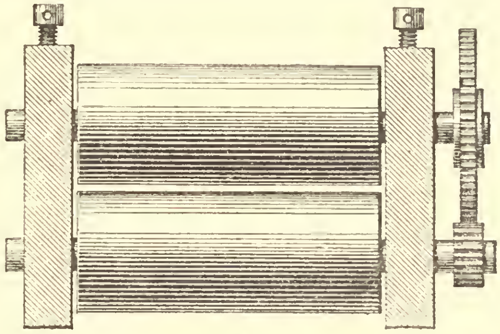


Fig. 8.—The Mixing Rollers.

ultramarine, orpiment, antimony, lamp black, or oxide of zinc, incorporation being effected either by means of the masticator or by a pair of rollers heated internally by steam, and so geared as to move in contrary directions at unequal speed (fig. 8). Most of the rubber now manufactured is not combined with sulphur when in the form of sheets, but is mechanically incorporated with about one tenth of its weight of that substance by means of the mixing rollers,—any required pigment or other matter, such as whiting or barium sulphate, being added. The mixed rubber thus obtained is readily softened by heat, and can be very easily worked into any desired form or rolled into sheets by an apparatus known as the calendering machine. Vulcanization is then ensured by exposure for half an hour or more to a temperature of 135°–150° C., usually in closed iron vessels into which high-pressure steam is admitted (fig. 9). Tubes are generally made up around mandrels, and allowed throughout the curing to remain imbedded in pulverized French chalk, which affords a useful support for many articles that tend to lose their shape during the process. Of late years a considerable amount of seamless tubing has been made, much in the same way as lead piping, by forcing the mixed rubber through a die, and curing as above. The calendered sheets are generally cured between folds of wet cloth, the markings of which they retain; and hollow articles, such as playing balls or injection bottles, are vulcanized in iron or brass moulds, tinned inside and

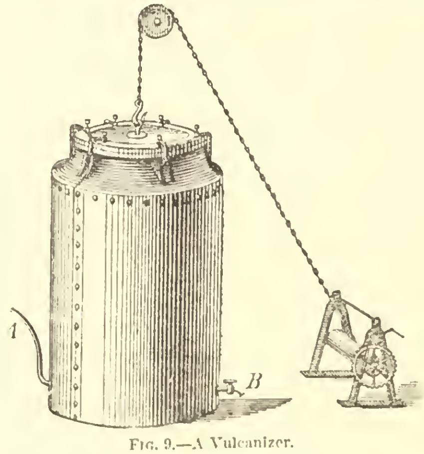


Fig. 9.—A Vulcanizer.

very slightly greased. Before it is put in, the article is roughly put together, and the expansion of the included air forces the rubber into contact with the internal surface of the mould, or a little carbonate of ammonia is enclosed. Belting intended for driving machinery is built up of canvas which has been thoroughly frictioned with the soft mixed rubber, and is cured by placing it in a kind of press kept by means of steam at a dry heat of about 140° C. Packing for the stuffing boxes of steam engines is similarly prepared from strips of rubber and frictioned canvas, as also are the so-called insertion sheets, in which layers of rubber alternate with canvas or even wire gauze. India-rubber stereotypes are now extensively made use of as hand stamps, and attempts have been made to introduce them for press and machine printing. A plaster cast of the type is, when dry, saturated with shellac varnish and redried. Rubber mixed in the usual way with about 10 per cent. of sulphur is now softened by heat, forced into the mould, and retained there by pressure during the operation of curing, which is usually effected in an iron box heated over a gas burner to 140° C.

The ordinary macintosh or waterproof cloth is prepared by spreading on the textile fabric layer after layer of india-rubber paste or solution made with benzol or coal-naphtha. If cotton or linen is used, it is usual to incorporate sulphur with the paste, and to effect vulcanization by steam heat; but, when silk or wool is employed, no sulphur is added to the paste, the dried coating of rubber being merely brought into momentary contact with the mixture of chloride of sulphur and carbon disulphide already mentioned. Double texture goods are made by uniting the rubber surfaces of two pieces of the coated material. Air goods, such as cushions, beds, gas bags, and so forth, are made of textile fabrics which have been coated with mixed rubber either by the spreading process above described, or by means of heated rollers, the curing being then effected by steam heat. The manufacture of overshoes and fishing boots is an analogous process, only the canvas base is more thickly coated with a highly pigmented rubber of low quality. The articles are first fashioned by joining the soft material; they are then varnished, and afterwards cured in ovens heated to about 135° C. The fine vulcanized "spread sheets" are made by spreading layers of india-rubber solution, already charged with the requisite proportion of sulphur, on a textile base previously prepared with a mixture of paste, glue, and treacle. Vulcanization is then effected by steam heat, and, the preparation on the cloth being softened by water, the sheet of rubber is readily removed. The required thickness of the spread sheet is very often secured by the rubber-faced surfaces of two cloths being united before curing. The threads used in making elastic webbing are usually cut from spread sheets. The manufacture of springs, valves, and washers does not require any very special notice, these articles being generally fashioned out of mixed rubber, and vulcanized either in moulds or in powdered French chalk. Rollers are made to adhere to their metal spindles by the intervention of a layer of ebonite, and after vulcanization they are turned. In order to make spongy or porous rubber, some material is incorporated which will give off gas or vapour at the vulcanizing temperature,—such as carbonate of ammonia, crystallized alum, and finely ground damp sawdust. Uncombined sulphur is injurious, and often leads to the decay of vulcanized goods; but an excess of sulphur is generally required in order to ensure perfect vulcanization. Sometimes the excess is partially removed by boiling the finished goods with a solution of caustic soda, or some other solvent of sulphur. In other cases the injurious effects of free sulphur are obviated by using instead of it a metallic sulphide,—generally the orange sulphide of antimony; but, for the best results, it is necessary that this should contain from 20 to 30 per cent. of uncombined sulphur.

When the vulcanization of rubber is carried too far—say from the presence of a very large proportion of sulphur and an unduly long action of heat, the caoutchouc becomes hard, horn-like, and often black. Rubber hardened by over-vulcanization is largely manufactured under the name of ebonite or vulcanite. It is usually made by incorporating about 40 per cent. of sulphur with purified Borneo rubber by means of the usual mixing rollers, shaping the required articles out of the mass thus obtained, and heating for six, eight, or ten hours to from 135° to 150°. Ebonite takes a fine polish, and is valuable to the electrician on account of its insulating properties, and to the chemist and photographer because vessels made of it are unaffected by most chemical reagents. A kind of vulcanite which contains a very large proportion of vermilion is used, under the name of dental rubber, for making artificial gums.

The following list of works and papers on the rubber industry enumerates the writings which are calculated to be especially useful to the enquirer:—Charles Goodyear, *Gum Elastic and its Varieties*, New Haven, U.S.A., 1853; Friedrich Harzer, *Gutta-Percha und Kautschuk, ihr Vorkommen*, &c., Weimar, 1853; Paulin Desormeaux, *Nouveau manuel complet du fabricant d'objets en caoutchouc, en gutta-percha, et en gomme factice*, 424 pp., Paris, 1855; C. H. Schmidt, *Der Fabricant von Kautschuk und Gutta-Percha Waaren*, 207 pp., Weimar, 1856; Thomas Hancock, *Origin and Progress of the Indian-Rubber Manufacture in England*, London, 1857; Heinrich Keysserling's edition of Friedrich Harzer's *Gutta-Percha und Kautschuk*, 273 pp. and atlas, Weimar, 1864; *Abridgments of Specifications relating to the Preparation of India-Rubber and Gutta-Percha*, 1791-1866, 262 pp., printed by order of the Commissioners of Patents, London, 1875; "India-Rubber and Gutta-Percha," a series of articles in the *Universal Engineer*, vol. ii., Manchester, 1879; Franz Clouth, *Die Kautschuk Industrie*, 76 pp., Weimar, 1879; T. Bolas, *Cantor Lectures on the India-Rubber and Gutta-Percha Industries*, London, 1880; M. Maigne, *Nouveau manuel complet du fabricant d'objets en caoutchouc*, &c., 2 vols., 506 pp., Paris, 1880. (T. B.)

INDICTMENT, in English law, is a formal accusation in writing, laid before a grand jury, and by them presented on oath to a court of competent jurisdiction. It is thus distinguished from a mere presentment by the grand jury made on information within their own knowledge, and from an INFORMATION (*q.v.*), by which a prosecution is instituted at the suggestion of a public officer without the intervention of a grand jury. The grand jury hears in private the witnesses in support of the application, and, if it considers that a *prima facie* case has been made out, it is its duty to find the indictment "a true bill." Otherwise it sends the indictment into court torn up, which is a finding of "no bill." In this case the indictment is said to be ignored. An indictment is said to consist of three parts—the commencement or caption, the statement of the facts constituting the crime, and the conclusion. In each part appropriate and highly technical language is still used, but verbal precision is not so essential as it once was, and departure from the ordinary formalities, if it involves no misapprehension or mistake, does not make a flaw in the indictment. The formal commencement of an indictment is after the following style:—"Middlesex to wit. The jurors for our lady the Queen on their oath present," &c. The name of the county and district in the margin is the "venue," and it should in general be the county in which the offence was committed, or the district over which the jurisdiction of the court extends. An indictment concludes with the words "against the peace of our lady the Queen, her crown and dignity," if the offence is a crime at common law. If the offence is a crime by statute, the indictment must also use the words "against the form of the statute in such case made and provided." In the "statement" great care must be taken to set forth the facts of the case with certainty and precision. It may be mentioned that in the Criminal Code Bill, which has been drafted on behalf of the crown by Mr Justice Stephen, and revised by a judicial commission, it is proposed to substitute for the existing formalities a simple statement of particulars, with a reference to the section of the code defining the offence. An indictment lies "for all treasons and felonies, for misprision of treasons and felonies, and for all misdemeanours of a public nature at common law." And if a statute prohibit a matter of public grievance, or command a matter of public convenience, all acts or omissions to the contrary, being misdemeanours at common law, are punishable by indictment if no other mode of proceeding is pointed out by the statute. The statement of the offence is called a count, and an indictment may consist of several counts. But only one offence ought to be charged in each count, and offences of a different nature, *e.g.*, murder and burglary, should not be charged in the same indictment. Until recently it was thought improper to charge theft in one count and receiving in another of the same indictment; but that is now made possible by statute. So a prisoner may be charged as accessory before the fact in one count, and as accessory after the fact in another. At common law an indictment may be preferred at any time after the offence committed; but various periods of limitation have been fixed by statute in special cases. For example, certain kinds of treason must be prosecuted within three years.

Prosecutions by indictment in the United States generally resemble those of English law, the offence being charged as "against the peace and dignity of the state or commonwealth," unless it is a statutory offence, when the conclusion "against the statute," &c., is used.

INDIGO is a well known and exceedingly valuable blue dyeing material. The substance has been known among Western communities from an early period, being mentioned by Dioscorides as Ἰνδικόν, and by Pliny as *Indicum*; when it made its appearance in England it was called indico. As all these names show, the material in its origin and production is closely related to India, among the commercial commodities of which it has always occupied a distinctive and important place. It was not, however, till after the establishment of the Cape route to India that indigo came to be largely used in the dyeing establishments of Western Europe, woad having in earlier times been utilized for purposes to which indigo was subsequently applied.

As a commercial substance indigo is entirely obtained from the vegetable kingdom, although it may be produced, in minute quantity, from a principle contained in urine, and its synthetical formation has also been accomplished. The number of plants from which indigo may be procured is known to be large, but only from a very few is it prepared in practice. These are various species of the leguminous genus *Indigofera*, especially the four species *I. tinctoria*, *I. Anil*, *I. disperma*, and *I. argentea*; and it is said that in China *Polygonum tinctorium* and other non-leguminous plants are used as the source of *lan* or Chinese indigo. The woad plant, *Isatis tinctoria*, owes its value as a dye to the presence of indigo matter, although indigo is not actually prepared from it. The most important source of indigo, and that most generally cultivated, is *I. tinctoria*, which is an herbaceous plant growing 3 to 5 feet high, and having bipinnate leaves. It is in the leaves that the indigo-yielding principle chiefly resides, and these are most gorged with it at the period when the flower-buds are about to open. It is then that the plant is cut down; and in some regions the same stock yields in one year a second and even a third crop of stems.

Two principal methods of preparing indigo are pursued, —dried leaves being operated on in the one, while the fresh green stalks and leaves are used in the other. It will be sufficient to describe the latter, the more important process, as it is conducted in Bengal, where the most highly esteemed varieties of indigo are made. The cut leaves and stems are tied up into small bundles and conveyed at once to the factory, in which there are two ranges of large tanks or vats, one series being at a lower level than the other. In the upper or fermenting vats the bundles are submerged; and cross-bars are fixed over the vats. A fermentation more or less rapid ensues, its completion occupying, according to the temperature, from nine to fourteen hours. The progress of the operation is judged by the tint assumed by the water, which under favourable conditions should at the end of this stage be of a fine clear yellow colour. In this condition the liquid is run off into the lower vats, in which it is necessary to maintain it in a state of violent agitation. For this purpose a number of men, armed with long bamboos, enter the vats and lash the water incessantly for two or three hours, thus constantly exposing new surfaces to the air. Gradually the liquid assumes a green colour, and indigo appears in broadish flakes, which as it forms begin to sink. After this transformation is complete, the liquid is allowed to settle, and as the indigo sinks the clear liquid is drawn off in a series of discharges by pipes at different heights in the vat. The deposit of indigo is then placed in a boiler, and, to prevent any further fermentation, is raised to the boiling point. After resting for about a day, it is boiled for three or four hours, and then filtered over a thick filtering cloth, and the paste is dried by pressure. The cakes formed during the pressing are then put away to dry gently in the shade, and in a few days are ready for packing.

Bengal indigo of good quality forms a porous earthy mass, light and easily pulverized; and when newly fractured it has that brilliant purple-blue colour distinctively known as indigo, with a kind of coppery lustre. Experts distinguish upwards of forty qualities of Bengal indigo, principally characterized by varying shades of colour,—the inferior qualities being dull in hue, with greenish or greyish tones, hard, dense, and not readily broken. The varieties of indigo which come into the European markets are classified according to their sources: the classes most frequently met with are Bengal, Oude, Madras, Manila, Java, Egypt, Guatemala, Caraccas, Mexico, and Brazil. The best qualities are the Bengal, Java, and Guatemala.

The condition in which the indigo-yielding principle exists in the fresh plants has been a subject of some speculation and controversy. Dr Schunck has investigated the leaves of the woad (*Isatis tinctoria*), the Chinese indigo-plant (*Polygonum tinctorium*), and others, and from all these has isolated a glucoside body indican, which, under the influence of dilute mineral acids, is decomposed, forming indigotin or indigo-blue and a variety of glucose which he calls indiglucin. It has been assumed that the same principle resides in *Indigofera* as in these other plants, and is the efficient source of the dye-stuff from that genus. In the decomposition of indican there are formed—in addition to indigo-blue—indigo-red (indigo-rubin or indigo-purpurin) isomeric with the blue, indigo-brown, and indigo-gluten, all of which, forming part of the precipitate, modify the colour of the product, and render commercial indigo a compound body. Indigo also contains a certain amount of inorganic matter and other non-tinctorial constituents, so that the proportion of indigo-blue may vary from about 72 down to 12 or 14 per cent. of the mass. Pure indigo-blue or indigotin, $C_{16}H_{10}N_2O_2$, is a neutral body of a deep blue colour, destitute of taste and odour, and insoluble in water, dilute acids, and alkalies, and in cold alcohol and ether. Boiling alcohol, ether, and aniline dissolve it, as do also petroleum, benzene, chloroform, and phenol, melted spermaceti and stearic acid, and several oils. It sublimes at

290°–300° C., giving off violet vapours which condense into right rhomboidal prisms possessing a brilliant coppery lustre. By destructive distillation, indigotin yields, among other products, aniline,—a circumstance to which that now well-known body owes its name (from the Sanskrit *nili* through the Portuguese *anil*, indigo). Treated with oxidizing agents, indigotin takes up oxygen, and is converted into isatin, thus :—

$$\underset{\text{Indigotin.}}{C_{16}H_{10}N_2O_2} + 2O = \underset{\text{Isatin.}}{C_{16}H_{10}N_2O_4} \;;$$

and by further oxidation nitro-salicylic acid and picric acid are evolved. The most valuable character, however, of indigotin is found in its behaviour under the influence of hydrogenizing or reducing agents. In the presence of nascent hydrogen indigotin absorbs that element and is converted into white indigo, a colourless body which is readily soluble in alkaline or earthy alkaline solutions, and by simple exposure to the air re-oxidizes and reverts to its original blue condition indigotin. The reduction to white indigo is thus formulated :—

$$C_{16}H_{10}N_2O_2 + 2H = C_{16}H_{12}N_2O_2 .$$

Advantage is taken of these properties in dyeing with indigo as detailed under DYEING, vol vii. pp. 576–7. See also CALICO-PRINTING, vol. iv. pp. 689–90.

Indigo when dissolved in strong sulphuric acid, forms with it two acid compounds, both of which have limited industrial applications. These are (1) sulphindigotic acid, $C_{16}H_8N_2O_4(SO_3H)_2$, known also as sulphate of indigo or soluble blue indigo, and (2) sulphophœnicic acid, sulphopurpuric acid, or indigo purple, $C_{16}H_9N_2O_2(SO_3H)$. These bodies are formed together in the sulphuric acid solution of indigo ; but, as the second is insoluble in weak acids, it precipitates when the solution in which it is formed is largely diluted with water. Both these acids are soluble in water. The first was formerly used in dyeing Saxon-blue on wool and silk, a style now little known ; and the sodium salt of the second is known as red indigo carmine.

The synthetical preparation of indigo is a subject which has long occupied the attention of chemists, as obviously any means by which the substance might be artificially obtained on a commercial scale could not fail to be of great industrial value. The numerous efforts made in this direction appear at last (1881) to be crowned with success ; and there is now little doubt that artificial indigo will soon become a commercial product. It is to Professor Adolf Baeyer of Munich that the measure of success already attained in manufacturing indigo is due. For many years he has patiently investigated the molecular constitution of indigotin and its derivatives. From isatin, prepared by the oxidation of indigotin, Baeyer and Knob produced successively di-oxindol, $C_{16}H_{14}N_2O_4$, oxindol, $C_{16}H_{14}N_2O_2$, and indol, $C_{16}H_{14}N_2$. Baeyer at a later period, with the assistance of Emmerling, succeeded in producing indol from cinnamic acid, and as that body can be prepared from coal-tar a new connecting chain was established between indigo at one extreme and coal-tar at the other, meeting in indol just as at a much earlier date they had similarly met in aniline. The task remained of reconverting these derivatives of indigotin into that body, and towards that, in 1870, Baeyer and Emmerling, by heating isatin with phosphorus trichloride, acetyl chloride, and phosphorus, succeeded in obtaining a mixture of indigotin and indigo-rubin. In 1878 the further steps necessary to complete the cycle were accomplished by Baeyer, when from phenyl-acetic acid he prepared oxindol. Acting on oxindol by nitrous acid he produced nitrosoxindol, which in its turn, by treatment with nascent hydrogen, was transformed into amidoxindol, a body which on oxidation yielded isatin. Thus the series of transformations was complete ; but they were effected by a process so roundabout and elaborate as to preclude all hope of any commercial issue from the method. Quite recently Baeyer, coming back to the use of cinnamic acid, has devised the much simpler and more direct process which now promises to become, and indeed already is in operation as, a method for the commercial preparation of indigo. By treating cinnamic acid with nitric acid, ortho-nitro-cinnamic acid is prepared, which on exposure to bromine vapour readily combines with that body, forming ortho-nitro-dibrom-hydro-cinnamic acid. This substance when treated with caustic alkali is converted by the loss of the bromine into ortho-nitro-phenyl-propiolic acid, which, lastly, when heated in an alkaline solution of grape sugar develops into indigotin. The steps in the process are therefore represented thus :—

$$(1)\quad \underset{\text{Cinnamic acid.}}{C_6H_5C_2H_2COOH} + \underset{\text{Nitric acid.}}{NO_2HO} = \underset{\text{Nitro-cinnamic acid.}}{C_6H_4(NO_2)C_2H_2COOH} + \underset{\text{Water.}}{H_2O} .$$

$$(2)\quad \underset{\text{Nitro-cinnamic acid.}}{C_6H_4(NO_2)C_2H_2COOH} + \underset{\text{Bromine.}}{2Br} = \underset{\text{Nitro-dibrom-cinnamic acid.}}{C_6H_4(NO_2)C_2H_2Br_2COOH} .$$

$$(3)\quad C_6H_4(NO_2)C_2H_2Br_2COOH + \underset{\text{Caustic soda.}}{2NaOH} = \underset{\text{Nitro-propiolic acid.}}{C_6H_4(NO_2)C_2COOH} + 2NaBr + 2H_2O .$$

$$(4)\quad \underset{\text{Nitro-propiolic acid.}}{2C_9H_5NO_4} + 2H_2 = \underset{\text{Indigotin.}}{C_{16}H_{10}N_2O_2} + 2CO_2 + 2H_2O .$$

The nitro-propiolic acid is now being manufactured by the Badische Anilinfabrik as a material for indigo printing. The acid has simply to be printed on the cloth with a thickening containing grape sugar and alkali, and, by steaming, indigo is developed in the fibre. This reaction is in itself a matter of no small importance, seeing that the printing of indigo direct is an extremely troublesome operation. Hitherto indigo in mass has not been produced, but there can be little doubt that the remaining difficulties, among which is the present expensiveness of cinnamic acid, will soon be overcome, and that artificial indigo will take its place among ordinary chemical manufactures. (J. PA.)

INDIUM, a metal discovered with the aid of the spectroscope in 1863 by Reich and Richter when testing certain specimens of Freiberg zinc-blende for thallium. Instead of the brilliant green line characteristic of this latter metal, they observed an intense indigo-blue line occupying a position different from that of any known line, and were thus at once led to suspect the presence of a previously unknown element. The name indium was chosen for the metal, when they succeeded in isolating it, on account of this circumstance. It has since been detected in blendes from various sources, but always in extremely minute amount, and still remains one of the rarest of the elements. Indium is best prepared from crude zinc made from indium-containing blendes. As it is less positive than zinc, if the crude zinc is treated with insufficient hydrochloric acid to dissolve it completely, a residue is obtained containing all the indium together with several other metals also present in small quantity in the zinc. The properties of indium have already been partially described (vol. v. p. 533). Its flame-spectrum exhibits, besides the indigo-blue line (w. l. 4509), a violet line of w. l. 4101. Lockyer has stated (*Royal Society Proceedings*, 1878, xxviii. p. 177) that the strongest line in photographs of the spectrum of indium in the electric arc is, as already recorded by Thalén, the *h* line of hydrogen, the hydrogen line near G being, however, absent. He argues that this is not to be explained by the supposition that the indium contains occluded hydrogen, since none of the hydrogen lines become impressed on the plate when palladium-hydrogen is volatilized in the arc. Indium is commonly regarded as closely allied to aluminium, on account of the general resemblance of corresponding compounds of the two metals, and especially on account of the existence of an indium alum isomorphous with ordinary alum. Hence indium chloride is usually represented by the formula In_2Cl_6, the formula of aluminium chloride being Al_2Cl_6. V. and C. Meyer have recently found, however, that the density of its vapour at a bright red heat corresponds with the formula $InCl_3$, indicating that indium is a *triad* and not a *tetrad* like aluminium and iron. Aluminium and iron (ferric) chloride boil readily at a temperature below that at which sulphur or mercury boil, but indium chloride does not volatilize in the vapour of perchlorodiphenyl, which boils considerably above 440° C., and only slowly sublimes in the vapour of phosphorus pentasulphide (b.p. 530°). It evaporates by no means rapidly at a dull red heat, but is momentarily converted into vapour at a bright red heat, furnishing a gas which behaves normally. It is noteworthy that aluminium chloride decomposes entirely at a temperature very little above that at which it gasifies. The issue raised by the Meyers' observation is of considerable theoretical interest, and the subject demands further investigation.

INDORE, or the Territories of the Mahárájá of Holkar, is one of the principal native states in India, under the Central India Agency. The name of the state is taken from that of the capital Indore, 22° 42′ N. lat., 75° 54′ E. long. The territory consists of many isolated tracts; but since 1861 arrangements have been made to concentrate the state as much as possible, and lands which were formerly held by Holkar in Ahmednagar district and in the Deccan have been exchanged for districts and *párgánás* bordering on the Nerbudda (Narbadá) river and the tract in which Indore town is situated. The area of the whole of Holkar's territories is estimated at 8075 square miles. Of these districts, those situated to the north are drained by the river Chambal and its feeders, those to the south by the Nerbudda. The tracts are fertile, producing in abundance excellent wheat and other grains, pulse, sugar-cane, cotton, and opium. The poppy is so generally cultivated that, when in bloom, it gives the country the appearance of a vast garden. Tobacco is also grown to a great extent, and is of admirable quality.

The great Vindhyá range traverses the southern division of Holkar's dominions, in a direction from east to west, a small portion of the territory lying to the north of the mountains, but by much the larger part to the south. The latter is a portion of the valley of the Nerbudda, and is bounded on the south by the Sátpura mountains. Basalt and other volcanic formations predominate in both ranges, although there is also much sandstone. The Nerbudda traverses Indore from east to west; and the valley at Mandlesar, in the central part of the district, is between 600 and 700 feet above the sea. The general appearance of the country is that of an undulating valley intersected by low rocky ranges, in some parts thickly clothed with stunted jungle, which also covers considerable tracts in the plains. The forests of the state form two belts, the southern and the northern. The former, which is considered unhealthy, borders on the Sátpura range, and the latter, a healthy tract, on the Vindhyá hills. From its inter-tropical position, the climate of Indore is sultry, the thermometer ranging from 60° to 90° Fahr. in the house. For some months from the close of the periodical rains, malaria is so deadly in the jungles that no European ventures into them.

Besides the ruling tribe of Marhattás, the population comprises many other classes of Hindus, a few Mahometans, and a considerable number of Gonds and Bhíls. The Vindhyá and Sátpura ranges are peculiarly the country of the Bhíls, who are considered to have been the earliest occupiers of the soil. This race is one of the wildest in India, its people living for the most part on vegetables and game, or on the plunder of their more civilized neighbours. They have, however, of late years been brought into more peaceful habits of life. The population of Holkar's territories was estimated in 1875 at 635,450. The revenue in 1875–76 amounted to £459,800, and the disbursements to £405,100. The number of schools in 1876 was 77, attended by 3235 pupils, costing the state £3000. The principal educational establishment is the Rájkumár college, for the education of the sons of the chiefs and nobles of Central India. The institution is maintained by the British Government, and is located within the grounds assigned for the purposes of the "Residency." The governor-general's agent for Central India has his headquarters at Indore town. A branch line from the Great Indian Peninsula Railway, known as the Holkar State Railway, runs from Khandwa junction to Indore. The principal engineering works are the ascent of the Vindhyá range and the bridge over the Nerbudda river. From Indore the line is taken up by the Neemuch Railway through part of Sindhia's dominions, connecting Indore with Nasírábád, and finally with Delhi and Agra. The chief means of communication are the Bombay and Agra Trunk Road, which runs through Indore, with branches at Mhow and Dhar, &c.; another road, 80 miles in length, joins Indore with Khandwa, crossing the Nerbudda by ferry.

There are cotton mills at work in the state, which have proved a regular source of income, as they turn out cloth for which there is a ready market. In 1878 the number of spindles was 10,000. Indore city contains a charitable and leper's hospital, and a dispensary. Cholera frequently prevails.

History.—The founder of this dynasty was Malhar Ráo, the son of a shepherd, who lived in the village of Hol, in the Deccan, whence he derived the surname of Holkar, the adjunct "kae," "kar," or "kur" signifying inhabitant. Disdaining his father's occupation, he enlisted in a troop of horse; his rise was rapid, and he eventually became one of the most distinguished leaders in the first Marhattá invasion of northern India, and obtained many possessions north of the Nerbudda and about Indore by grant from the peshwá. At his death he was succeeded by his grandson Malli Ráo, who died shortly after his accession. Alia Bái, the mother of Malli Ráo, then took the management of affairs, and appointed as commander of her army Malhar Túkaji Holkar, a chief of the same tribe as, but in no way related to, Malhar Ráo. Alia Bái died in 1795, and was not long survived by Túkaji Ráo, after whose death the power of the house of Holkar was nearly extinguished by family quarrels and the dissensions which distracted the Marhatta confederacy at the close of the last century. The fortunes of the family were, however, restored by Jeswant Ráo, an illegitimate son of Túkaji Holkar, who, after a signal reverse from the army of Sindhia, employed European officers to introduce their discipline into his army, and in 1802 defeated the united forces of Sindhia and the peshwa at the battle of Poona. Twice Holkar attacked British territory, but was totally routed, and finally was forced to sign a treaty on the banks of the Biás, by which he was stripped of many of his conquests. He died insane in 1811, and was succeeded by his son Malhar Ráo, during whose minority the state was torn by the most violent dissensions, and overrun by Pindáris. The army mutinied, and British intervention became necessary to restore the government. Malhar Ráo dying in 1833 without issue, his wife and mother adopted Martand Ráo Holkar as his successor. He was summarily deposed by Harí Ráo, a cousin of Malhar Ráo, whose accession was welcomed by the troops. His rule was a tissue of intrigue and disorder. He died in 1843, and his adopted son, who succeeded him, died in a few months, leaving no heir. The succession was declared to rest with the British Government, and Túkaji Ráo (the present maháráj), at that time eleven years old, was selected and placed on the *gadi*. Holkar maintains a military establishment of 3100 regular and 2150 irregular infantry, 2100 regular and 1200 irregular cavalry, and 340 artillerymen, with 24 field guns equipped.

INDRE, a department of central France, consisting of parts of the old provinces Bas-Berry, Orléanais, and Marche, is bounded N. by the departments of Indre-et-Loire and Loir-et-Cher, E. by Cher, S. by Creuse, Haute-Vienne, and Vienne, and W. by Vienne and Indre-et-Loire. It lies between 46° 22′ and 47° 15′ N. lat., and between 0° 52′ and 2° 13′ E. long., being 60 miles in length from north to south and 54 miles in breadth from east to west. It derives its name from the river Indre, which flows through it from south-east to north-west. The Creuse, Claise, and Vienne, tributaries, like the Indre, of the Loire, are the other principal streams. The surface forms a vast plateau, sloping from south to north, and divided into three districts, the Bois-Chaud, Champagne, and Brenne, varying with the characteristics of the soil. The Bois-Chaud is a large well-wooded plain, comprising seven-tenths of the entire area, and covered with a sandy and stony soil. In the river valleys, however, the soil is extremely fertile. The Champagne, a bare though fertile district to the north-west, produces abundant cereal crops, and affords excellent pasturage for large numbers of sheep, celebrated for the fineness of their wool. The Brenne is an unhealthy marshy district to the south. The climate of Indre is mild and temperate, though moist. On the southern heights the cold is often severe, and throughout the department the crops suffer much from hailstorms. The growth of cereals in Indre exceeds the requirements of the inhabitants; the pasturage is good and abundant; and there are numerous valuable forests of oak, elm, beech, and other timber. Fruit-trees are plentiful, and market-gardening is a flourishing industry. The vine is cultivated to a small extent, and yields a mediocre red wine. Chestnuts, potatoes, turnips, beetroot, hemp, and colza are also grown. The rearing of horses and horned cattle is carried on in the Bois-Chaud, and of sheep in the Champagne. The mineral resources of the department include large quantities of iron, besides marl, sandstone, limestone, marble, lithographic and mill-stones, granite, and other stones. The chief industry is the working of the iron; tobacco, paper, parchment, cloth, woollen goods, leather, felt, pottery, porcelain, bonnets, scythes, and tiles are also manufactured. Indre has considerable trade in its natural productions and manufactured articles, and in wool, horses, and oxen. The department is divided into the arrondissements of Châteauroux, Le Blanc, La Châtre, and Issoudun, with 23 cantons and 245 communes. The chief town is Châteauroux. The total area is 2624 square miles, and the population in 1866 was 277,860, and in 1876 281,248.

INDRE-ET-LOIRE, a department of central France, consisting of parts of the old provinces Touraine, Orléanais, Anjou, and Marche, is bounded N. by the departments of Sarthe and Loir-et-Cher, E. by Loir-et-Cher and Indre, S. and S.W. by Vienne, and W. by Maine-et-Loire. It lies between 46° 45′ and 47° 43′ N. lat., and between 0° 4′ and 1° 18′ E. long., being 70 miles in length from north to south and 59 in breadth from east to west. It derives its name from the Loire and its tributary the Indre, which flow through it. The other chief affluents of the Loire in the department are the Loir, Cher, and Vienne. Indre-et-Loire is generally level, and conveniently divides itself into the following districts, according to the characteristics of the soil: the Gâtine, a flat sterile region to the north of the Loire, with some forests; the Varenne, a rich and fertile district between the Loire and Cher; the Champeigne, a chain of vine-clad slopes, separating the valleys of the Cher and Indre; the Véron, between the Loire and Vienne, the most highly cultivated district, but subject to inundation by the former river; the plateaus of Sainte-Maure, a bare hilly region, the most unproductive of the department; and the Brenne, between the Claise and Creuse, forming part of the marshy territory which extends under the same name into Indre. The valley of the Loire in this department, from its beauty and fertility, receives the name of the Garden of France. The climate of Indre-et-Loire is singularly agreeable and equable, avoiding extremes of both heat and cold. About two-thirds of the entire area is suited for cultivation, but the south far exceeds the north in fertility. Cereals of all kinds are grown in greater abundance than is required by the inhabitants. Vines are cultivated to a considerable extent, and yield excellent white and red wines, exported chiefly to Holland and Belgium. Vegetables, potatoes, fruits (plums especially being cultivated for the trade in *pruneaux de Tours*), hemp, liquorice, coriander, anise, truffles, walnuts, and mulberries are also produced. Owing to the deficiency of well-watered pasture, domestic animals are few. Agriculture has been for some time in a backward state, from the conservative adherence to old systems and implements by the small peasant proprietors, who hold much of the land. The mineral resources of the department are unimportant. Iron, marble, limestone, millstone, lithographic stone, and various kinds of marl are worked. Copper, though found, is not worked. The presence of clay, suitable for bricks and pottery, has encouraged the manufacture of these articles. The chief industry is the manufacture of gunpowder at Ripaut near Tours. Silk-weaving, formerly very flourishing, is again beginning to revive. The refining of beetroot sugar and the preserving of fruits occupy many hands. Cloth, carpets, files, woollen goods, paper, and basket work are made in the department; and there is a considerble trade in many of the manufactured articles. Indre-et-Loire is divided into the arrondissements of Tours, Loches, and Chinon, with 24 cantons and 282 communes. The chief town is Tours. The total area is 2360 square miles, and the population in 1866 was 325,193, and in 1876 324,875

INDULGENCE, in Roman Catholic theology, is defined as the remission, in whole or in part, by ecclesiastical authority, to the penitent sinner, of the temporal punishment due for sin.[1] The word (from *indulgeo*, and perhaps connected with *dulcis*) in its classical use has the meaning which it still bears in ordinary parlance; but by post-classical writers it is often employed in a more special sense to denote a remission of taxation or of punishment. The *Codex Theodosianus* has two titles "De indulgentiis debitorum" (lib. xi. tit. 28) and "De indulgentiis criminum" (lib. ix. tit. 38). In this sense it was taken up by ecclesiastical writers; thus Ambrose says "nemo recte egerit pœnitentiam nisi a Deo per Christum speraverit indulgentiam;" and Augustine (*Con. Jul.*, i. 3) quotes Reticius of Autun (313 A.D.) to the effect that "baptism is the principal indulgence known to the church." The natural and actual synonyms of the word are "gratia," "venia," "relaxatio," and "remissio."

The penitential discipline of the ancient church was very severe in its treatment of a large class of scandalous offences; and in the canonical punishments or penances (which from a very early date began to be determined with considerable precision) time was always a prominent element. But a certain power of showing leniency (φιλανθρωπία) or the

[1] "Est autem indulgentia remissio pœnæ temporalis adhuc post absolutionem sacramentalem peccatis debitæ, in foro interno coram Deo valida, facta per applicationem thesauri ecclesiæ a superiore legitimo" (Perrone, *Præl. Theol.*, "Tract. de Indulg.," proœm.).

reverse, in the way of shortening or lengthening the prescribed duration of the period during which ecclesiastical penance was to be done, was always left to the discretion of the bishop. An early and explicit proof of this is found in the fifth canon of the council of Ancyra (314).[1] This discretionary leniency was sometimes, as appears from the writings of Cyprian, granted by the bishop on the intercession of those who were witnessing for the truth in prison; sometimes also at the instance of the civil magistrate. The episcopal power was occasionally exercised, not only in a shortening of the canonical duration of the penance, but in some mitigation of the nature of the penalty itself (Syn. Ancyr., can. 2). We find indications at a very early period that some of the minor ecclesiastical offences could be readily and canonically atoned for by almsgiving (Aug., *De Fid. et. Op.*, c. 19); thus gradually arose, by steps which can readily be conjectured, a regular system of commutations (redemtiones, commutationes), set forth in "libri penitentiales," offering striking analogies to the provisions made by the various criminal codes by which the Theodosian was supplanted throughout Europe. In the *Penitential* of the Greek Theodore of Canterbury, for example (690), which is to be found in Migne's *Patrologia*, a canonical fast of days, weeks, or years may be redeemed by saying a proportionable number of psalms, or by paying an adequate fine. For more than four centuries this work held a position of great authority all over Europe. At the time of the crusades, to go to Palestine and take part in the struggle against the infidel was held to be a work of such extraordinary merit as to render unnecessary any other penitential act on the part of the sinner who engaged in it. Thus at the council of Clermont, held under Urban II. (1095), it was decreed "iter illud pro omni pœnitentia reputetur." The great schoolmen were the first to reduce to a theory the praxis which had gradually thus sprung up within the Western Church. That theory may be said to resolve itself into the two positions—(1) that, after the remission of the eternal punishment due for sin, there remains due to the justice of God a certain amount of temporal pain to be undergone, either before death in this world, or after death in purgatory; (2) that this pain may be remitted by the application of the superabundant merits of Christ and of the saints out of the treasury of the church, the administration of which treasury is the prerogative of the hierarchy. A characteristically elaborate statement and defence of these theses will be found in the supplement to the *Summa* of Thomas Aquinas (p. 3, qu. 25) and in the *Summa* of Alexander Halesius (p. 4, qu. 23, art. 2, membr. 5). In their Tridentine form they occur in sess. 6, can. 30, and sess. 14, can. 12–14. With these passages must be compared the condemnation of the synod of Pistoia by Pius VI. in 1794.

Indulgences are either general or particular, *i.e.*, either open to the whole church or confined to particular localities. The most general of all is that which is proclaimed in the year of jubilee. Indulgences again are either plenary or non-plenary, the former being a total remission of all the temporal punishment which may have been incurred by the recipient. It must carefully be borne in mind that, in Roman Catholic orthodoxy, indulgence is never absolutely gratuitous, and that those only can in any circumstances validly receive it who are in full communion with the church, and have resorted to the sacrament of penance, in which alone, after due contrition and confession, provision is made for the remission of the graver penalty of sin. The doctrine of indulgences, however, is singularly open to misunderstanding; and in its practical applications it has too often been used to sanction the most flagrant immorality. The scandalous abuses connected with the "pardoner's" trade, and in particular the reckless conduct of the hawkers of the papal indulgence granted to those who should contribute funds for the completion of St Peter's, Rome, were, as is well known, very prominent among the proximate causes of the Protestant Reformation. In the 14th article of the Church of England the doctrine of the "thesaurus meritorum" or "thesaurus supererogationis perfectorum" is by implication rejected; and in art. 22 "the Romish doctrine concerning purgatory and pardons" is expressly condemned. It is hardly necessary to add that "the power of the keys" is inseparable from the idea of a church, and that in this power is plainly involved a certain discretion as to the time and manner in which discipline shall be administered. This discretion is claimed by every organized body of Christians.

See Amort, *De Origine, Progressu, Valore, et Fructu Indulgentiarum*, Vienna 1735; and Hirscher, *Die Lehre vom Ablass* Tübingen, 1844.

[1] See Bingham, *Antt.*, xviii. 4; and Hefele, *Conciliengesch.*, i. 226, &c.

INDUS, one of the three greatest rivers of northern India, rises in unknown regions on the northern slopes of the sacred Kailas Mountain in the Himálayas. On the south of this same hill rises the Sutlej, the great feeder of the Indus, which unites with it after a separate course of about 1000 miles. The Indus rises in 32° N. lat. and 81° E. long., enters the Punjab in 34° 25′ N. lat. and 72° 51′ E. long., leaves the Punjab in 28° 27′ N. lat. and 69° 47′ E. long., enters Sind in 28° 26′ N. lat. and 69° 47′ E. long., and finally falls into the Arabian Sea in 23° 58′ N. lat. and 67° 30′ E. long. The basin of the Indus is estimated at 372,700 square miles, and its total length at a little over 1800 miles.

The first third of its course lies outside of British territory. It at first flows north-west for about 160 miles under the name of "Sinh-ka-bab," until it receives the Gar. Shortly after this junction it enters Kashmír. Near Iskardoh in Little Tibet is the wonderful gorge by which the river bursts through the western ranges of the Himálayas, said to be 14,000 feet in depth. For about 120 miles the river passes south-west through the wilds of Kohistán until it reaches the Punjab frontier near Derbend. A little way above Attock, in Rawál Pindí district, it receives the Cabul river, which brings down to it the waters from Afghánistán *via* Jalálábád and the Khyber Pass. The two rivers have about the same volume; both are very swift, and are broken up with rocks. Their junction during floods is a scene of wild confusion of waters. At Attock the river has fallen from its elevation of 16,000 feet at its source in Tibet to under 2000 feet. After leaving Attock, the Indus flows almost due south down the western side of the Punjab, parallel to the Suláimán hills. Just above Mithankot, in the south of the Derá Ghází Khán district, the Indus receives the accumulated waters of the Punjab. Between the Indus and the Jumna (Jamuná) flow the five great streams from which the Punjab (Panj-áb, literally "The land of the five rivers") takes its name. These are the Jhelum, the Chenáb, the Rávi, the Biás, and the Sutlej. After various junctions these rivers all unite to form the Panjnad, literally "The five rivers." The Panjnad marks for a short space the boundary between the Punjab and Baháwalpur, and unites with the Indus near Mithankot, about 490 miles from the sea. The breadth of the Indus above the confluence is about 600 yards, its velocity 5 miles an hour, its depth from 12 to 15 feet, and its estimated discharge 91,719 cubic feet per second. The breadth of the Panjnad above the point of junction is 1076 yards, with a depth of 12 to 15 feet, but a velocity of only 2 miles an hour. Its estimated discharge is 68,955 cubic feet per second.

Below the junction the united stream, under the name of the Indus, has a breadth which varies from 2000 yards to several miles, according to the season of the year. The whole course of the river through the Punjab is broken up by islands and sandbanks. The Indus enters Sind in 28° 26′ N. lat. and 69° 47′ E. long., and empties itself by many mouths into the Arabian Sea, after a generally south-westerly course in this province of 580 miles. Its average width during the low season is 680 yards; its depth varies from 4 to 24 feet. Its velocity in the freshes averages 7 knots per hour, at ordinary times 3 knots. The discharge per second varies at the two periods from 446,086 cubic feet to 40,857. The average temperature is 10° lower than that of the air.

The delta of the Indus covers an area of about 3000 square miles, and extends along the coast-line for 125 miles. It is almost a perfect level, and nearly destitute of timber, the tamarisk and mangrove alone supplying fuel. In the marshy portions good pasturage is obtained, and in the drier rice grows luxuriantly. The climate of the delta is cool and bracing in the "winter" months, excessively hot in the "summer," and most healthy during the floods.

The Indus begins to rise in March, attains its maximum depth and width in August, and subsides in September. The registered rise at Gidu-Bandar is 15 feet. Fish abound,—at the mouths, the salt-water varieties, notably the *Clupea neowhii*, a species of herring; the chief of the freshwater varieties is the *pala*. The local consumption and export of the dried *pala* are both very large. The boats of the Indus are the *dúndhi* and *zaurak* (cargo boats), the *kauntál* or ferry-boats, and the *dúndo* or fishing boats. The aggregate burthen of the native craft on the river in 1861–62 was as follows:—up-stream to Sukkur 20,232 tons, and beyond that town 16,317; down-stream to Sukkur 7694 tons, and beyond it 11,456. In 1874 the number of steamers plying was fourteen, and of barges forty-three, with an aggregate burthen of 10,641 tons; the receipts amounted to £83,370.

END OF VOLUME TWELFTH.

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PRINCIPAL CONTENTS.